THE HERPETOFAUNA OF SOUTHWESTERN NEW ENGLAND

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Thesis submitted for the degree of

Doctor of Philosophy (in Ecology)

University of Kent, Canterbury

1990

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ABSTRACT

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1990. THE HERPETOFAUNA OF SOUTHWESTERN NEW ENGLAND.

A thesis submitted for the degree of Doctor of Philosophy (Ecology) at the University of Kent, Canterbury, U.K.

The distributions, variations, and abundances of the 45 species of amphibians and reptiles found in southwestern New England (USA) are described and analyzed using multivariate statistical techniques. These data are compared to historical information contained in museums and literature reports. Activity and reproductive parameters are described and compared to published data from other areas of North America. The conservation status of each species is discussed, and where appropriate, recovery strategies proposed.

DEDICATION

My wife, Nicole Silton Klemens, has provided continued moral support, advice, and assistance throughout this project. She has endured, mostly with good humor, my frequent absences, late night salamander forays, as well as countless specimens, books, maps, and papers scattered and piled in our tiny home. Nicole has helped me wash laundry that should have been buried, repaired nets, seines, and turtle traps, and compiled field notes while I preserved specimens. She has edited, proof-read, and critiqued, and above all, has been my friend. So to my friend and strongest supporter, Nicole, I dedicate this work.

ACKNOWLEDGMENTS

The field work and data analysis for this study has spanned fifteen years, innumerable state and local political jurisdictions, not to mention two continents. The number of individuals who have contributed data or assisted me in one way or another is enormous. By listing the following individuals by name, I will undoubtedly omit some deserving people. I ask the forbearance of those individuals, be assured I am indebted to each any every person who contributed information or in some way facilitated my research.

The two members of my doctoral committee deserve special mention. My supervisor, Dr. Ian R. Swingland, provided me with a unique opportunity to achieve this goal. He challenged me, encouraged me, and aggravated me, but we always remained friends. I profited greatly from stimulating conversations with my adjunct supervisor, Dr. Robert Schmidt of Simon's Rock College. He gave freely of his time and expertise during all facets of this project.

Although many individuals accompanied me on field trips, submitted specimens, or shared their data with me, the contributions of Bob Fritsch, Hank Gruner, and Chris Raithel were truly exceptional.

I am grateful to the following University of Kent faculty: Dr. Ian Joliffe who provided statistical advice, and Ms. Joan Dobby, Dr. Patricia Pack, and Ms. Christine Wilson who assisted me in coming to grips with various computing applications.

The production of the final copy my dissertation was a trans-Atlantic operation. Kathleen Schmidt designed the maps, converting my crude drawings into a professional presentation. Christine Wilson printed out the text from diskettes. Jo Lemon coordinated the printing, copying, binding, and submission of the final product. Ludwik and Miriam Finkelstein provided advice, encouragement, and hospitality during my frequent trips to London. Ian and Fiona Swingland as well as Mike and Marg Nicholls helped me feel at home during my half year at the University of Kent.

Financial support for portions of this work was provided by: SSAR Grants-in-Herpetology, Sabin Conservation Fund, IUCN-Operation Tortoise, The Connecticut Geological and Natural

History Survey, The Nature Conservancy (Connecticut Chapter), University of Connecticut Research Foundation, The Massachusetts Nongame and Endangered Species Program, The Nature Conservancy (Massachusetts Field Office), Simons Rock College, Dr. and Mrs. P. G. Klemens, and Mr. and Mrs. Walter Cliff.

The facilities and staff of the American Museum of Natural History have assisted this project in many ways. I am especially thankful to the following individuals: Margaret Arnold, Jackie Beckett, Bea Brewster, Phil Damiani, Norma Feinberg, Linda Goldberg, Monika Kerschus, Les Marcus, Chuck Myers, Andy Sabin, Peggy Shaw, Lou Sorkin, Bruce Stutz, Grace Tilger, and Dick Zweifel.

The following museums and their curatorial staff provided information about and/or access to their collections: Academy of Natural Sciences (Edmond Malnate, Charles Smart), British Museum of Natural History (Nick Arnold), Bruce Museum (Marianne Smith), Carnegie Museum of Natural History (C. J. McCoy), Cornell University (F. Harvey Pough, Bob Schoknecht) Field Museum of Natural History (Alan Resetar, H. K. Voris), Illinois Natural History Survey (Philip Smith), Illinois State University Museum of Natural History (Donald Hoffmeister), Museum of Comparative Zoology (Jose Rosado, Greg Mayer), Museum of Vertebrate Zoology, University of California (Harry Greene), National Museum of Natural History (George Zug, Ron Crombie, Roy McDiarmid), New York State Museum (E. M. Reilly, M. C. Zarriello) Rijksmuseum vor Natuurlijke Historie (Marinus Hoogmoed), Southern Connecticut State College (Noble Proctor, David Avery), Staten Island Institute of Arts and Sciences (Ed Johnson), Texas Cooperative Wildlife Collection (Jim Dixon), Texas Memorial Museum (Robert Martin), University of Connecticut, Museum of Natural History (Bob Dubos, Carl Rettenmeyer), University of Kansas, Museum of Natural History (Joe Collins, Marc Nadeau), University of Massachusetts, Museum of Natural History (Doug Smith), University of Michigan, Museum of Zoology (Arnold Kluge, Ron Nussbaum, Greg Schneider), and Yale University Peabody Museum (Fred Sibley, Peter Bottjer)

The following individuals or organizations assisted me in the field, submitted specimens, or in some way facilitated this project:

Alan and Karin Altman, Barth Anderson, Jim Andrews, Sperry and Doris Andrews, Sally Austin, Karen Backer, Spider Barbour, Ann Elizabeth Barnes, Ted and Cindy Beck, Liz Bell, George Benz, Julie Bijou, John and Nancy Blum, Barbara Bockbrader, Jim Bogart, Bruce Bowker, Al Breisch, Ann Maria Brennan, Bridgeport Hydraulic Company, Lauren Brown, Walker Bucker, Caren Caljouw, John Clark, John Coakley, Chet Coddington, Dennis Collins, Connecticut Herpetological Society, Bob Cook, Susan Cooley, Bob and Sue Craig, Chip David, Dennis DeCarli, Ellie DeCarli, Marc DesMeules, Mark Dill, Tony Douglas, Rita Duclos, Rick Enser, Bill Fenwick, Bob Ford, Owen Ford, Linc Foster, Wayne Frair, Tom French, Gunther and Ursula Frey, Janie Fritsch, Steve Fuller, Jon Gaboriault, Steve Garber, Greg George, Steve Gephard, Eric and Lotte Gerstel, Art Gingert, J. Glowa, Tony Gola, Raelene Gold, Becky Goldberg, Dick Goodwin, Terry Graham, Jeff Greenwood, Mary Hake, Geoff Hammerson, David Hayes, Sarah Heady, Clint Hendrickson, Paul Herig, Henry Higginbotham, Meredith Johnson, Ed Kanze III, Jay Kaplan, Robert F. Kennedy, Jr., Erik Kiviat, Paul and Ruth Klemens, Sue Klemens, Warren Koehler, Vlaho Krstelj, J. Kuchle, R. Kuchta, Susan Langevin, Beth Lapin, Werner and Toni Laqueur, Gordon Loery, Paul Luikart, Paul Lyons, Andy Main, Arthur Manthorne, Bill Maple, Stuart and Edith Marks, Peter Marra, Bill Martha, Dawn McKay, Les Mehrhoff, Scott Melvin, Metropolitan District Commission (Connecticut), Metropolitan District Commission (Massachusetts), Metropolitan Transportation Authority (New York/Connecticut), Ken Metzler, Pete Mirick, Bob Moeller, Judy Momm, Dale Monette, John Moriarity, Brad Mutch, New Haven Water Company, New London Water Company, Dave Norris, Tim O'Donoghue, Mary Peccerillo, Jim and Maggie Pepe, Dick Petersen, Engalena and Fosca Pieratti, Joe Pratt, Tanja Pyles, Paul Rabenold, Sarah Conyngham Raithel, Tom Rawinski, Ethan Roberts, Dan Root, Dave Rosgen, Margaret Schuster, Jon Schwartz, Norm Scott, Mike Seidel, Debbie Shea, Don Sias, Andy Silton, Peter and Lore Silton, Jim and Betty Slater, Ed Smith, Nancy Smith, Sean Smith, Ken Soltesz, Bruce Sorrie, Norman Soule, Jim Stapleton, Richard Stavdal, Tom Steinke, Dave Stillman, Shawn Stockford, Will Stoddard, Fred Streams, Gene Twaronite, Jim Utter, Robyn Van En, Stan Voket, Julie Victoria, Jim Warner, Peter Warny, Ralph Wetzel, George and Dot Whitney, Page Williams, Bruce Woodward, Henry Woolsey, Julie Zickefoose, Bill Zovickian, and Mike Zulich.

CHAPTER ONE: INTRODUCTION

PROLOGUE:

New England's bountiful flora and fauna were noted by the region's earliest European settlers. Although most of their written commentaries concerned exploitable resources such as timber, furs, and fish, occasional references were made to both reptiles and amphibians. Scientific reports on the herpetofauna of eastern North America began to appear in the mid-eighteenth century. The volume of these reports had increased tremendously by the mid-nineteenth century. DeGraaf and Rudis (1983) in their Amphibians and Reptiles of New England reviewed a large body of historical information, summarizing almost 150 years of publications and collections. Craig (1984) stated that although their book provided a "substantial compilation", it neglected the important issues of the systematic, morphological, and ecological variation of New England's herpetofauna. Because most of the scientific literature concerning New England's herpetofauna was limited to species lists and catalogues, DeGraaf and Rudis (1983) relied heavily upon studies done in other areas to provide ecological, life history, and population data. Part of the purpose of my study was to gather ecological and life history data specifically on New England populations of amphibians and reptiles.

The six New England states, located at the northeastern end of the United States, can be divided into three major zoogeographical sections. For expediency, I used political boundaries to delineate these regions, although their zoogeographical limits are not as clearly defined. Southwestern New England, which was the focus of my study, begins at the Hudson River's east bank in New York State. Its 9,808 square miles include southeastern New York (2,111 square miles = Columbia, Dutchess, Putnam, and Westchester counties), the entire state of Connecticut (4,872 square miles), western and central Massachusetts (2,777 square miles = Berkshire, Franklin, Hampshire, and Hampden counties), and a minute portion (48 square miles) of western Rhode Island. Storer (1840), DeKay (1842), Linsley (1844), Henshaw (1904a, 1904b), Drowne (1905), Lamson (1935), and Babbitt (1937) published lists of amphibians and reptiles found in southwestern New England. The accuracy of these lists varied greatly. Locality data, if included, were quite limited, and many of these authors reported observations they had received secondhand from "correspondents". Bishop's (1941) monograph on the salamanders of New York is a notable exception, providing detailed locality and life history information.

Southeastern New England, which lies outside the scope of this study, encompasses both the coastal plain and coastal plain transition zone, including most of Rhode Island, eastern Massachusetts (from Worcester County eastward including Cape Cod and its islands), and a small portion of southeastern New Hampshire. Lazell (1976) reported on the herpetofauna of Cape Cod and Chris Raithel is preparing a monograph on Rhode Island's amphibians and reptiles. The states of Maine, New Hampshire, and Vermont comprise northern New England. Until recently, little work had been done in this region since Oliver and Bailey's (1939) account of New Hampshire's Connecticut River watershed. Fortunately, several individuals aided by private and governmental agencies have begun herpetological survey work in this area.

THE CHANGING LANDSCAPE:

To many, "New England" conjures up images of rolling fields, verdant forests, stone walls, and white clapboard houses and churches clustered in bucolic villages. To others, who travel only on the interstate highway system, "New England" is part of megalopolis, the ever-growing urban sprawl of cities, decaying mill towns, and suburbia. Both images represent extremes on a continuum of changing land uses, which spans more than three centuries. The present distribution of the flora and fauna of southwestern New England has been profoundly influenced by these patterns of land use and settlement. The ecological and social histories of New England are inextricably intertwined. Detailed accounts of this relationship are provided by Thomson (1977) and Cronon (1983).

Beginning in the early 1600's, settlements spread throughout the region. Land was cleared, cultivated, and pastured. Brooks were impounded to provide energy for grist and saw mills. Game was hunted for food and trapped for fur, the rivers and estuaries were fished. Coastal settlements became centers of commerce, ship building, and foreign trade. By the end of the eighteenth century the industrial revolution began, bringing opportunity as well as untold misery to thousands of men, women, and children in New England's mill towns.

During the early nineteenth century, immense tracts of fertile prairie were opened up for settlement in the midwestern United States. As people moved west, farming began to decline in New England, a trend which continues to this day. Gradually, the forests began to reclaim the fields and villages. Although urban areas continued to grow, the populations of many small villages declined. Rural areas became increasingly impoverished and stagnant. The forests continued to expand and by the Depression of the 1930's, New England was once again cloaked with a mantle of forest. The end of World War II heralded the dawn of a new era in New England. The newly constructed interstate highway system brought rural areas within easy reach of urban centers. Postwar prosperity initiated a massive exodus from the cities into the suburbs. Moribund farms and second growth forest were purchased by developers and converted to tract housing. Although subject to economic upswings and downturns, this type of development will continue well into the twenty-first century.

This intensive development presents a serious long-term threat to many amphibian and reptile species. Over previous centuries, when land was cleared, grassland species flourished and woodland species were restricted to uncleared ravines, hillsides, and woodlots. Conversely, when the forests returned, the range of grassland species contracted to fields and other open patches. However, it is unlikely that many amphibians and reptiles will be able to adapt to a patchwork suburbanized landscape. Although I have no evidence that any species of amphibian or reptile has become extinct in New England since colonial times, localized extirpations are increasing, and several species are now in danger of regional extinction. Fortunately, some large tracts of land have been set aside in state parks, forests, and game management areas. Private conservation groups have established smaller wildlife sanctuaries. These sites will becomes increasingly important as refuges for amphibians and reptiles in the years to come.

REGIONS OF SOUTHWESTERN NEW ENGLAND:

A tremendous amount of ecological diversity is found within southwestern New England. For descriptive purposes, I divided the region into six divisions. Dowhan and Craig (1976) and Bell (1985) provided detailed descriptions of Connecticut's topographic and ecological regions. Some of the key natural features mentioned in the following paragraphs are illustrated on the range maps contained in the species accounts (Chapters 3-6).

COASTAL REGION

The coastal region of Connecticut and adjacent New York (Westchester County) is a rocky and impoverished habitat in comparison to Long Island's coastal plain. Although southwestern New England has an extensive coastline, it borders on a large, protected bay (Long Island Sound). Southwestern New England lacks the deep deposits of glacial till found on Long Island and southeastern New England. The action of oceanic waves and wind upon this glacial till form the unique coastal community of barrier beaches and lagoons found in eastern Massachusetts, Rhode Island, and Long Island. Connecticut and Maine are the only states on the eastern seaboard which lack this distinctive formation.

The coastal region of southwestern New England is quite narrow, with topographic relief increasing rapidly as one moves inland. The maritime influence extends inland along some of the larger river valleys, but is generally limited to a zone only a few miles wide. This coastal region is drained by small rivers, which have headwaters 10-30 miles inland, and flow directly into Long Island Sound. Some examples include Blind Brook, and the Byram, Mianus, Hammonasset, and Mystic rivers. Population levels are high in this region, with areas west of New Haven (CT) essentially urban.

HUDSON DRAINAGE BASIN

The Hudson River drainage basin extends from the east bank of the Hudson River and encompasses almost all of the New York portion of southwestern New England as well as small areas of Connecticut and Massachusetts. This is an area of rugged topography, both along the Hudson River and further inland. Several low lying north-south valleys dissect this landscape. The two major valleys are the Hudson Valley in the west and the Harlem Valley in the east (near the Connecticut border). Smaller valleys occur throughout the region. Calcareous bedrock underlies many of the valleys in the eastern parts of the drainage basin. Elevations are generally above 500 feet, areas above 1,000 feet are not uncommon, and some sites in eastern Dutchess and Columbia counties approach 2,000 feet. Examples of rivers flowing westward into the Hudson are the Croton River, Wappinger Creek, Fall Kill, Saw Kill, and Crum Elbow Creek. Population levels vary considerably with the highest densities found along the Hudson River and in the south (Westchester County). Many rural areas of eastern Dutchess and Columbia counties are sparsely settled.

TACONIC UPLIFT

The Taconic Uplift is a fairly continuous north-south mountain range, forming a divide between the Hudson and Housatonic drainage basins. It stretches from northwestern Connecticut and northeastern Dutchess County northward into Columbia and Berkshire counties. Relief is extremely rugged and elevations reach well over 2,000 feet. This steep and craggy wilderness area remains sparsely settled and is the last refuge for species that have become extinct in more populous areas. Clean, cold brooks cascade off the divide into the surrounding calcareous valleys. Examples are Bashbish Brook (Hudson drainage) and Karner Brook (Housatonic drainage). Several lakes on top of the Taconic Uplift have been affected by acidic rainfall.

WESTERN HILLS AND UPLANDS

This is an area of variable topography, stretching from the New York state line eastward to the Central Connecticut Lowland, and south to within a few miles of Long Island Sound. This region lies primarily in the Housatonic drainage basin, although its eastern portion is drained by tributaries to the Connecticut River including the Westfield and Farmington rivers. The northern half of this region is an area of moderate to high relief with elevations frequently exceeding 1,000 feet. The lower portions of the Housatonic drainage basin are hilly, usually at least several hundred feet above sea level, and heavily suburbanized. The upper Housatonic drainage is a pleasing mosaic of farms, villages, and forests in a mountainous setting. It is a popular vacation and second home location which is experiencing ever-increasing development pressure. Many of the valleys are underlain with calcareous bedrock. Large swamps and lakes are scattered throughout the region. Many streams and rivers drain into the Housatonic including Schenob Brook, and the Green, Williams, Konkapot, Blackberry, Shepaug, and Naugatuck rivers. The population density is quite variable, but generally is heaviest in the southern sections of the region.

CENTRAL CONNECTICUT LOWLAND

The Central Connecticut Lowland is a flat, sandy peneplain that stretches from New Haven north through central Massachusetts. At some points it is over 20 miles wide. This lowland corridor is one of the most densely populated areas of southwestern New England. It includes cities such Meriden, Hartford, and Springfield as well as numerous suburban towns.

Elevations are below 250 feet, except for a series of basalt ridges that rise abruptly from the valley floor to elevations of 500-1,000 feet. Over millions of years, the sandstone and shale bedrock has eroded away, leaving these hard volcanic rocks towering above the surrounding peneplain. These ridges form a unique ecological community, and are considered some of Connecticut's most important natural areas. Lee (1985) provided an informative overview of these ridges.

The western edge of the Central Connecticut Lowland forms a well defined escarpment, which is the eastern edge of the western hills and uplands. A similar transition takes place at the Central Connecticut Lowland's eastern boundary, but as the eastern hills and uplands are quite low, this transition is not as dramatic. This large valley is primarily drained by the Connecticut River, which has numerous large and small tributaries including the Farmington, Scantic, and Hockanum rivers. The Quinnipiac River, which empties directly into Long Island Sound, drains the valley's southern end.

EASTERN HILLS AND UPLANDS

This is a subdued version of the western hills and uplands, stretching from the eastern edge of the Central Connecticut Lowland to the coastal transition zone, which roughly corresponds to the Connecticut-Rhode Island border. Relief is much lower, with many inland areas only several hundred feet above sea level. Elevations in many areas fall into the 500-700 foot range, with a small section of uplands over 1,000 feet. Large glacial deposits of sand and gravel are quite common, especially in river valleys.

This region is primarily drained by the Thames River and its tributaries which include the Natchaug, Shetucket, Moosup, Quinebaug, Willimantic, Pachaug, and Yantic rivers. The Pawcatuck River, which flows directly into Block Island Sound, drains a small section of southeastern Connecticut. The countless mill ponds and abandoned factories scattered along these rivers serve as silent reminders of more prosperous times. Farming remains an important industry in this region. Light industry is now housed in some of the old mills. Suburban development is rapidly increasing in this area, fueled by the availability of relatively cheap land. Although the population density is increasing, many areas still retain their rural character.

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CHAPTER TWO: MATERIALS AND METHODS

INTRODUCTION:

Field work for this project was divided into three phases spanning a fifteen year period (1975-1990). Phase One began in 1975 and ended in the early summer of 1978. During this phase, I concentrated on studying the distribution and variation of the painted turtle, Chrysemys picta, within Connecticut (Klemens, 1978). However, I also collected data on other reptiles and amphibians which are included in this monograph. Most importantly, by travelling throughout Connecticut, I gained an appreciation of the tremendous ecological diversity contained within this relatively small geographical area. These experiences provided the impetus to conduct an in-depth study of amphibian and reptile distributions in southern New England.

Phase Two began in spring 1979 and ended in 1986. This period was characterized by intensive survey work throughout Connecticut, repeatedly covering all major ecological and political divisions. The years 1984-1986 saw an increasing shift in my field work beyond Connecticut's borders into adjacent areas of Massachusetts, New York, and Rhode Island. All data collected in Phases One and Two were subsequently computer coded and examined utilizing various multivariate statistical techniques detailed in Chapters 7-9.

Phase Three spanned the years 1987-early 1990. Field work in 1987-88 was primarily conducted beyond Connecticut's borders. Field work in 1989 and early 1990 was quite limited because my time was spent conducting data analyses and writing up the results. Phase Three data were collected too late in my study to be incorporated into the statistical analyses. Data from all phases, however, were utilized in preparation of the range maps and species accounts.

FIELD WORK TECHNIQUES:

A variety of standard capture techniques were used to gather samples of amphibians and reptiles for documentation and study. Hand capture was most frequently employed. Likely looking areas such as forest edges and the margins of streams and ponds were carefully searched. Specimens were captured before they had time to flee. Generally, this method was most successful during the first half of the day, between 8:30-11:00 AM, although during cool or damp weather specimens were found throughout the day. Turtles were hand captured while wading in shallow water and by poking through shallow, muddy areas with my hands.

Log rolling, debris turning, and rock lifting revealed snakes and salamanders. Piles of rock and debris situated in the open near wooded areas were especially productive for snakes. Damp piles of debris, leaves, and rotten wood often contained salamanders. Rock turning in streams and seepage areas yielded salamanders, often captured with the aid of a small net or scoop. Flat, partially submerged rocks, lying on stream banks were very productive.

Driving slowly or walking along a road during wet weather yielded large numbers of amphibians, especially during the spring and autumn. Roads bordering wooded swampland or situated at the base of rocky, steep, wooded hillsides were good sites for road collecting. Series of Ambystoma required for karyotyping were obtained using this technique. A plastic milk container cut into the shape of a scoop proved useful for collecting slimy, delicate salamanders on flat road surfaces. The flexible scoop, which hugged the contour of the road's surface, was placed in front of the salamander. The salamander was gently nudged from behind and crawled into the scoop. Once safely in the scoop, a moistened plastic bag was placed over the open end, the scoop gently inverted, and the salamander retraced its steps, crawling into the plastic bag which was closed with a knot. Small, delicate salamanders were secured without the scrapes and injuries that often occur when they are picked up off of a smooth, wet, road surface.

Dip nets of varying sizes were employed in a variety of ways. Turtles and frogs were captured by placing the net in front of fleeing animals or by scooping up mud or aquatic vegetation into which these animals had retreated. Larval amphibians and newts were captured by sweeping the dip net through the water while standing on the edge of a vernal pool or pond. Ambystomid salamanders were individually netted at night during their spring breeding congregations. A headlamp left both hands free to use the net and manipulate captured salamanders into plastic bags. Salamanders were netted from the shoreline or by wading into pools with hip or chest waders. A long handled dip net was extended as far as six feet below ground level into springs and wells to capture aquatic salamanders such as Eurycea and Gyrinophilus. A lightweight net proved useful for capturing Rana pipiens, which frequently escaped by hopping into tall grasses in an evasive zig-zag pattern. By swiftly bringing the net down atop the grass clump into which the frog had just jumped, its next leap landed it in the net.

Seines were of limited use in collecting amphibians, as most aquatic habitats sampled were shallow, weed choked, and full of snags and rocks, rendering seine pulls very difficult. Turtles were not captured by seines, but newts, frogs, and larval amphibians were collected in vernal pools, ponds, lakes, and large brooks.

Unbaited minnow traps were used to collect newts and Ambystomid salamanders. These proved especially useful when breeding pools were frozen over or too deep or steep-sided to wade into. Minnow traps were secured to a tree on the shoreline using a strong piece of clothesline and allowed to sink to the bottom of the pool. If the pool was frozen over, a hole was punched through the ice allowing the trap to be lowered to the bottom. Minnow traps were set during the afternoon and collected at night, or at night and collected the following morning. Traps needed to be in the water during part of the night to effectively gather salamanders, but were collected within 6-12 hours to prevent salamanders from drowning.

Baited turtle traps consisting of three 30" metal hoops, covered with 1" nylon mesh with a single funnel opening, were very effective in sampling aquatic turtles in lakes, ponds, vernal pools, and slow moving rivers. Traps were placed in likely looking locations, (e.g. near basking areas or in open weed-choked shallows) and, for maximal success, left overnight. Rainy days were also productive. Traps were staked out using wooden and metal poles of varying lengths. At least two inches of the trap remained above water, allowing turtles to breathe. Bait consisted of a freshly opened can of sardines packed in vegetable oil, suspended in a nylon mesh bag in the center of the trap at the end of the funnel opening. Cans were only partially opened, assuring a slow, continuous leaching of oil into the surrounding water, which dispersed the bait's scent. Tidal and reservoir habitats required frequent trap checks as rapidly fluctuating water levels could submerge traps and drown turtles. Water levels in small ponds and vernal pools rose rapidly during prolonged rainy weather necessitating frequent trap checks. Traps were pulled within 12-24 hours, though occasionally were allowed to remain in situ for 48 hours. Although Chrysemys picta and Clemmys guttata were collected in traps set during daylight hours, overnight trapping was usually required to collect Chelydra serpentina and Sternotherus odoratus.

Road kills and salvaged specimens were an important source of reptile specimens. Snakes, including many large species such as Elaphe and Coluber, were frequently found dead on the road. Turtle shells were picked up in woods and along the edges of lakes and streams. Maximum use was made of road kills and salvage specimens. Although some were discarded after dissection and examination, many were preserved as voucher specimens. Salvage specimens were also collected by a network of contributors throughout my study area. Although ecological information was often incomplete, locality data were usually sound. Any unclear data or specimens of dubious origins were discarded. By encouraging nature centers, small museums, and naturalists to salvage specimens, I obtained many uncommon species, often documenting new localities. I prepared a standardized questionnaire and data sheet to accompany each salvaged specimen. This "user friendly" form led the salvager step by step through the data collection process, facilitating the gathering of complete data upon collection as opposed to writing up details later from memory. This form greatly improved the accuracy and quality of information submitted accompanying salvage specimens.

SPECIMEN PRESERVATION AND DATA COLLECTION:

Specimens for preservation were euthanized by immersion in Chlorotone solution (amphibians) or by injection of dilute Nembutal (reptiles). The snout-vent length (SNVL) and tail length (TL) of snakes were measured prior to preservation. Amphibians were positioned on damp paper towels in trays and fixed in 13:1 buffered formalin solution which was absorbed through the skin. The formalin solution was injected into the peritoneum of large frogs to ensure preservation of the internal organs and gut contents. Reptiles were injected with 10:1 buffered formalin solution into the limbs and peritoneum. Care was taken to ensure complete penetration of the fixative without distending the specimens which were positioned in trays for fixing. The tails of lizards, snakes, and snapping turtles were longitudinally slit to ensure preservation. All collections were made under the provisions of scientific collecting licenses issued by the following states: Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. In some instances additional permits were required for properties under federal or private jurisdictions. These permits are on file at the American Museum of Natural History.

Each specimen was assigned an individual sequentially numbered field tag (AMNH-MWK) with the exception of amphibian larvae and eggs which were assigned one tag per lot. Tags were tied securely onto a hind limb, around the waist of small amphibians, or sewn around the vertebral column of snakes. For each field tag assigned, as much of the following data as available were recorded in India ink in a field notebook. Precise locality including state, county, town, specific locality, elevation, genus, species, subspecies, sex, date of collection, time, weather conditions, number of specimens observed, other species observed, habitat data, method of collection, collector(s), food habitats, reproductive data, behavioral observations, and type of preparation. In some instances photographs were used as documentation or to augment field notes. These field notes and photographs will be archived at the American Museum of Natural History.

After five to seven days, specimens were removed from formalin and transferred to a soaking solution of 65-75% ethanol. After soaking for up to a week, specimens were transferred to fresh ethanol, 65% for amphibians and 75% for reptiles, for permanent storage. Amphibian larvae and eggs were collected and stored in 13:1 buffered formalin. Periodically, specimens were accessioned and cataloged into the permanent research collection at the American Museum of Natural History (AMNH). Each specimen received an AMNH catalog number, which was cross-referenced to my field numbers and my field notes. A small number of specimens were also deposited at the University of Connecticut (UCS) and University of Michigan (UMMZ) with similar cataloging protocols.

Gravid preserved turtles were radiographically examined (a modification of Gibbons and Greene, 1979) to determine clutch size. I also gathered meristic and ecological data on turtles which were captured, numerically marked (a modification of Cagle, 1939), and released. Measurements of small turtles were taken with a 200 mm Mitutoyo dial caliper. Large turtles were measured with a 650 mm Haglof forestry caliper. Measurements, which were rounded to the nearest millimeter, included straight line carapace length (SLC), straight line plastron length (SLP), maximum width (MW), and maximum height (MH). Stomach contents and clutch sizes of snakes were obtained by making a ventral incision along the specimen's midline. If eggs, embryos, or stomach contents were removed from the body cavity, they were placed in sealed glass vials, appropriately labelled, and stored with the specimen.

MUSEUM SPECIMENS AND HISTORICAL INFORMATION:

Additional information on present and past distributions of New England's herpetofauna were obtained from the literature and the major United States herpetological museum collections (Anon., 1975), as well as small museums specializing in the northeastern United States. Most specimens were examined to verify their determinations and gather meristic data. Table One lists these institutions and their abbreviations.

TABLE ONE

Museum Collections Examined

INSTITUTION (ABBREVIATION)	CITY
Academy of Natural Sciences (ANSP)	Philadelphia
American Museum of Natural History (AMNH)	New York
includes field tagged specimens awaiting cataloging into the AMNH collection:	
AMNH-MWK (M. W. Klemens, field series)	
AMNH-JPB (J. P. Bogart, field series)	
AMNH-FS (C. J. Raithel, field series)	
British Museum of Natural History (BMNH)	London
Carnegie Museum of Natural History (CMNH)	Pittsburgh
Field Museum of Natural History (FMNH)	Chicago
Illinois Natural History Survey (INHS)	Urbana
Illinois State University, Museum of Zoology (IMNH)	Urbana
Museum of Comparative Zoology (MCZ)	Cambridge
Museum of Vertebrate Zoology, University of California (MVZ)	Berkeley
National Museum of Natural History (USNM)[1]	Washington
Rijksmuseum vor Natuurlijke Historie (RMNH)	Leiden
Southern Connecticut State College (SCSC)	New Haven
Staten Island Institute of Arts and Sciences (SIIAS)	New York City
Texas Cooperative Wildlife Collection (TCWC)	College Station
University of Connecticut, Museum of Natural History (UCS)	Storrs
University of Kansas, Museum of Natural History (KU)	Lawrence
University of Massachusetts, Museum of Zoology	Amherst
University of Michigan, Museum of Zoology (UMMZ)	Ann Arbor
Yale University Peabody Museum (YPM)	New Haven

[1] includes Wesleyan University's collection donated in 1951

MAPPING PROTOCOLS:

The visual presentation of a species' distribution is an integral part of any zoogeographical study. There were several issues which had to be addressed in the construction of the maps. These were documentation criteria, treatment of historical data, and visual presentation of ubiquitous species versus species with restricted distributions.

Documentation for most localities plotted on the maps consists of either a voucher specimen deposited in a museum collection, a clearly identifiable photograph with locality data, or a published report in a scientific journal. At the conclusion of my study, I included observations from my field notes, as well as those of Hank Gruner, Chris Raithel, and Geoff Hammerson. However, these undocumented observations were only used to augment the maps within the species' known Connecticut range, i.e. range extensions or peripheral populations were not documented in this manner.

I omitted a number of undocumented reports received from a wide variety of naturalists. The majority of these are probably correct, however a standard of accuracy needed to be established. When I received an unconfirmed report that constituted a range extension, I made a concerted effort to document that occurrence. One should note that these maps illustrate the distribution of a species and should not be construed as an attempt to illustrate every occurrence. If I were to continue sampling for another fifteen years, the number of localities on many maps could be doubled. However, I anticipate that the patterns of abundance, scarcity, and absence as illustrated on these maps would remain fairly consistent. Certainly, range extensions still await discovery, and long term shifts in both species composition and abundance may occur due to habitat loss or alteration.

The assignment of a record as historical or current required the establishment of some arbitrary guidelines. If a specimen had been collected since 1950, I treated it as a current record, unless I had strong evidence to the contrary. Any record prior to 1940 was considered historical based solely on age (i.e. in excess of 50 years). Historical records were usually not mapped unless they added distributional or abundance information not provided by current records. The Heterodon platyrhinos map is a good example of extensive mapping utilizing historical records. This map indicates the decline of this snake in many urbanized areas.

The period between 1940-1950 received discretionary treatment. These years witnessed the construction of the interstate highway system, making rural areas accessible to urban centers. Increased post-war prosperity and mobility resulted in large scale suburban development in formerly rural areas. If little habitat change could be noted since the date of collection, and if the species was still found in surrounding areas, the record was treated as "current". If the habitat had undergone development or modification, and/or the species had not been recently reported from the general vicinity, I considered the record "historical".

For instance, in 1940 a small series of Sternotherus odoratus was collected at Wononpakook Lake in Salisbury. Although additional development has occurred around this lake since the 1940's, it has been quite minimal. I collected Sternotherus in Mudge Pond, located approximately one mile downstream from Wononpakook Lake, in the same drainage system. There is little reason to doubt that if Wononpakook Lake was sampled, Sternotherus would be found. Therefore I mapped this collection as a current record. In contrast, a Storeria occipitomaculata was collected at the University of Connecticut at Storrs in 1941. Since the 1940's, the University has expanded tremendously. Despite numerous local field trips and the presence of collections-oriented faculty and graduate students, this localized species has not been recollected. Therefore, I mapped this specimen as a historical record.

The maps have two types of symbols, circles and triangles. Circles indicate a point locality, i.e. the site of collection, whereas a triangle denotes that at least one collection was made within the town where the triangle lies. The town boundaries are outlined in gray on the distribution maps. The New England "town" corresponds to the more familiar term "township", which includes both a built up village and surrounding rural areas. Solid circles and triangles indicate current sites, whereas open symbols enclosing a smaller circle or triangle are considered historic sites. Due to the volume of locality data, ubiquitous species were mapped only by town, whereas species with restricted or limited distributions were mapped with point localities whenever possible.

COMPUTER CODING OF ECOLOGICAL DATA:

Although I had originally envisioned writing a descriptive account of the distribution of Connecticut's herpetofauna, I had been entering a great deal of ecological information in my field notes. In 1986, the original scope of my project was enlarged to attempt to utilize this large body of accessory information. Although I had not collected the ecological data in a standardized format, I was able to extract and numerically code a great deal of information from my notes into a 25 variable matrix. Missing data were prevalent, but I was able to retrieve some information including elevation, from other published sources. Although I prepared a coding sheet which facilitated this process, it took almost a year to code and key in the data from twelve years (1975-1986) of field notes. When I completed this task, I had 3,861 computerized records, each consisting of 25 variables, for a total of 96,525 pieces of information. The variables are described in detail as follows. Missing data were coded as "99", and variables 1-6 served primarily as label data:

SPECIES (Variable 1)

The 45 species in my study area were each given a two digit number code ranging from 01-45.

NUMBER OF INDIVIDUALS (Variable 2)

Actual counts of individuals were used up to 20. Terms such as "several, many, numerous, etc." as well as counts in excess of 20 were scored as 21.

LIFE STAGE (Variable 3)

Adult was scored as "1", eggs or egg mass as "2", larvae which applied to amphibians only as "3", and eft which applied only to the terrestrial stage of Notophthalmus was "4".

CONDITION (Variable 4)

Alive was scored "1", recently dead "2", remains "3", frog calls i.e. heard but not seen "4". By default, if a specimen scored a "3" or "4" it would have missing data in most of the ecological categories.

QUADRANGLE NUMBER (Variable 5)

In a Connecticut drainage basin atlas (Anon., 1982), the USGS topographic quadrangles comprising the State are numbered 1-116. This numbering system was used to identify the topographic quadrangle of collection.

QUADRANGLE SECTION (Variable 6)

I divided each of the previous topographic quadrangles into quarters to further pinpoint the collection site as follows: NW quarter "1", NE quarter "2", SW quarter "3", SE quarter "4".

ELEVATION (Variable 7)

Altitude at the collection site was obtained from USGS topographic maps as follows: 0-100 feet "1", 101-300 feet "2", 301-500 feet "3", 501-700 feet "4", 701-900 feet "5", 901-1100 feet "6", 1101-1300 feet "7", 1301-1500 feet "8", 1501-1700 feet "9", and above 1700 feet "10". As many reptile species were near their northern range limit, I suspected that elevation would play an important role. Owen (1989) also found elevation to be a significant factor in the distribution of reptiles in Texas.

BEDROCK GEOLOGY (Variable 8)

The bedrock geology of the collection site was obtained from Prucha et al. (1968), Pelligrini (1977), and Rodgers (1985) and coded as follows: Calcareous "1", non-calcareous, non-basalt "2", and basalt which included the trap rock ridge system and the pockets of shale lying between or associated with the trap rock "3".

COLLECTION YEAR (Variable 9)

The year of collection was given a two digit code ranging from 70 (=1970) to 86 (=1986).

COLLECTION MONTH (Variable 10)

The month of collection was numbered from 1-12 corresponding to January-December.

COLLECTION DAY (Variable 11)

The collection day corresponded to the date and was numbered from 01-31.

TIME (Variable 12)

The time of collection was numbered from 01 (=1:00 AM) through 24 (=midnight). If my field notes contained a time spread of several hours, I coded the median hour. Fractional hours were rounded up to the nearest hour.

WEATHER CONDITIONS (Variable 13)

The weather conditions during collection were coded as follows: Sunny, dry or wet "1", intermittent sun, dry or wet "2", overcast, dry "3", overcast, wet or rainy "4", night, dry "5", night, wet "6".

AIR TEMPERATURE (Variable 14)

The temperature in degrees Fahrenheit was coded from 01-98. If a temperature spread was given, I took the median temperature.

LOCATION OF SPECIMEN (Variable 15)

The microhabitat location of the specimen was recorded as follows: Arboreal, exposed "1", arboreal, under cover "2", on ground surface, exposed "3", on ground surface, under cover "4", below ground surface "5", on bank, exposed, water present "6" (<u>if water is not present such as a dry stream bed code as "3"</u>), on bank, under cover "7" (<u>if water not present, code as "4"</u>), exposed on emergent rock, tussock, log, or bush "8", under cover on emergent rock, tussock, log, or bush "9", in water less than two feet deep "10", in water more than two feet deep "11", in subterranean water "12".

HYDRIC CONDITIONS (Variable 16)

The presence or absence of water, as well as the type of waterbody was coded as follows: Terrestrial, normal/moist, rarely (if ever) inundated "1", terrestrial, dry/xeric, rarely (if ever) inundated "2", tidal or brackish with daily fluctuations "3", periodically inundated (usually seasonally) e.g. floodplains, wooded swamps, and seasonal streams "4", temporary water such as vernal pools and puddles, differing from the previous category by being filled primarily by rainfall as opposed to overflow from an adjacent riparian system "5", permanent, still, discrete bodies of fresh water which are not part of a riparian system "6", permanent fresh water, relatively still but with an inflow and outflow e.g. impoundments "7", permanent, fresh water, moderate flow "8", permanent fresh water, rapid flow, limited to high water and steeply cascading rivers and streams "9", upwellings, springs, and seepage areas "10".

SURFICIAL GEOLOGY (Variable 17)

The condition of the top layer of soil or rock was coded as follows: Bare sand and gravel dominate the habitat "1", rock outcroppings, talus, or large pebbles dominate the habitat "2", soils, mud, loam, clay, or sandy soils present and not dominated by bare rock, sand, or gravel "3".

TOPOGRAPHY (Variable 18)

The slope of the collection area was determined by using either notes or USGS topographic maps as follows: Flat to gently rolling "1", hilly 2", steeply graded to precipitous "3".

GROUND COVER (Variable 19)

The amount of vegetated ground surface at the collection site was recorded as follows: Bare, scarified "1", partially bare, partially vegetated "2", largely vegetated "3".

HERBACEOUS LAYER (Variable 20)

The herbaceous layer are non-woody plants which die back to ground level each year. The collection site was coded as follows: Ferns and other forest floor plants "1", short grasses and sedges, etc. mostly less than 12 inches high "2", tall grasses, forbs, weeds over 12 inches high, often mixed with shorter plants "3", submergent and emergent aquatic plants and grasses "4", herbaceous plants absent "5".

LOW SHRUB LAYER (Variable 21)

The low shrub layer was defined as shrubs and bushes, terrestrial and emergent, which usually do not exceed 3-4 feet in height. The area surrounding the collection site was characterized and coded as follows: Absent, or a few widely scattered clumps "1", scattered clumps throughout the habitat "2", dominates the habitat "3".

HIGH SHRUB LAYER (Variable 22)

The high shrub layer was defined as shrubs and sapling trees, terrestrial or emergent, the majority above five feet tall. The area surrounding the collection site was characterized as follows: Absent, or a few widely scattered clumps "1", scattered clumps throughout the habitat "2", dominates the habitat "3".

TREE LAYER (Variable 23)

The type and amount of tree cover surrounding the collection site was characterized as follows: Absent, or a few widely scattered individuals "1", scattered individuals or clumps throughout the habitat "2", deciduous or mixed forest dominates the habitat "3", coniferous forest dominates the habitat "4".

CANOPY CLOSURE (Variable 24)

The canopy closure surrounding the collection site was characterized as follows: Open "1", partially closed (open areas present) "2", closed "3".

DISTURBANCE FACTORS (Variable 25)

All areas in New England have been modified by human activity, the present habitats largely resulting from these disturbances. This category focuses on both the severity and frequency of these disturbances over the last 20-30 years, as well as the regularity of present disturbances to a site. In the case of aquatic habitats, the surrounding terrestrial habitats often gave a good indication of the disturbance level. The habitats were characterized and coded as follows:

Low level "1". These habitats are largely undisturbed though they may be dissected by a road, trail, or railroad bed and usually contain a low density of human habitation. Passive recreational uses often occur in these areas. Large forested areas of Connecticut that are essentially rural fall in this category.

Intermittent level "2". These habitats usually occur within low level disturbance areas but are periodically disturbed with intervening recovery times. Examples include powerline rights-of-way and selectively cut woodlots.

Regular disturbance "3". These habitats, while essentially rural, are subject to annual disturbances most frequently associated with agriculture. These activities maintain habitats at a particular seral stage. Grazing, mowing, haying and controlled burning are included within this category. Many areas of Connecticut that are a mosaic of agricultural land, fields, forests, and scattered human settlement are included in this category.

Suburban "4". Although large open spaces may remain, human settlement predominates. One of the distinguishing features of this landscape is a road network designed solely to disperse humans to their residences, as opposed to roads linking settlements. The suburban road network is quickly distinguished on the USGS topographic maps as a series of winding and twisting roads joining one another or terminating in a cul-de-sac. High level disturbances occur at the edges of residential areas, and natural areas are often patchwork in distribution.

Urban "5". This is a more developed continuation of the preceding category with large tracts of open land mostly built upon. Open space that remains is usually heavily utilized and frequently abused. Introduced plants and feral animals are common.

Radically disturbed "6". Severe disturbance and habitat alteration is the norm in these areas. Plowed, bulldozed, and scarified habitats, vacant lots, quarries, sand pits, and large dumps are terrestrial examples of this habitat type. Aquatic examples include quarry ponds, channelized streams, culverts, actively used swimming pools, settling ponds, and sewage treatment plants.

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CHAPTER THREE: CAUDATA

INTRODUCTION

Salamanders are represented in southwestern New England by twelve species distributed among four families (Ambystomatidae, Necturidae, Plethodontidae, and Salamandridae). They are generally secretive and nocturnal, often best found under adverse conditions (late at night during torrential spring rainstorms) or by using specialized searching and capture techniques. Consequently, their distributions are the most poorly known of any of the New England herpetofauna.

Two extralimital species, Ambystoma tigrinum and Pseudotriton ruber were included in Babbitt's (1937) Amphibia of Connecticut. Babbitt had no records of the red salamander, Pseudotriton ruber from Connecticut, but included it in the State's herpetofauna on the basis of its occurrence "in the highlands along the Hudson River" in New York as well as Deckert's (1914) record from Silver Lake near White Plains (Westchester County, NY). Bishop (1941:275) illustrated the New York distribution of Pseudotriton ruber as restricted to the west side of the Hudson River with two exceptions. He included Deckert's (1914) record of a single young (larval?) specimen from White Plains as well as Smith's (1882:729) report of two specimens found under a stone at Vassar College in Poughkeepsie (Dutchess Co.). Neither of these reports were documented with specimens. Salamanders, especially larvae and young, are quite variable and are frequently misidentified, even by knowledgeable individuals. Although I found Pseudotriton on the west bank of the Hudson River in Orange, Ulster, and Albany counties, I was unable to find any evidence of their natural occurrence on the east bank. I consider Smith's (1882) and Deckert's (1914) identifications questionable. These vague, undocumented reports do not provide sufficient evidence for the inclusion of the Hudson River's east bank within the range of Pseudotriton ruber. Therefore, I do not consider them native to southwestern New England.

The eastern tiger salamander (Ambystoma tigrinum) is a coastal plain species reaching its northeastern range limit on Long Island (NY). A disjunct population probably occurred in the Albany Pine Bush (Stewart and Rossi, 1981). Babbitt (1937) stated that this species "has not yet been recorded as indigenous to the State, but may occur in southwestern Connecticut". I have no evidence that Ambystoma tigrinum is indigenous to Connecticut. Babbitt (1937) reported that "it has been successfully established around New Haven". A preserved Ambystoma tigrinum in Yale's collection (YPM 20) from Woodbridge (near New Haven) collected in 1938 is likely attributable to this introduction. The established populations referred to by Babbitt (1937) have apparently since died out, as no additional specimens have been reported.

As a group, salamanders are adapted to cool, mesic environments. However, unlike frogs, many species appear to be localized or restricted to specific regions while other species appear far more abundant in certain areas than in others. Although my survey has yielded many new localities for species previously thought to be quite rare, salamanders are not necessarily secure within southwestern New England. They appear quite sensitive to certain types of habitat alteration, nutrient, chemical and thermal pollution, as well as acidification of wetlands and forest habitat. Salamanders provide excellent indicators of changes in environmental quality. In a study conducted in Quassaick Creek (Newburgh, NY) I was able to demonstrate the presence of a serious pollution problem by sampling the numbers as well of species composition of the stream's salamander fauna. Significant differences were found above and below the pollution entry point. In southern New York, Wyman (1988) found that the distributions of four widespread salamanders were limited by soil acidity. Although more baseline information is needed both on soil pH and salamander distributions, acid precipitation may pose a serious threat to terrestrial as well as aquatic salamanders.

Ambystoma jeffersonianum

Jefferson's Salamander

IDENTIFICATION:

This is a large (110-180 mm) slender mole salamander with a broad head, long toes, and deep brown dorsal coloration. A line of lighter pigment is present on the keel of its long, laterally compressed tail. The venter is brown-gray and is always lighter than the dorsum. Small areas of faint blue foxing may be present on adults, while juveniles are heavily pigmented with blue specks. The larvae possess large, bushy gills and a highly variable, marbled pattern on the caudal fin.

Throughout southwestern New England this salamander has extensively hybridized with the blue spotted salamander, Ambystoma laterale. These hybrids are morphologically intermediate between these species and difficult to identify without biochemical and karyological analysis. For many years, Ambystoma jeffersonianum and Ambystoma laterale were considered one polymorphic species, which complicated the literature concerning the identification of these salamanders. Extracting distributional and life history data from published reports is difficult. Many older references to Ambystoma jeffersonianum in fact refer to Ambystoma laterale, including Kumpf and Yeaton's (1932) classic study on courtship behavior and Bleakney's (1957) report on egg laying habits.

Uzzell (1963, 1964) unravelled part of the puzzle, distinguishing two species Ambystoma jeffersonianum and Ambystoma laterale, and erecting two triploid all female hybrid species, each associated with one of the parental species. Uzzell (1964) revived the names Ambystoma platineum for the triploid associated with Ambystoma jeffersonianum and Ambystoma tremblayi for the triploid found with Ambystoma laterale. Lazell (1971) questioned the validity of these species but they received wide usage (Conant, 1975; Behler and King, 1979). Despite lack of evidence, gynogenesis was suspected (MacGregor and Uzzell, 1964; Uzzell, 1964) and subsequently accepted as the reproductive mode of polyploid Ambystoma. Bogart and Licht (1986) and Licht and Bogart (1987) finally refuted this firmly entrenched assumption.

Bogart et al. (1989) reported that the reproductive mode of polyploid Ambystoma appeared to be a function of temperature-dependent variability in sperm nuclear incorporation. They reported triploid offspring, derived gynogenetically, were more frequent at lower temperatures, whereas sexually derived tetraploid offspring were far more frequent at higher temperatures. Therefore, temperature has both ecological and evolutionary importance in hybrid Ambystoma. Genetic variability and ploidy may be function of water temperature, which may vary from year to year within a pool. Females breeding earlier in the season, when water temperatures are often cooler, may produce offspring of differing ploidy than females breeding later. Microhabitat selection along a thermal gradient within a pool may influence the offspring's ploidy. Licht and Bogart (1989) reported variability in growth rates and maturity in diploid and polyploid Ambystoma.

Between 1980-1990, I conducted field work throughout New England collecting samples of Ambystoma jeffersonianum, Ambystoma laterale, and their hybrids. In collaboration with James Bogart, these samples were karyotyped and examined by electrophoresis using the methods described in Bogart (1982) and Bogart et al. (1985). In addition to both parental species, our work revealed the presence of six different hybrid combinations in southwestern New England (Klemens, 1989; Bogart and Klemens, ms in prep.). Data from southwestern New England were utilized in Lowcock et al. (1987) which formally relegated the "species" Ambystoma platineum and Ambystoma tremblayi to hybrids. They proposed a system to annotate these diverse hybrid combinations by indicating each chromosome set with a letter corresponding to its origin. For example, Ambystoma tremblayi became Ambystoma 2-laterale x jeffersonianum (LLJ) a triploid hybrid with two sets of laterale and one set of jeffersonianum chromosomes.

The term "Ambystoma jeffersonianum complex" was frequently used to include both parental species and their hybrids. For the purposes of this monograph, I divide these salamanders into two distinct species groups. Ambystoma jeffersonianum "group" includes both Ambystoma jeffersonianum (JJ) and hybrids (LJJ) and (LJJJ). Hybrids (LJ) and (LLJJ) are included within A. jeffersonianum "group" if they were found with any of the salamanders previously described (JJ, LJJ, LJJJ). Likewise, Ambystoma laterale "group" comprise Ambystoma laterale (LL) and hybrids (LLJ) and (LLLJ), with hybrids (LJ) and (LLJJ) assigned to A. laterale "group" if they occur with any of the salamanders previously described (LL, LLJ, LLLJ).

I found the distribution and ecology of the two parental species (A. laterale and A. jeffersonianum) differed in many ways. Hybrids shared the ecology and distribution of the parental species to which they were genetically closer. The truly intermediate hybrids (LJ, LLJJ), which comprise a very small percentage of animals sampled, appear to "fit in" with the surrounding population.

DISTRIBUTION:

Jefferson's salamander is distributed from southern Indiana and northern Kentucky eastward through West Virginia and the Appalachian Mountain region of Virginia, northward through western Maryland, most of Pennsylvania, northern New Jersey, southern New York, and western New England (Conant, 1975:Map 206). Weller and Sprules (1976) and Weller et al. (1979) extended the range of Ambystoma jeffersonianum to include the western end of Lake Ontario in Canada.

In southwestern New England, Ambystoma jeffersonianum is locally common west of the Connecticut River favoring upland sites. Between 1975-1986, I made 42 collections of Ambystoma jeffersonianum in Connecticut at elevations between 300-1300 feet as follows: 300-500 feet (6), 500-700 feet (17), 700-900 feet (6), 900-1100 feet (12) and 1100-1300 feet (1). Ambystoma jeffersonianum possibly exists at higher elevations in southwestern New England, as Mohr (1931) found them at 1475 feet in central Pennsylvania.

In Connecticut, Ambystoma jeffersonianum is widespread in the State's northwest corner (Litchfield Co.). In northern Fairfield County, I found them at scattered sites in a cluster of three towns (Bethel, Redding, and Newtown), as well as at Ridgefield. In the Central Connecticut Lowland, they were found atop one long trap rock ridge (Talcott Mountain), within the towns of West Hartford, Avon, and Farmington in western Hartford County. The salamanders in the northwestern part of the State exhibit a greater diversity of hybrid genotypes than those found in Fairfield or Hartford counties. Bogart (1989) identified western Connecticut as sympatric or parapatric zone for Ambystoma jeffersonianum and Ambystoma laterale based upon my collections.

A disjunct population occurred on Saltonstall Ridge, a trap rock slope located near Foxon, in southern New Haven County. Examination of specimens in Yale's collection revealed these were referable to the Ambystoma jeffersonianum "group". I was unable to collect specimens at this locality as the breeding pond had been damaged by dredging and channelization. The Foxon site is noteworthy as the lowest elevation (100-200 feet) from which Ambystoma jeffersonianum has been reported in New England, as well as the only site in Dowhan and Craig's (1976) coastal ecoregion. Additional populations may be found atop other trap rock ridges in the Central Connecticut Lowland, although I was unable to find any specimens despite intensive field efforts.

Ambystoma jeffersonianum appears widespread in the western uplands of Massachusetts where a diversity of hybrid genotypes are found. In the Central Connecticut Lowland (Hampden Co.), I located several populations atop or near trap rock ridges on the west side of Connecticut River. I was unable to confirm a report (R. Cook, pers. comm.) from South Hadley (Hampshire Co.), on the east side of the Connecticut River. Ambystoma jeffersonianum extends its range onto the east side of the Connecticut River in northern Franklin County and adjacent New Hampshire. Uzzell (1964) reported Jefferson's salamanders at Montague and Miller's Falls. I found a population at New Salem, twelve miles east of Miller's Falls and just west of the Worcester County line. To date, this is the easternmost documented locality for Ambystoma jeffersonianum in New England. French and Master (1986) found a specimen within ten miles of the Connecticut River at Winchester (extreme southwestern New Hampshire) which is the only report of Ambystoma jeffersonianum from that state.

In New York, Ambystoma jeffersonianum is locally common and genotypically diverse in upland areas of Columbia, Dutchess, and Putnam counties. Deckert (1914) found a salamander at Silver Lake in Westchester County which he identified as Ambystoma jeffersonianum. Deckert's detailed description of this specimen most closely matches that of Ambystoma jeffersonianum x A. laterale. I did not find this species in Westchester County, but specimens were collected in nearby areas of Putnam County (NY) and Fairfield County (CT). Therefore, I anticipate this species may be found in the northern part of Westchester County.

LIFE HISTORY AND ECOLOGY:

Almost all adult Ambystoma jeffersonianum were found in or near deciduous forest, though several breeding pools were located in hemlock groves. Steep, rocky areas with rotten logs and a heavy duff layer are favored microhabitats. These salamanders appear intolerant of disturbed areas. Of 41 collections made in Connecticut, 29 (71%) were from undisturbed second growth forest while 12 (29%) were from essentially rural areas with a mosaic of forest, open fields, and light development. Jefferson's salamanders were not found in suburban, urban, or radically disturbed habitats.

Most Jefferson's salamanders were found during their breeding season, from mid March through April. Between 1975-1986, I made 41 collections in Connecticut distributed as follows: March (22), April (15), May (2), August (1), and October (1). Jefferson's salamanders are fossorial with surface activity limited to wet nights. Adults were collected under rocks and logs near the ground surface from March through May, but were rarely found later in the year.

One of the major ecological distinctions between Ambystoma jeffersonianum and Ambystoma laterale are the types of wetlands used for breeding. I found Ambystoma laterale breeding in swamps and marshes with a weak or moderate water flow. These breeding sites were directly connected to a lake, stream, or small river. In contrast, Ambystoma jeffersonianum favored discrete vernal pools filled by rainwater. These were frequently located in ledge areas. Pools in ledge areas were often steep-sided and quite deep for their small size. I also found Jefferson's salamanders breeding in grassy pasture ponds, small impoundments filled by seasonal streams, vernal shrub swamps, and fire ponds. If present, flowing water is both weak and seasonal. Pools with emergent shrubs are favored, the submerged branches providing egg attachment sites.

My earliest date of breeding activity in southwestern New England is March 15 at West Hartford (CT). Several egg masses were observed in a vernal pool and females (spent and gravid) collected under debris near the water's edge. Jefferson's salamanders often bred in ice-covered pools, which necessitated chipping holes through the ice to collect specimens. Jefferson's salamanders were observed in breeding pools on March 20 (NY:Hyde Park), March 21 (CT:Sharon), March 23 (NY:Crofts Corners), March 26 (NY:Clinton Hollow), March 28 (NY:Hillsdale), March 29 (CT:Redding), March 30 (CT:Kent; MA:West Springfield), March 31

(MA:Gill), April 1 (NY:Pawling, Stanford), April 2-3 (MA:Egremont), April 8 (MA:West Stockbridge; NY:Stanford), April 9 (CT:Colebrook), April 10 (MA:New Salem), and April 17 (CT:Colebrook). My data indicated an earlier breeding season for Ambystoma jeffersonianum in southwestern New England than Wilson's (1976) data from a single breeding pool near Ithaca (NY). He observed salamanders first entering the pool on March 29 (1968), April 2 (1969), April 15 (1970), and April 11 (1971). Ninety percent of the breeding population had left the pool by April 23 (1968), April 17 (1969), May 2 (1970), and May 9 (1971). Salamanders referable to Ambystoma jeffersonianum observed by Bishop (1941:98) near Albany (NY) deposited eggs as early as March 16.

Females deposit several small (± 30 eggs) sausage-shaped egg masses on a submerged twig or branch as illustrated in Bishop (1941:95). I noted considerable egg failure in most Ambystoma jeffersonianum egg masses in southwestern New England. The dead eggs are iridescent pearly-white in appearance. I observed newly hatched larvae at Hyde Park (NY) on April 23. Metamorphosis is dependent upon a wide variety of factors. I found a transforming Jefferson's salamander on July 9 at Joyceville (CT), but other larvae observed in this pond did not begin metamorphosis until several weeks later. Ten metamorphs were collected on the bottom of a dried-up vernal pool at Southwick (MA) on August 10. My data on hatching and metamorphosis does not substantially differ from Bishop (1941:98). Between 1923-1927 he observed a population of salamanders at Albany (NY) referable to Ambystoma jeffersonianum based on his descriptions of adults, eggs, and breeding site. He found eggs hatching between April 25 and May 9, with the incubation period varying between 30-45 days. Transformation occurred from July 4 to September 13. Near Ithaca (NY), Wilson (1976:79) reported metamorphs leaving the pool from July 11 through August 17.

Bishop (1941:104) reported that adults ate earthworms, insects, insect larvae, millipedes, and spiders, while larval salamanders fed upon small aquatic organisms, insects, worms, and smaller Ambystoma larvae. I fed captive specimens earthworms, crickets, and vestigial-winged fruit flies, and reared larvae on tubifex worms.

Ambystoma jeffersonianum appears secure in an extensive area of southwestern New England centered on the Taconic uplift, encompassing northwestern Connecticut, western Massachusetts, as well as Dutchess and Columbia counties (NY). Disjunct populations occurring atop trap rock ridges in the Central Connecticut Lowland are more vulnerable to localized extinction, as demonstrated by the Foxon (CT) salamanders, which may be extirpated. Their apparent intolerance of disturbed habitats may result in increased local extinctions if development continues unchecked in the species' stronghold within the mountainous areas of the Taconic Uplift. Although Pough (1976) reported that acid rain may be implicated in the reproductive failure of Ambystoma near Ithaca (NY), salamanders from the Central Connecticut Lowland of Massachusetts have not yet been affected, despite increasing acidification of their breeding pools (Cook, 1983). As soils and bedrock of the Central Connecticut Lowland are acidic, salamanders may have evolved higher acidity tolerances than at Ithaca. Road mortality is substantial at several sites in Connecticut's northwest corner. The long term effects of this sustained adult mortality should be investigated.

SPECIMENS EXAMINED BY KARYOTYPING AND ELECTROPHORESIS

Ambystoma jeffersonianum

Connecticut

Fairfield Co. (n=2): AMNH 114051-52

Hartford Co. (n=4): AMNH 108266, 114055, 124700-01

Litchfield Co. (n=9): AMNH 114053-54, 121998-99, 129413-17

Massachusetts

Berkshire Co. (n=6): AMNH 129316, 131615-19

Franklin Co. (n=9): AMNH 125335, 129328-34; AMNH-JPB 16349

Hampden Co. (n=4): AMNH 125336, 129341-43

New York

Dutchess Co. (n=10): AMNH 129290, 131570-76, 131592-93

Ambystoma laterale x *jeffersonianum*

Connecticut

Fairfield Co. (HYBRIDS=LJJ) (n=13): AMNH 114059-65, 114070, 121968-70, 121991, 129412

Hartford Co. (HYBRIDS=LJJ) (n=15): AMNH 108025, 108268-73, 108276, 114067-69, 124702, 131663-65

Litchfield Co. (HYBRIDS=LJ, LJJ, LJJJ) (n=28): AMNH 114066, 122000-09, 129418-32; AMNH-MWK 7886, 7930

Massachusetts

Berkshire Co. (HYBRIDS=LJ, LJJ, LJJJ) (n=24): AMNH 114080, 129314-15, 129317-27, 131620-29

Franklin Co. (HYBRIDS=LJJ) (n=9): AMNH 129335-40, 131635-37

Hampden Co. (HYBRIDS=LJJ) (n=16): AMNH 114081, 129344-53, 131641-45

Hampshire Co. (HYBRIDS=LJJ) (n=3): AMNH 131638-40

New York

Columbia Co. (HYBRIDS=LJ, LJJ) (n=9): AMNH 122087, 129293-300

Dutchess Co. (HYBRIDS=LJ, LJJ, LLJJ, LJJJ) (n=64): AMNH 122088-116, 129288-89, 129291-92, 131560-69, 131577-91, 131594-599

Putnam Co. (HYBRIDS=LJ, LJJ) (n=10): 129301-10

SPECIMENS EXAMINED BY MORPHOLOGY ONLY

Ambystoma jeffersonianum "group"

Connecticut

Fairfield Co. (n=11): AMNH 67510, 71445-48, 72559, 108021-24, 114056

Hartford Co. (n=2): AMNH 107566, AMNH-MWK 7839

Litchfield Co. (n=17): AMNH 108026-35, 115961, 128733; UCS 4319, 4426-27, 7465, 7711

New Haven Co. (n=8): AMNH 116400 (=YPM 121); YPM 4, 6, 172-74, 296-97

Massachusetts

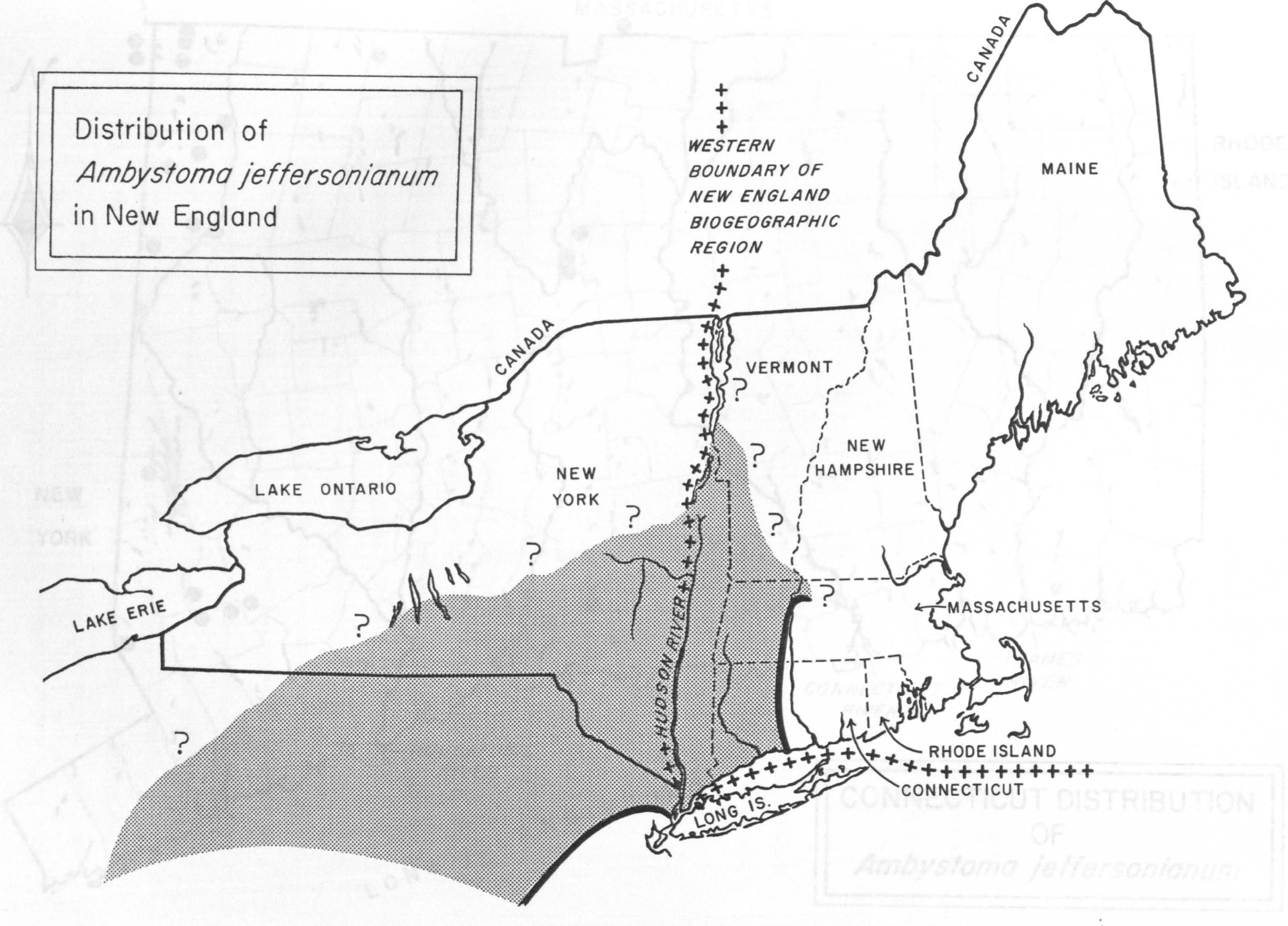
Berkshire Co. (n=5): AMNH 122259, 125332-34, 132196

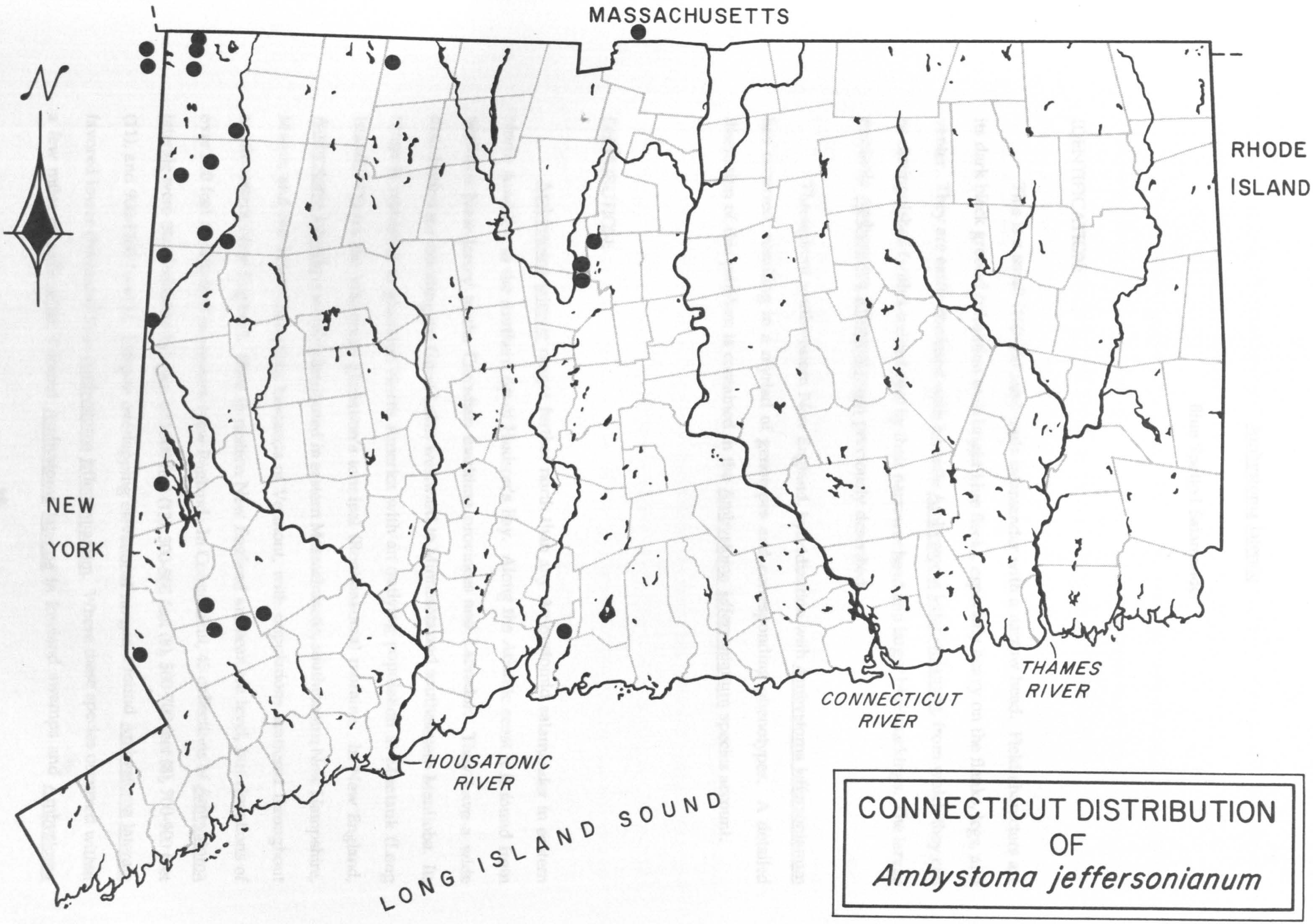
Hampden Co. (n=12): AMNH 131815-26

New York

Dutchess Co. (n=3): AMNH 132762-64

Putnam Co. (n=2): AMNH 125514-15


Distribution of
Ambystoma jeffersonianum
in New England
WESTERN BOUNDARY OF NEW ENGLAND BIOGEOGRAPHIC REGION
CANADA
CANADA
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW YORK
LAKE ONTARIO
LAKE ERIE
HUDSON RIVER
LONG IS.



CONNECTICUT DISTRIBUTION
OF
Ambystoma jeffersonianum

Ambystoma laterale

Blue Spotted Salamander

IDENTIFICATION:

This is a small (100-130 mm) mole salamander with a narrow head. Field characters are its dark black ground coloration with bright blue flecks, especially heavy on the flanks, legs, and venter. They are easily confused with juvenile Ambystoma jeffersonianum, from which they can be distinguished (with a trained eye) by their narrower head and larger blue markings. The larvae resemble Ambystoma jeffersonianum previously described.

Throughout southwestern New England, hybridization with Ambystoma jeffersonianum has occurred, resulting in a myriad of genotypes and corresponding phenotypes. A detailed discussion of this problem is contained in the Ambystoma jeffersonianum species account.

DISTRIBUTION:

Ambystoma laterale ranges further north than any Ambystomid salamander in eastern North America, to the southern tip of Hudson's Bay. Along the Atlantic coast it is found from northern New Jersey to the Canadian maritime provinces and Labrador. They have a wide distribution surrounding the Great Lakes westward to Minnesota and southeastern Manitoba. Its range is restricted to glaciated North America with an outlying population at Montauk (Long Island, NY) on the Wisconsin glaciation's terminal (Ronkonkoma) moraine. In New England, Ambystoma laterale is widely distributed in eastern Massachusetts, southeastern New Hampshire, Maine, and the Lake Champlain lowlands of Vermont, with populations scattered throughout southwestern New England. Sites in eastern New England are near sea level, but elevations of over 900 feet are attained in western New England. In Connecticut, 43 collections of Ambystoma laterale were distributed as follows: 100-300 feet (13), 300-500 feet (8), 500-700 feet (8), 700-900 feet (11), and 900-1100 feet (3). Despite overlapping elevational ranges, I found Ambystoma laterale favored lower elevations than Ambystoma jeffersonianum. Where these species occurred within a few miles of each other, I found Ambystoma laterale in lowland swamps and Ambystoma jeffersonianum several hundred feet higher on adjacent ridges. Nyman et al. (1988) noted a similar distributional pattern in northern New Jersey.

In Connecticut, Ambystoma laterale was first reported by Klemens and Dubos (1978) at Bloomfield (Hartford Co.). Lazell (1979a) reported the State's second record from "Center Pond Brook" (in error for Corner Pond Brook) at Danbury (Fairfield Co.). Babbitt (1937) published a photograph of "Ambystoma jeffersonianum" from Simsbury (Hartford Co.), which is referable to Ambystoma laterale. I collected Ambystoma laterale in widely scattered localities throughout Connecticut. Although locally common, statewide it is rare. In western Connecticut, I found Ambystoma laterale associated with extensive riparian swampland and swamps fringing natural lakes. Maximum genotypic diversity occurred in salamanders from Litchfield and Fairfield counties. In the Central Connecticut Lowland, Ambystoma laterale was found in several swamps pooling along the base of trap rock ridges in Hartford and New Haven counties. A specimen (YPM 17) collected in 1922 at Middlefield is the only record from Middlesex County.

On the east side of the Connecticut River, I found Ambystoma laterale at several sites within the Scantic River basin near the Hartford-Tolland county line. Isolated populations in the Quinebaug Valley at Plainfield (Windham Co.) and Griswold (New London Co.), not far from the Rhode Island border, are among six pure diploid populations reported from the northeastern United States (Klemens, 1989; Bogart and Klemens, ms in prep.).

In Massachusetts, Ambystoma laterale was only found east of the Connecticut River, although I anticipate scattered populations occur in western Massachusetts. They are widespread on the coastal plain of eastern Massachusetts, from Cape Ann (Essex Co.) south to Bristol County, including many of Boston's suburbs. They have not been reported from Cape Cod. Although hybrids are common, genotypic diversity is lower than in western Connecticut or eastern New York. A population comprised of pure diploid salamanders occurs at South Attleboro (Bristol Co.), just over the Rhode Island state line. These salamanders are similar to those found at Plainfield and Griswold (Klemens, 1989; Bogart and Klemens, ms in prep.). Four specimens collected at West Bridgewater (Plymouth Co.) probably represent a pure diploid population, although the sample is too small to be conclusive.

Drowne (1905) reported specimens from Roger Williams Park at Providence (RI), close to South Attleboro (MA). Although this is a heavily urbanized and industrial section of Rhode

Island, Ambystoma laterale may still persist in remnants of riparian swamp in the Providence-Pawtucket metropolitan area. Raithel (pers. comm.) and I both searched unsuccessfully for Ambystoma laterale in western Rhode Island.

On the eastern New York mainland, Ambystoma laterale occurs at a few scattered sites in and near the Hudson Valley (Albany, Dutchess, and Orange counties). These sites are genotypically diverse. In Dutchess County, I collected Ambystoma laterale at two sites in the southwestern portion of the county. I did not find specimens in Columbia, Putnam, or Westchester counties, but suspect they may occur in the Corner Pond Brook drainage in eastern Putnam County, near the Connecticut state line. Bishop (1941:90) cited localities in western New York for small, dark "Ambystoma jeffersonianum", which are referable to Ambystoma laterale. They appear widespread in western New York, surrounding the Great Lakes and Saint Lawrence River. An isolated population occurs on Long Island's eastern tip at Montauk (Suffolk Co.), comprised totally of diploid individuals (Klemens, 1989; Bogart and Klemens, ms in prep.)

Klemens (1989) considered these isolated diploid populations of Ambystoma laterale in eastern New England and Long Island evidence of a coastal plain refugia (Georges Banks) for Ambystoma laterale during the Pleistocene glaciation(s). Schmidt (1986:142) illustrated the Georges Bank refugia (about 8,000-10,000 years ago) as a northern extension of the coastal plain, bounded on the north by the Gulf of Maine and on the south by the Atlantic Ocean. From this coastal plain refugia, Ambystoma laterale dispersed westward into New England. Ambystoma laterale may have invaded western New York via the Prairie Peninsula (Schmidt, 1938) from a second refugia in the Midwest. Ambystoma jeffersonianum migrated northeastward into New England from its Appalachian refugia. A hybrid zone between these species occurs throughout southeastern New York and western New England. Apparently, Ambystoma jeffersonianum did not cross the Connecticut River until reaching northern Massachusetts. They may have been impeded from crossing the Central Connecticut Lowland further south by a wide expanse of water or stagnant ice. Although there has been considerable "jeffersonianum" gene flow into eastern New England via hybrids of the Ambystoma laterale "group", populations at Montauk, Plainfield, Griswold, and South Attleboro were not affected due to their geographic isolation.

Lowcock and Bogart (1989) and Lowcock (1989) expanded on this theme, comparing large sets of Ambystoma genetic and biochemical data (including my New England and New York collections) from eastern North America. They examined the role of paleoclimatological, paleoecological, geological, post-glacial, and human created factors upon the distribution of the parental species and their hybrids.

LIFE HISTORY AND ECOLOGY:

I found Ambystoma laterale in a wide variety of habitats in and near wooded swamps with soils varying from water saturated loam to slightly damp, crumbly sand. Many of the habitats were acidic, red maple and sphagnum swamps, but I also found Ambystoma laterale in calcareous wetlands. Unlike Ambystoma jeffersonianum, they exhibit a much greater tolerance for disturbed habitats. Of 43 collections made in Connecticut, 4 (9%) were from undisturbed sites, 33 (77%) were from rural areas with a mosaic of woodland, open fields, and light development, 4 (9%) were from suburban areas, and 2 (5%) were from severely disturbed sites. Ambystoma laterale appears to occur in much larger populations than Ambystoma jeffersonianum. Under optimal conditions, scores of Ambystoma laterale were observed on a short stretch of road skirting a marsh or swamp. Young and subadult specimens were found with much greater frequency than those of other Ambystomid salamanders. Bishop (1941:104) also found hundreds of "Ambystoma jeffersonianum", including many young, under logs and debris along the Clyde River in Wayne County (NY). These salamanders are referable to Ambystoma laterale, as Ambystoma jeffersonianum is absent from the south shore of Lake Ontario, which includes Wayne County (Conant, 1975:Map 208).

I found Ambystoma laterale most frequently during their breeding season in March and April. Between 1975-1986, I made 43 collections in Connecticut as follows: February (1), March (12), April (17), May (3), June (3), July (1), September (3), and October (3). They are fossorial with surface activity limited to wet nights. Unlike Ambystoma jeffersonianum, adults were found under cover, near the ground surface, throughout the year.

My observations indicated they favored grassy, floodplain wetlands for breeding. Fish were observed in several Ambystoma laterale breeding sites. At Northborough (MA), I collected a gravid female in a small vernal pool, perched on a hillside above a wooded swamp. Anderson and Giacosie (1967) found Ambystoma laterale breeding in two discrete temporary ponds located in open fields bordering the Great Swamp in New Jersey. They did not find salamanders breeding in the nearby swamp or marsh, though they easily could have escaped detection.

Nyman et al. (1988) found New Jersey Ambystoma laterale breeding in floodplain pools, ponds, and swamps. Fish, particularly eastern mudminnows (Umbra pygmaea), were found in these breeding sites.

Ambystoma laterale scatter their eggs, attaching them singly or in small clusters to grass blades, often at the base of tussocks. They appear shy and were observed only a few times in their breeding pools. As many of their breeding sites are extensive, salamanders may be scattered throughout the wetland. Their small size, coupled with the thick grass in many of the breeding sites, makes locating them very difficult. Many Ambystoma laterale were found on roads traversing marshes and swamps, but rarely were observed in the adjacent wetlands. Ambystoma laterale, including many gravid females, were found crossing roads near swamps and marshes on the following dates: February 25 and March 1 (CT:Wallingford), March 17 (CT:East Granby, Suffield), March 18 (CT:Danbury, Wallingford), March 21 (CT:Bloomfield, Wallingford), March 27 (CT:Bloomfield), March 31 (CT:East Granby), April 3 (CT:Canaan, Griswold, North Canaan, Plainfield), April 4 (CT:Litchfield, Wallingford), April 5 (CT:Wallingford), April 6 (CT:East Granby), April 10 (CT:Plainfield), and April 15 (CT:Suffield, Wallingford). Salamanders were observed in wetlands on March 21, 24, and 25 (CT:Danbury), March 25 (CT:Wallingford), and April 5 (CT:Somers). I observed pairs in amplexus on March 19 at Montauk, Long Island (NY). Metamorphs were observed on August 27 at Twin Lakes (CT) and September 22 at Plainfield (CT).

I have no data on feeding habits of Ambystoma laterale but assume they feed on a wide variety of invertebrates. I found Ambystoma laterale in the stomachs of Thamnophis sirtalis collected at South Attleboro (MA) and Wilbraham (MA). Road mortality is substantial in some areas. Ambystoma laterale is secure in eastern Massachusetts where they are widespread. In Connecticut and the Hudson Valley of New York, populations are scattered and vulnerable to local extinction. Of special conservation concern are the pure diploid populations at Montauk (NY), Plainfield and Griswold (CT), and South Attleboro (MA). Although several sites at Montauk are protected in state and county parks, the Plainfield and Griswold sites are on private land which should be protected. The South Attleboro site is severely degraded and much reduced in size. A large development was planned there several years ago, but fortunately wetland permits were denied. However, the site is still at risk from small developments and deteriorating environmental quality. At Danbury (CT), development has severely damaged one of their prime breeding sites. This population is unique, comprised solely of different hybrid genotypes (Bogart, 1989). Recent land acquisitions by the Connecticut Department of Environmental Protection and

The Nature Conservancy in Robbins Swamp (Litchfield Co.) will help protect this species. They are also protected at the White Memorial Conservation Center in Litchfield (CT). In order to adequately ensure their survival in Connecticut and adjacent New York, additional wetlands containing populations of these salamanders should be protected.

SPECIMENS EXAMINED BY KARYOTYPING AND ELECTROPHORESIS

Ambystoma laterale

Connecticut

Hartford Co. (n=4): AMNH 114057, 131653-54; AMNH-MWK 7842

Litchfield Co. (n=6): AMNH 122011-13, 122033-34; AMNH-MWK 7941

New Haven Co. (n=24): AMNH 114058, 122047-62, 122064-70

New London Co. (n=3): AMNH-MWK 8047, 8053-54

Windham Co. (n=20): AMNH 122078-79, 129436-45; AMNH-MWK 8045-46, 8063-68

Massachusetts

Bristol Co. (n=13): AMNH 125337, 129400-11

Essex Co. (n=1): AMNH 131631

Plymouth Co. (n=4): AMNH-JPB 17422-25

Worcester Co. (n=24): AMNH 129355-56, 129372-93

New York

Dutchess Co. (n=4): AMNH 131601-04

Suffolk Co. (n=35): AMNH 122159-90, 129311-13

Ambystoma laterale x jeffersonianum

Connecticut

Fairfield Co. (HYBRIDS=LJ, LLJ, LLJJ) (n=26): AMNH 121971-90, 121992-97

Hartford Co. (HYBRIDS=LLJ) (n=22): AMNH 108274-75, 114071-79, 131655-62; AMNH-MWK 7840, 7844-45

Litchfield Co. (HYBRIDS=LJ, LLJ, LLJJ, LLLJ) (n=49): AMNH 108067, 122010, 122014-32, 122035-46; AMNH-MWK 7932-40, 7942-48

New Haven Co. (HYBRIDS=LLJ) (n=6): AMNH 122063, 122071-75

Tolland Co. (HYBRIDS=LLJ) (n=5): AMNH 122076-77, 129433-35

Massachusetts

Essex Co. (HYBRIDS=LLJ, LLLJ) (n=12): AMNH 122080-86, 131630, 131632-34; AMNH-JPB 10268

Hampden Co. (HYBRIDS=LLJ) (n=8): AMNH 129354, 131646-52

Worcester Co. (HYBRIDS=LJ, LLJ, LLLJ) (n=21): AMNH 129357-71, 129394-99

New York

Dutchess Co. (HYBRIDS=LJ, LLJ, LLLJ) (n=12): AMNH 122117-18, 131605-14

SPECIMENS EXAMINED BY MORPHOLOGY ONLY

Ambystoma laterale

Connecticut

Windham Co. (n=2): UCS 8261, 8685

Ambystoma laterale "group"

Connecticut

Fairfield Co. (n=8): AMNH 117739-44; MCZ 96573; UMMZ 152961

Hartford Co. (n=8): AMNH 108036-38, 121400; UCS 6643-45, 6760

Litchfield Co. (n=9): AMNH 108039-41, 115962-64; UCS 6285, 8047, 8317

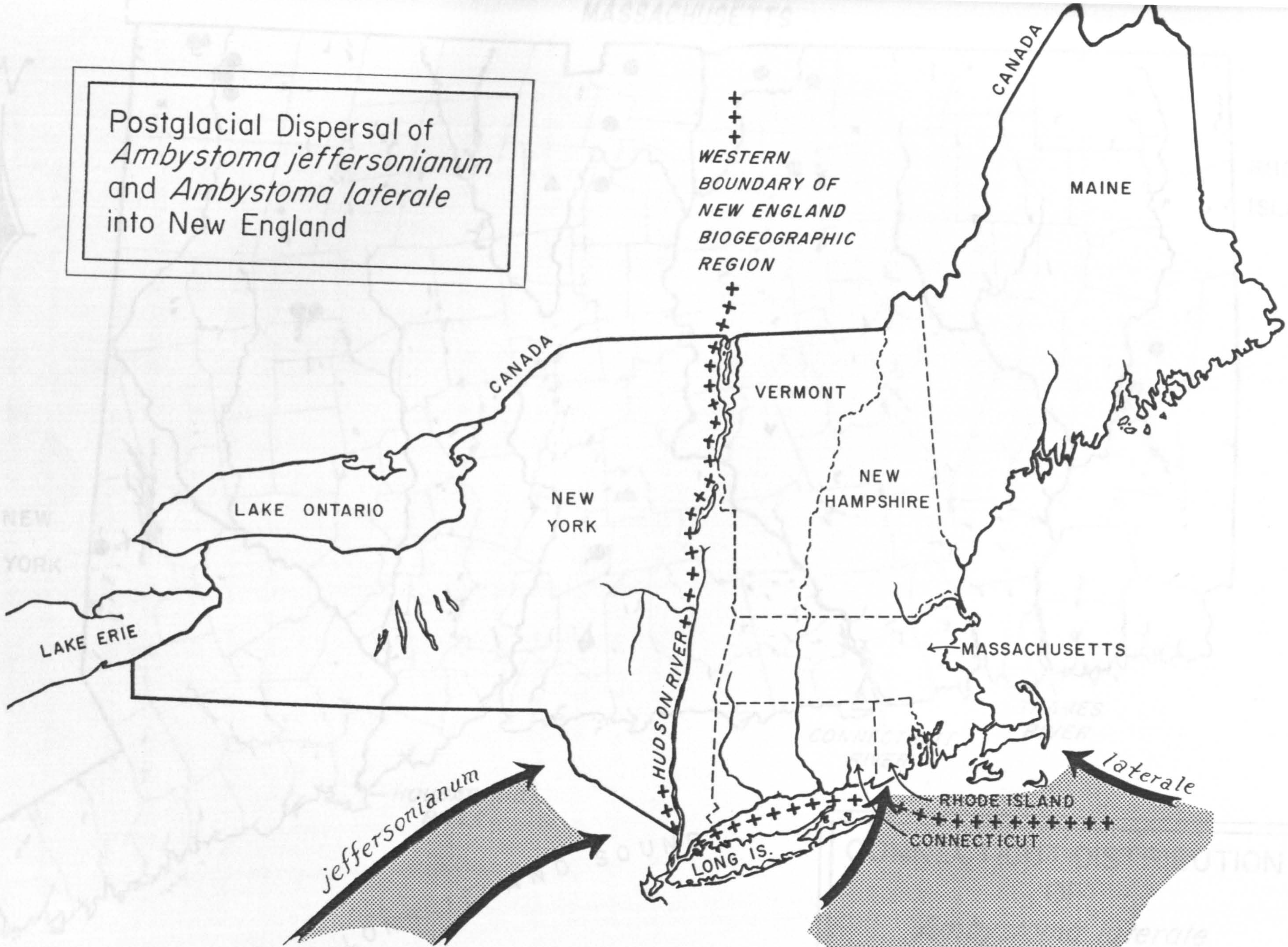
Middlesex Co. (n=1): YPM 17

New Haven Co. (n=1): AMNH 117745

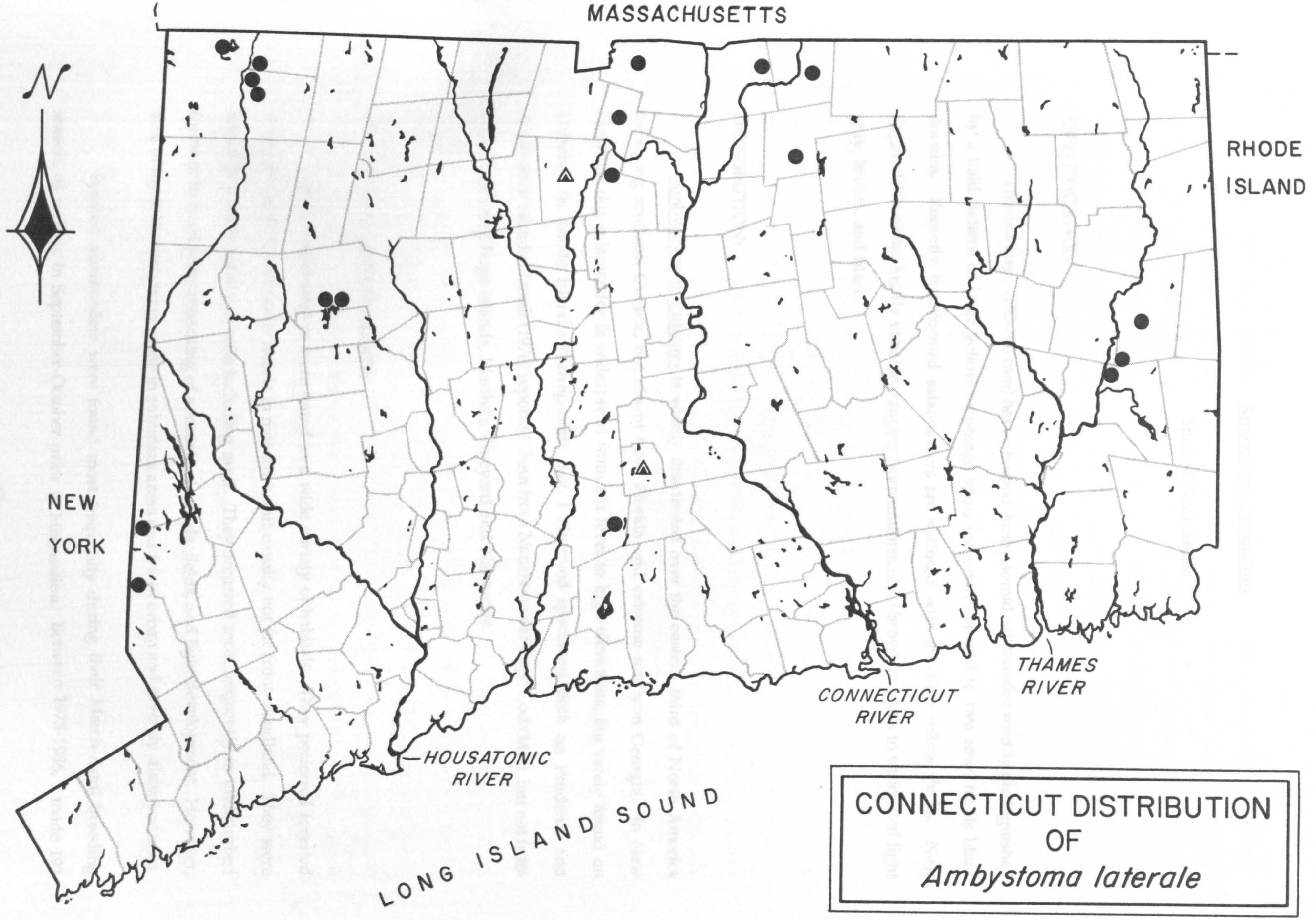
Tolland Co. (n=3): AMNH 117746, 121401; UCS 6761

Massachusetts

Worcester Co. (n=1): AMNH 131827



Postglacial Dispersal of *Ambystoma jeffersonianum* and *Ambystoma laterale* into New England
+++ WESTERN BOUNDARY OF NEW ENGLAND BIOGEOGRAPHIC REGION
CANADA
CANADA
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW YORK
LAKE ONTARIO
LAKE ERIE
HUDSON RIVER
LONG IS.
jeffersonianum
laterale



CONNECTICUT DISTRIBUTION OF *Ambystoma laterale*

Ambystoma maculatum

Spotted Salamander

IDENTIFICATION:

This is a large (150-200 mm) heavy bodied Ambystomid salamander readily distinguished by a bold pattern of large yellow or orange spots irregularly spaced in two rows on its black dorsum. Recently transformed salamanders are suffused with greenish-yellow flecks. New England larvae are highly variable, ranging from uniform olive-brown or black to variegated light gray, brown, and black.

DISTRIBUTION:

Ambystoma maculatum is widely distributed over the eastern third of North America including southern Canada, but absent from Florida and extreme southern Georgia. In New England, this salamander is widespread from sea level to high elevations, but rarely found on islands. In Rhode Island's Narragansett Bay, I observed specimens both on Prudence and Aquidneck islands. Lazell (1976) reported them from Naushon near Cape Cod (MA), but not from Cape Cod's two large islands, Martha's Vineyard and Nantucket.

LIFE HISTORY AND ECOLOGY:

Spotted salamanders were found in a wide variety of habitats. They preferred forested areas, but were found under debris in meadows, but usually not far from woodland. They were found in a wide variety of soils including sand. They occurred most frequently in undisturbed forest or in rural areas consisting of a mosaic of woods, fields, and light development. However, 10% of my collections were made in suburban areas and 5% in urban and severely disturbed sites.

Spotted salamanders were found most frequently during their March-April breeding season, as well as in September-October prior to hibernation. Between 1975-1986, I made 192 collections in Connecticut distributed as follows: March (39), April (64), May (31), June (12), July (4), August (6), September (19), October (14), and November (3). The earliest date I found active spotted salamanders was March 14, both at Pound Ridge (NY) and at Copake (NY). The latest activity date was November 11 at Wethersfield (CT). Spotted salamanders are fossorial with surface activity limited to wet nights. They were found during the day under cover near the ground surface. The larvae are active during the daytime as well as at night. They are expert burrowers as evidenced by a specimen from Shippan (CT) found two feet below ground (Bishop, 1941:128).

During the spring, spotted salamanders migrate en masse to breeding wetlands. Occasionally I observed large migrations in late autumn prior to hibernation. Spring migrations are triggered by a combination of rising air temperatures and high humidity provided by rain, rapid snow melt, or fog (Blanchard, 1930; Baldauf, 1952). Although ephemeral wetlands without fish are favored, I observed breeding activity in a wide variety of wetlands including: vernal pools, floodplain swamps, marshes, bogs, margins of lakes and reservoirs, beaver impoundments, pasture ponds, ornamental ponds, non-chlorinated swimming pools, gravel and sand pit ponds, fire ponds, springs, ruts in dirt roads, and backwaters of streams and small rivers.

I observed spotted salamanders in breeding pools on the following dates: March 19 (CT:Kent), March 21 (CT:Danbury, Sharon), March 23 (NY:Crofts Corners), March 24 (CT:Bozrah, Danbury), March 25 (CT:Danbury; NY:Armonk), March 26 (MA:Holyoke), March 27 (MA:Egremont), March 28 (MA:Sheffield; NY:Hillsdale), March 30 (CT:Cornwall, Kent; MA:Granby, South Hadley, West Springfield), March 31 (MA:Gill; NY:Clinton Hollow), April 1 (NY:Pawling, Stanford), April 2 (MA:Egremont; NY:Travis Corners), April 3 (MA:Egremont), April 5 (CT:Somers), April 7 (CT:Somers; MA:Sheffield, Great Barrington), April 8 (CT:Hampton; MA:West Stockbridge), April 9 (CT:Colebrook), April 10 (MA:New Salem; NY:Pound Ridge), April 12 (NY:Armonk), and April 17 (CT:Colebrook). Bishop (1941:114) reported that salamanders first appeared in breeding ponds at Ithaca (NY) on March 13 and at Albany (NY) on March 18. Wilson (1976) studied a single pool for four years near Ithaca (NY) and found that salamanders entered the pool as early as March 29 and remained there as late as May 9. Bishop's and Wilson's data indicated that spotted salamanders have a more protracted breeding season at Ithaca than I observed in southwestern New England.

I found males arrived prior to females at the breeding pools, often preceding them by several days. After the first migration, males were observed depositing their white spermatophores upon leaves and twigs lying on the bottom of the pool. Subsequent rains brought the gravid females to the water. My observations agree with Bishop (1941:113). At several localities balls of writhing salamanders were observed as described by Breder (1927). Approximately 100 eggs are deposited in a globular mass usually attached to a twig. Both clear and milky egg masses were observed in my study area. Bishop (1941:119) illustrated both clear and opaque egg masses as well as spermatophores. Freda (1983) studied the diet of larval spotted salamanders in New Jersey and found that they fed on invertebrates including Cladocera, Copepoda, Isopoda, Anostraca, Odonata, Coleoptera, and Trichoptera as well as larval red spotted newts, Notophthalmus v. viridescens. The larvae are in turn fed upon by a wide variety of aquatic invertebrates and vertebrates. Whitford and Vinegar (1966) reported overwintering larvae in a spring fed pond at Kingston (RI), which they attributed to cool water temperatures which slowed hatching and subsequent larval development. I did not observe overwintering Ambystoma maculatum larvae during my study.

I observed metamorphosing spotted salamanders on: July 10 (CT:Thompson), August 2 (MA:Egremont Plain), August 14 (MA:Sheffield), August 26 (CT:Andover), August 27 (CT:Twin Lakes; MA:New Salem), August 28 (MA:New Salem, Stockbridge), August 29 (CT:Colebrook), September 21 (CT:Ledyard, North Stonington), October 1 (MA:Holyoke), and October 2 (CT:Pomfret; MA:Hampden). At Pomfret (CT), a metamorph was collected under debris at the edge of a pasture pond on October 2. Larvae were also found in the water, therefore the metamorphosis period at this site may have lasted well into October. Dunn (1930) found transforming specimens at Mount Tom (MA) on October 4. Bishop (1941:127) reported transformation as early as July 7 near Albany (NY) but stated that in colder waters they may not complete metamorphosis until late October. My data from southwestern New England closely fits the time span given by Bishop. Wilson (1976) found salamanders metamorphosing as early as July 20 and as late as September 5 at a single pond at Ithaca (NY).

Bishop (1941:128) cited several sources who reported that Ambystoma maculatum fed on earthworms, slugs, snails, spiders, millipedes, centipedes, stone crickets, grasshoppers, ground beetles, rove beetles, scavenger beetles, ants, and pill bugs. Their noxious skin secretions afford them some protection from predation, however I dissected a spotted salamander from a garter snake's (Thamnophis sirtalis) stomach, and Babbitt (1932) reported a specimen eaten by a hognose snake, Heterodon platyrhinos. Bishop (1941:131) reported an adult taken from the stomach of a 15" brown trout (Salmo trutta) at Canaan (NY) and R. Schmidt (pers. comm.) found one in a chain pickerel (Esox niger) caught at Storrs (CT).

Spotted salamanders are secure in southwestern New England, occurring in many state parks, forests, and sanctuaries as well as on private land. Pough (1976) attributed spotted salamander embryonic mortality to acid rain near Ithaca (NY). Cook (1983) suggested that Ambystoma maculatum in the Central Connecticut Lowland of Massachusetts were able to tolerate elevated acidity levels as they were adapted to the naturally acidic conditions of that region. He reported that salamanders had not yet been affected by acid precipitation in the Central Connecticut Lowland. Clark (1986) examined twenty ephemeral ponds in central Ontario and found larvae from acidic ponds had a greater acidity tolerance than those from more alkaline ponds. Road mortality of adults moving to and from the breeding pools is significant in many areas. The long term effects of this sustained mortality are not known, but generally assumed to be detrimental. In an effort to mitigate this problem, two salamander tunnels were constructed under a road at Amherst (MA) to funnel salamanders to and from their breeding pond (Jackson and Tyning, 1989).

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=46): AMNH 72560-61, 107567-68, 108042-50, 108267, 114082-85, 114173, 115965-72, 117747-52, 116035, 121402, 125131, 128734-36, 129461-67

Hartford Co. (n=17): AMNH 107569-71, 115973-75, 117753, 121403, 125132-34, 128737, 131752-55; AMNH-MWK 7846

Litchfield Co. (n=44): AMNH 33962-63, 41385-90+5, 40147-48, 108051-61, 114086-88, 115976-80, 117754-55, 128738-42, 131666; AMNH-MWK 7931, 7949

Middlesex Co. (n=6): AMNH 114089-90, 117756, 121404-05, 125135

New Haven Co. (n=9): AMNH 108062-63, 115981, 121406-08, 125136-38

New London Co. (n=29): AMNH 107572, 108064, 114091-95, 117757-60, 121409, 128571-72, 128743-47, 131667-70, 131756-58; AMNH-MWK 7851, 7971, 7973

Tolland Co. (n=11): AMNH 114096, 114098, 117761, 121410-12, 128748, 131671-72, 131759-60

Windham Co. (n=19): AMNH 114097, 117762-69, 121413-19, 128749, 131673, 132942

Massachusetts

Berkshire Co. (n=40): AMNH 115863-64, 118072-75, 121643-45, 125338-53, 131830-39, 132197-201

Franklin Co. (n=13): AMNH 125354-56, 132202-10, 133208

Hampden Co. (n=31): AMNH 125357-69, 131840, 132211-21; AMNH-MWK 7974-77, 7996-97

Hampshire Co. (n=20): AMNH 125370-74, 132222-36

Rhode Island

Kent Co. (n=7): AMNH 128560-65, 132520

Newport Co. (n=4): AMNH 128690-92, 133248

Providence Co. (n=9): AMNH 133253-58, 133263-64, 133462

Washington Co. (n=9): AMNH 125001-04, 128566-68, 132523, 133463

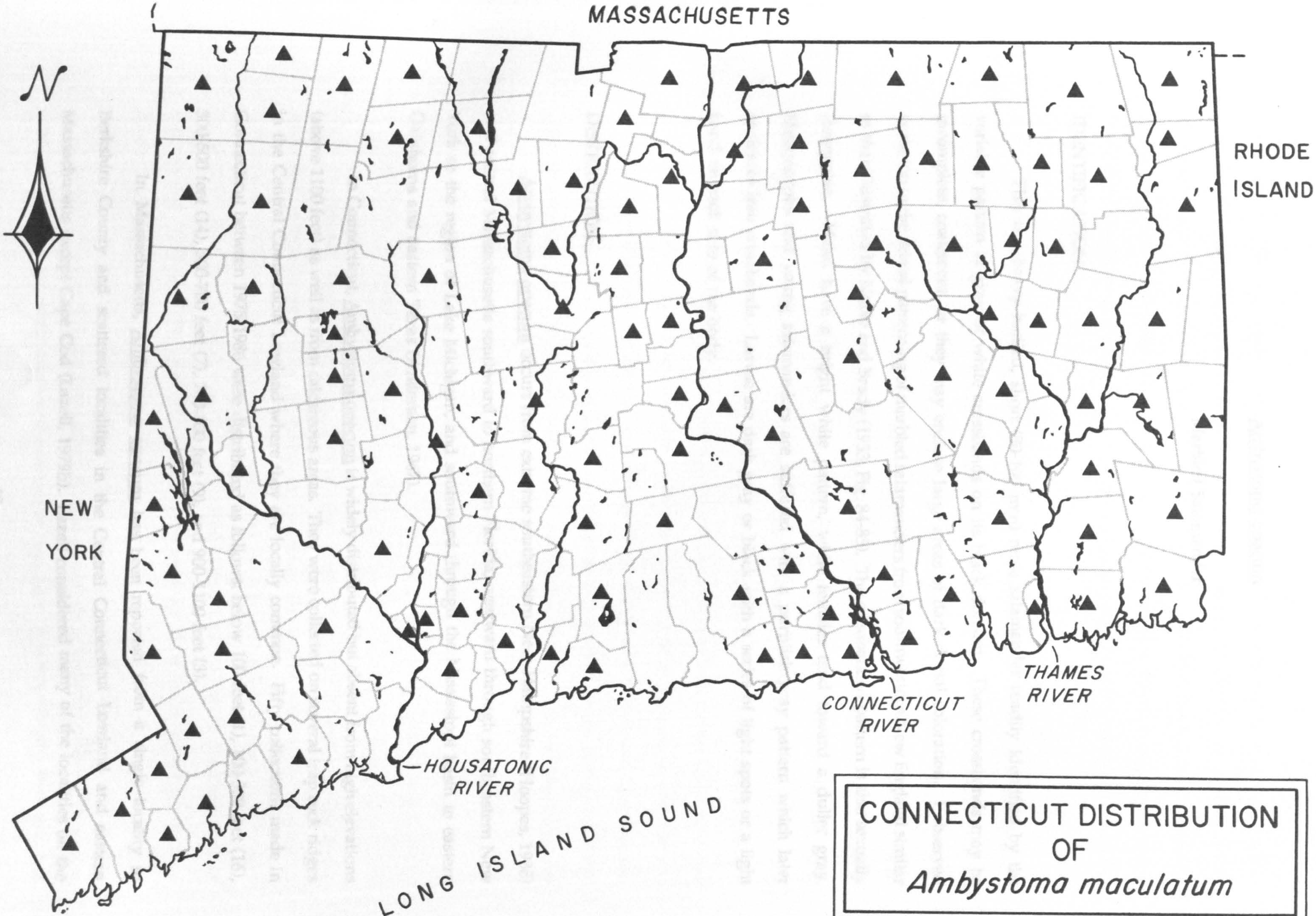
New York

Columbia Co. (n=13): AMNH 114718-25, 129156, 132673-76

Dutchess Co. (n=47): AMNH 116446, 118039-40, 121805-06, 132677-81, 132725-61

Putnam Co. (n=12): AMNH 121807-11, 125516, 132992-97

Westchester Co. (n=14): AMNH 108385-87, 125517-18, 129158-62, 130201, 132999, 133046, 133439



CONNECTICUT DISTRIBUTION
OF
Ambystoma maculatum

Ambystoma opacum

Marbled Salamander

IDENTIFICATION:

This is a heavy bodied, short (80-100 mm) mole salamander readily identified by the variable pattern of gray or white crossbands on its black dorsum. These crossbands may be incomplete, coalescent, or they may enclose large areas of dark dorsal coloration. I observed variation in the dorsal patterning of marbled salamanders from southwestern New England similar to that illustrated by Noble and Brady (1933, Fig. 84-85). The crossbanded pattern is also sexually dimorphic. Males have a bright white pattern, while females tend toward a duller gray. Metamorphs and young salamanders are suffused with a purplish gray pattern which later coalesces into crossbands. Larvae are dark gray or black with a series of light spots or a light band on each side of the body.

DISTRIBUTION:

Ambystoma opacum occurs from extreme southeastern New Hampshire (Hoopes, 1938) and central Massachusetts southward to northern Florida, westward through southeastern New York to the region of Lake Michigan, and southward through the Mississippi basin to eastern Oklahoma and eastern Texas (Anderson, 1967).

In Connecticut, Ambystoma opacum is widely distributed but absent from high elevations (above 1100 feet) as well as from calcareous areas. They were collected on several trap rock ridges in the Central Connecticut Lowland where they are locally common. Fifty collections made in Connecticut between 1975-1986 were distributed as follows: below 100 feet (1), 100-300 feet (16), 300-500 feet (14), 500-700 feet (7), 700-900 feet (9), and 900-1100 feet (3).

In Massachusetts, Ambystoma opacum has been reported from a single locality in Berkshire County and scattered localities in the Central Connecticut Lowland and eastern Massachusetts except Cape Cod (Lazell, 1979b). Lazell considered many of the localities on the coastal plain of Massachusetts extirpated. In eastern Massachusetts, I collected a specimen at Uxbridge (Worcester Co.) and received reports from southwestern Bristol County, near the Rhode Island state line (Raithel, pers. comm.). This species was reported from the Central Connecticut Lowland by Dunn (1919, 1930) at Florence (Hampshire Co.) and Mount Tom, a basalt ridge on the Hampshire-Hampden county line. I found three breeding populations at Holyoke (Hampden Co.), two near the base of Mount Tom.

Recent work by Raithel (pers. comm.), has documented many new localities for Ambystoma opacum in Rhode Island, where they appear widespread in the State's southwestern corner. They have not been reported from the Narragansett Bay Islands. In New York, Ambystoma opacum is well known from Long Island, with a few records from Staten Island, as well as Orange, Rockland and southern Westchester counties (Bishop, 1941:154-55). Bishop apparently overlooked AMNH specimens from Putnam County and did not cite any other mainland localities except Baird's (1852) report from Coxsackie (Greene Co.), on the Hudson River's west bank near Albany. Benton and Smiley (1961) reported specimens from three sites in Ulster County. My field work has added specimens from northern Westchester County, as well as Putnam, Dutchess, and Ulster counties. Although several of these sites are in and near the Hudson Valley, I found scattered sites in upland areas including the southwestern New England elevational record of 1300 feet at Washington in northeastern Dutchess County. Bishop (1941:154) reported a specimen collected at 1400 feet on Bear Mountain (Orange Co.) on the western side of the Hudson River.

LIFE HISTORY AND ECOLOGY:

I collected Ambystoma opacum in a wide variety of habitats in and near deciduous woodland. Although collected in lowlying swampy areas, this species prefers dry, friable soils such as sand and gravel deposits as well as rocky slopes. A typical collection site would be near the edge (ecotone) of a forested area on a well drained slope, under a deeply imbedded rock or log. Bishop (1941:152) also cited this species' preference for drier areas compared to other Ambystomids.

Although I found Ambystoma opacum most frequently in undisturbed areas, they were common in rural areas which contained a mosaic of land uses. A few specimens were found at more disturbed sites. Between 1975-1986, I made 50 collections of Ambystoma opacum in Connecticut of which 28 (57%) were from undisturbed areas, 16 (33%) from rural areas, and 5 (10%) from suburban, urban, and other disturbed sites. One specimen was excluded from the previous analysis as collection data were incomplete resulting in a sample size of 49.

I found Ambystoma opacum active from March through November. In Connecticut, I made 50 collections between 1975-1986 distributed as follows: March (4), April (6), May (13), June (10), July (2), August (3), September (10), October (1), November (1). Although adults were found from April through November, larvae predominated in the March-June collections. Only adults were found from late June onward, with peak collecting success occurring during their autumn breeding season. My latest date of adult activity was November 11 at Wethersfield (CT). Ambystoma opacum is fossorial with surface activity usually limited to wet nights in the summer and early autumn. I have received a few reports of movements in late March and April concurrent with migrations of Ambystoma maculatum.

Unlike other Ambystomid salamanders, Ambystoma opacum breeds in the autumn, migrating to dried-up vernal pools and swamps in late August and early September. Their migratory orientation was examined by Shoop and Doty (1972) at West Greenwich (RI). Courtship takes place on land as described and illustrated by Noble and Brady (1933). The eggs are deposited under cover or below ground on the bottom of the dry pond. The female remains with the eggs until the autumn rains fill the pond, covering the eggs which subsequently hatch. Selection of egg deposition sites is crucial to the reproductive success of the female. If eggs are deposited near the dry pond's deepest section, a light rainfall will fill the pond sufficiently to immerse the eggs and cause them to hatch. If the rains do not continue steadily, the water may evaporate and the newly hatched larvae will perish. However, if the female places her eggs too high up on the pond's side, they may be immersed and hatch late in the autumn or early winter. This may place the newly hatched larvae at a disadvantage, as they would be forced to compete for food with larger larvae that had hatched earlier in the autumn. Optimal egg deposition sites would be those that minimize both the risks of early as well as late hatching. Autumn breeding enables several species of Ambystomid larvae to use a single vernal pool in "shifts". In late April and early May, when the larvae of spring breeding species such as Ambystoma maculatum hatch, Ambystoma opacum are nearing metamorphosis. During the short period that both species share the pond, the larger Ambystoma opacum larvae exploit different invertebrate food resources than the minute Ambystoma maculatum.

I was able to find only two clutches of Ambystoma opacum eggs. On September 15, I found a male and female together with a clutch of eggs on top of Ragged Mountain (Southington, CT). The adults and eggs were under a flat stone imbedded into the bottom of a dried-up vernal pool. Three other marbled salamanders were found under logs on the surrounding forested ledges. On October 1, I found a female with eggs under a stone which was imbedded into the edge of a partially filled vernal pool on Mount Tom (Holyoke, MA). On September 25, Deckert (1916) found two females, each brooding a clutch of eggs with developed embryos, under debris in a dried up vernal pool at Silver Lake (Westchester Co., NY). Noble and Brady (1933) reported a female at Hartsdale (Westchester Co., NY) which laid eggs between October 2-4.

My scant data indicate that Ambystoma opacum may deposit their eggs at least as early as September 15th in Connecticut. This is slightly earlier than reported by Bishop (1941:142). He stated that the egg laying season "may start as early as September 18th on Long Island or as late as the first week in October in Westchester County". However, my earlier Connecticut date agrees with Anderson and Williamson's (1973) data from northern New Jersey (Sussex Co.). Their earliest egg laying dates were September 10-15, but over a ten year period nesting activity peaked in mid September.

Many factors determine the length of the larval period which may vary at a single site from year to year. These include the time of hatching, water temperature and depth, and amount of food available within the pond. By late May I found marbled salamander larvae fully developed. On June 17, a metamorph was collected crossing a road at night during a rainstorm at Griswold (CT). This specimen still had vestiges of its gills. Bishop (1941:149) reported metamorphosis on June 17 at Reed's Valley (Staten Island, NY) and June 23 at Coram and Miller Place (Long Island, NY), and on July 4 at Miller Place.

I have no data on the food habits of Ambystoma opacum. Bishop (1941:151) reported that adults ate earthworms, snails, slugs, staphylinid beetles, ants, Orthoptera, and Diptera and that larvae ate small crustaceans and snails (Physa sp.).

Ambystoma opacum is secure in Connecticut and Rhode Island where they are widely distributed. Road mortality is minimal as they do not migrate en masse to their breeding ponds. Breeding populations occur in many state parks, forests, game management areas, and private sanctuaries. In New York, the distribution of Ambystoma opacum is quite small compared to the

State's total area. Urbanization has eliminated marbled salamanders from large portions of their range on western Long Island and lower Westchester County. They are still relatively common on eastern Long Island and on the mainland. Although populations occur on protected land, I anticipate they will become rarer as urbanization eliminates breeding sites on eastern Long Island and in the Hudson Valley. In Massachusetts, this species has been placed on the list of endangered and rare species. Lazell (1979b) attributed the drastic declines in Massachusetts to a combination of factors including pollution, habitat fragmentation, and acid rain. However, these factors are also present in Connecticut and Rhode Island where marbled salamanders remain widespread. In the decade following Lazell's (1979b) paper, a handful of additional sites for Ambystoma opacum have been located in Massachusetts, but statewide they remain rare. As Massachusetts is at the periphery of this species' range, marbled salamanders may be undergoing a long term range contraction due to climatic or ecological changes. Conversely, these peripheral populations may be more vulnerable to the short term effects of environmental degradation discussed by Lazell than those of adjacent states. Additional field work is needed to assess their current status within Massachusetts.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=9): AMNH 6380, 84321, 107573; UCS 1288, 4699, 7813, 7819-20, 8323

Hartford Co. (n=33): AMNH 107574, 108065, 115982-83, 121420-21, 125139-46, 128750-51, 131761-63; AMNH-MWK 7841, 7847-49, 7897-99, 7955-56; UCS 4698, 6420, 6546, 6640, 8473

Litchfield Co. (n=9): AMNH 108066, 114099-100, 115984-85, 121422; TCWC 24235; UCS 2983, 4900

Middlesex Co. (n=10): AMNH 22829, 114101, 115986, 125147-51, 128752; UCS 6774

New Haven Co. (n=16): AMNH 121423, 125152-55; SCSC 2; UCS 5226; UMMZ 98035; YPM 2, 5, 100, 119-20, 170-171, 5069

New London Co. (n=14): AMNH 107575, 117770-73, 125156, 131674, 131764; AMNH-MWK 7830, 7860, 7969; UCS 1286, 8324-25

Tolland Co. (n=20): AMNH 125157, 128753, 131675, 131765; AMNH-MWK 7929; UCS 1276-85, 3053, 4763-65, 4897

Windham Co. (n=13): AMNH 114102, 115987-89, 117774-75, 121424-25, 125158, 131766; UCS 1287, 8056, 8656

Massachusetts

Hampden Co. (n=3): AMNH 132237-39

Worcester Co. (n=1): AMNH 128876

Rhode Island

Kent Co. (n=8): AMNH 128573, 133269-75

Providence Co. (n=1): AMNH 133468

Washington Co. (n=7): AMNH 124556-58, 125005-06, 133469, 133471

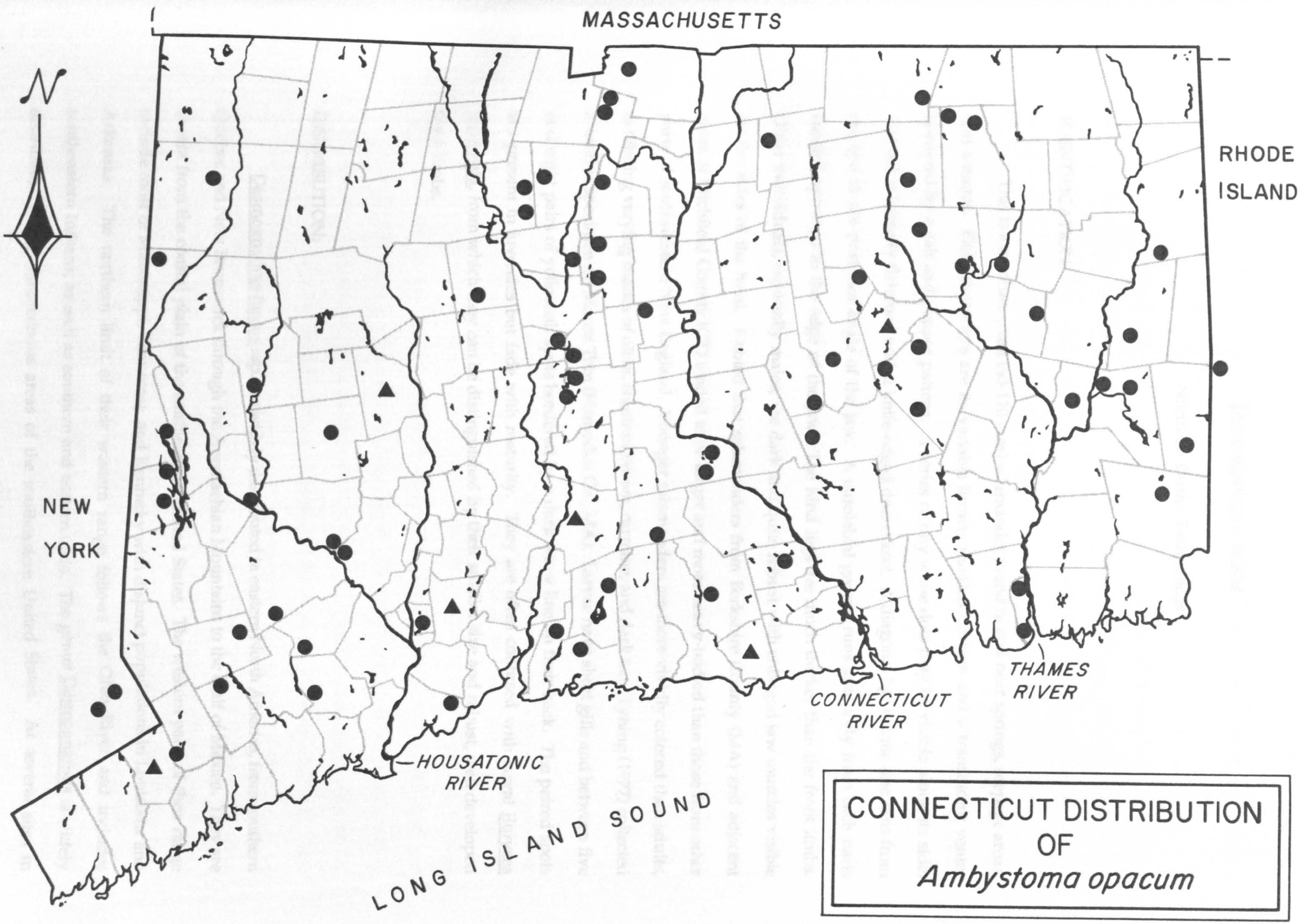
New York

Dutchess Co. (n=9): AMNH 71454-55, 108354-55, 118043, 121815, 132765-67

Putnam Co. (n=5): AMNH 46016, 49823, 51555, 121816, 133000

Ulster Co. (n=2): AMNH 118041-42

Westchester Co. (n=8): AMNH 37579, 51728, 125519, 129164-65, 132686, 132768, 133438



CONNECTICUT DISTRIBUTION OF *Ambystoma opacum*

Desmognathus f. fuscus

Northern Dusky Salamander

IDENTIFICATION:

This is a medium sized (60-110 mm) salamander found in and near springs, seepage areas, and streams. Field characters are its variable brown, mottled dorsum and a translucent venter bordered by a salt and pepper pattern. A series of tiny white dots may be visible along its side. The tail is laterally flattened with a knife-edged dorsal keel. A diagonal light white line runs from the eye to the posterior angle of the jaw. A nasolabial groove runs anteriorly from each naris (nostril opening) to the edge of the jaw. The hind legs are much thicker than the front limbs. Older individuals, especially males, are dark and quite robust with enlarged jaw muscles visible on the sides of the head. I noted that salamanders from Berkshire County (MA) and adjacent areas of Litchfield County (CT) tended to be larger and more heavy-bodied than those from other parts of southwestern New England. Younger salamanders are more vividly colored than adults, exhibiting varying shades of olive, chestnut brown, carmine, and dark tan. Tyning (1977) collected a xanthic specimen on Mount Tom (Hampden Co., MA). Larvae have short gills and between five and eight pairs of yellowish spots bordered by a dark wavy line on their back. The paired spots are present in juveniles but fade with maturity. They are often confused with larval Eurycea bislineata, from which they can be distinguished by their smaller size and robust, well developed hind limbs.

DISTRIBUTION:

Desmognathus fuscus ssp. are widely distributed in eastern North America, from southern Quebec and New Brunswick through the Appalachian Mountains to the Gulf of Mexico. They are absent from the coastal plain of the southeastern United States. The western parts of their range include most of Mississippi, Tennessee, and Kentucky with disjunct populations in Louisiana and Arkansas. The northern limit of their western range follows the Ohio River and includes southeastern Indiana, as well as southern and eastern Ohio. The genus Desmognathus is widely distributed in the mountainous areas of the southeastern United States. At several sites in southwestern Virginia (Bland and Wythe counties), I collected Desmognathus fuscus, D. monticola, and D. quadramaculatus within the same brook.

In southwestern New England, Desmognathus fuscus is widely distributed from sea level to high elevations, but rarely found on the deep glacial deposits of the coastal plain. In Connecticut, it is common statewide, except Fairfield County where it has become rare, probably due to habitat degradation. They are widespread in Massachusetts, except along the east coast and Cape Cod (Lazell, 1976). In Rhode Island, Desmognathus fuscus is uncommon, reported from scattered inland localities. A notable exception is a population recently found in a spring on the Charlestown recessional moraine at Westerly (Raithel, pers. comm.).

In New York, museum specimens (AMNH) and published reports (Bishop, 1941) have shown that Desmognathus fuscus was formerly widespread in Westchester and Dutchess counties. They appear to have declined tremendously in Westchester County and Kiviat (pers. comm.) rarely finds them in Dutchess County. I have no data on their current status in either Putnam or Columbia counties but anticipate they are widespread in the eastern section of Columbia County adjoining Berkshire County (MA). The distribution of Desmognathus fuscus in the New York City metropolitan region which includes Long, Staten, and Manhattan islands as well as Bronx County on the mainland, fits the pattern I described previously for southern New England.

Long Island is part of the northern end of the Atlantic coastal plain, which encompasses sections of eastern Rhode Island and eastern Massachusetts as well as Cape Cod. With the exception of extreme western Long Island, these areas share a common surficial geology of deep, glacial sand and gravel deposits with bedrock rarely exposed. Although Dunn (1926:94) and Bishop (1941:329) noted specimens from "Long Island", Conant (1975:Map 213) did not consider them native to Long Island. Conant overlooked a series of Desmognathus fuscus collected by Nicholas Pike in the late nineteenth century, deposited at the American Museum. Although these specimens were cataloged only as "Long Island", several other Long Island collections made by Pike were from the western end of Long Island, now part of New York City (Kings and Queens counties). Therefore, there is a distinct possibility that these specimens came from western Long Island. A specimen collected in the 1930's on the northwestern end of Long Island (Bayside, Queens Co.) remained misidentified as a Eurycea bislineata until 1979, and therefore was not included in Conant (1975). The northwestern end of Long Island is covered with thin glacial deposits, with bedrock lying only 200-300 feet below the ground surface (Swarzenski, 1959).

Under the rest of Long Island lying to the south and east, the bedrock rapidly drops away to depths ranging between 800-1800 feet (Perlmutter and Crandall, 1959).

In contrast, Desmognathus fuscus is well documented from Staten Island (Bishop 1941:328) where specimens (AMNH 130202-06) were collected as recently as 1986. Desmognathus fuscus was reported at Harlem on Manhattan Island by Rafinesque (1820) and Gans (1945) was still able to collect specimens (AMNH 51943+9) there in 1944. Although these islands are located near Long Island, they differ by being primarily comprised of bedrock which is similar to the adjacent mainland (Schuberth, 1968:304).

In summary, Desmognathus fuscus is rare or absent in coastal areas lying atop deep deposits of sand and gravel, specifically the coastal plain. They occur in coastal areas where bedrock outcroppings predominate or where glacial deposits are thin, including the Connecticut shoreline, western Long Island, Staten Island, Manhattan Island, and the New York mainland (Bronx and Westchester counties).

LIFE HISTORY AND ECOLOGY:

I collected Desmognathus fuscus in a wide variety of freshwater habitats. Cool seepage areas, springs, and swift flowing brooks were favored habitats. They preferred areas with a closed canopy of either deciduous or coniferous forest. They were found in both muddy-bottomed streams and mossy seeps as well as scoured, high gradient, mountain brooks. They often occurred microsympatrically with two other stream salamanders, Eurycea b. bislineata and Gyrinophilus p. porphyriticus. This salamander was extremely common, or at least easy to collect, in streams which had many flat stones or logs providing cover. Favored sites were large, flat stones which lay on the bank, partially submerged and partially above the water line. Many salamanders were found by digging into the streambank in areas of soft mud and gravel. Some of the most productive areas in terms of salamander density were located at the confluence of subterranean water (seepage or spring) with surface water (stream or brook). Salamanders were found under cover during dry or sunny weather, except in deeply shaded ravines where they foraged along the stream's edge with little regard for prevailing weather conditions. However, in habitats other than dark ravines, daytime foraging was prevalent only during cool, cloudy, and rainy conditions. On rainy nights, salamanders were collected on roads.

I found salamanders from March through November but gathered no data on their reproductive cycles. Wilder (1913) provided life history information from western Massachusetts and Bishop (1941) from New York which I will briefly summarize. The production of spermatophores can take place in the spring or autumn. Up to several dozen eggs are deposited under a stone or log, not far from water, and brooded by the female. The egg laying period runs from June through September. Wilder (1913:260) found eggs near Northampton (MA) from June 11 through September 24. The eggs collected on September 24 were near the point of hatching and were probably deposited in late August. After a five week incubation period, followed by a variable one to two week post-hatching terrestrial stage, Wilder (1913:293) reported the larvae entered the water where they remained throughout the winter and spring for a larval period of eight to ten months. Wilder (1913:293) found the majority of larvae entered the water in September. The total length of mature larvae from western Massachusetts examined by Wilder (1913:294) averaged 25 mm, with the largest individual measuring 33 mm. Bishop (1941:320) found mature larvae at Rochester (NY) larger, with an average size of 31 mm, and the largest measuring 36 mm. Dunn (1926:92) found a mature larva measuring 44 mm at Haverford, Pennsylvania. In western Massachusetts, Wilder (1913:295) reported transformation between June 17 and July 1. At Rochester (NY), Bishop (1941:321) reported the transformation period was much longer, as he found recently transformed individuals as early as March 12.

Bishop (1941:323) listed food items of Desmognathus fuscus which he obtained from various sources. A great diversity of invertebrates were eaten on including crustaceans, insects, arachnids, earthworms, snails, centipedes, and mites. Adults may feed on larval Desmognathus. I found an adult at Sheffield (MA), which had eaten such a large earthworm that it could not swallow all of it.

Desmognathus fuscus has declined or become extirpated in many urbanized areas of the New York metropolitan area, Westchester County (NY), and Fairfield County (CT). It remains abundant in upland regions of southwestern New England, where it is secure. Conservation concern should focus on the localized, often widely separated populations located near the edge of the coastal plain. These are usually limited to a single spring or small seepage and therefore are extremely vulnerable to extirpation. If active sites still exist on western Long Island or Manhattan, they should be conservation priorities, as should the remaining populations on Staten Island.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=8): AMNH 2183, 6381, 70370-71, 72562, 76116-17, 133440

Hartford Co. (n=37): AMNH 107577, 108068-69, 115990-92, 117776-80, 121426-30, 125159-68, 128754-62, 131767, AMNH-MWK 7953

Litchfield Co. (n=89): AMNH 36481-82, 41452, 44878-905, 50787, 108070-73, 114103, 115993, 117781-88, 121431-39, 125169-85, 128763-64, 131676-90

Middlesex Co. (n=34): AMNH 107578-80, 114104-08, 115994-98, 117789-96, 121440-46, 128765-70

New Haven Co. (n=18): AMNH 108074, 114109-10, 115999-6000, 117797-807, 125186-87

New London Co. (n=13): AMNH 107581-82, 108075-76, 117808-09, 121447-48, 128576, 131691-94

Tolland Co. (n=4): AMNH 117810-13

Windham Co. (n=7): AMNH 107583-85, 116001-03, 117814

Massachusetts

Berkshire Co. (n=150): 3877, 13945-49, 115865, 121646-78, 125375, 125794-801, 128877-84, 131849-912, 132240-68

Franklin Co. (n=9): AMNH 132269-73, 133209-12

Hampden Co. (n=36): AMNH 125376-90, 131913-19, 132274-77; AMNH-MWK 7978-87

Hampshire Co. (n=11): AMNH 22849, 132278-87

Rhode Island

Kent Co. (n=1): AMNH 133288

Providence Co. (n=6): AMNH 2181, 124559-61, 133472-73

Washington Co. (n=6): AMNH 124562, 125007-11

New York

Bronx Co. (n=24): AMNH 2182, 15763, 16581-97, 52317-21

Columbia Co. (n=3): AMNH 13070-72

Dutchess Co. (n=46): AMNH 50788-89, 52777-81+7, 57881-82+1, 57892-96+8, 68423+1, 71457-58, 73563, 76133-34+7, 132769-70

Putnam Co. (n=13): AMNH 2231-42, 63774

Westchester Co. (n=89): AMNH 2184-85, 6395-96, 21335-41, 23042, 33015-27, 34231, 34998, 36032-42, 36044-76, 36293, 36948-50, 49716-18, 51584+1, 52322-27+2, 103329

New York: Long Island

Long Island (n=39): AMNH 2061-65, 2067-82, 2084-85, 2140, 2755-69

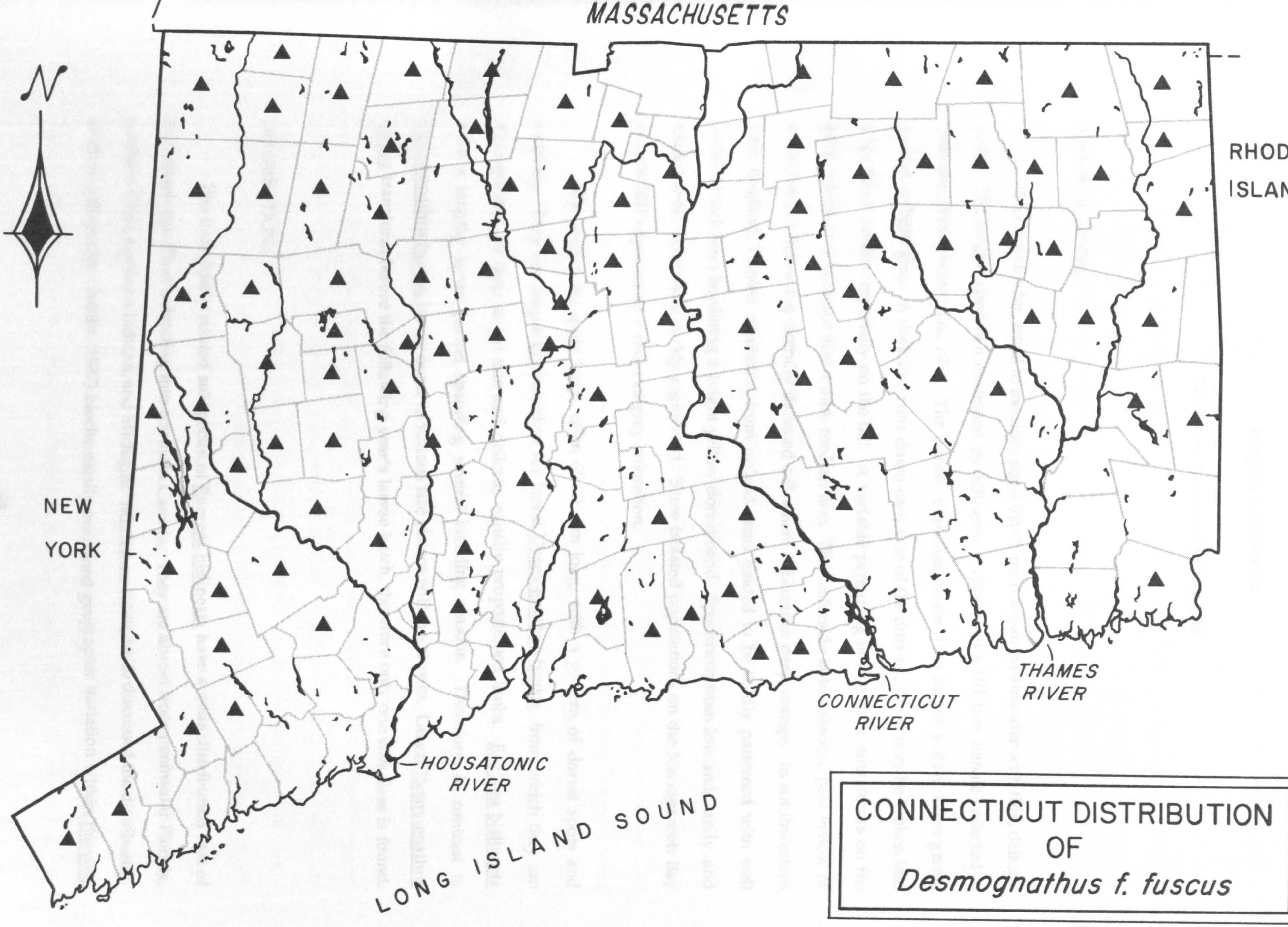
Queens Co. (n=1): AMNH 103509

New York: Manhattan Island

New York Co. (n=10): AMNH 51943+9

New York: Staten Island

Richmond Co. (n=42): AMNH 2176-78, 2246-69, 38140-43, 51591+5, 130202-06



CONNECTICUT DISTRIBUTION
OF
Desmognathus f. fuscus

Eurycea b. bislineata

Northern Two-lined Salamander

IDENTIFICATION:

This is a slender, small to medium sized (65-95 mm) stream salamander with thin, delicate limbs. The largest specimen examined by Mittleman (1949) was a 109 mm female collected at Harrison (Westchester Co., NY). The dorsal coloration varies from bright yellow, olive green, bronze, to light gray. A dark line runs down each side of the dorsum, but it may be broken into a speckled pattern, especially on the tail. A variable peppering of fine dark dots occurs on the back, which may coalesce into a thin, median line. The underside is translucent, pale yellow or white, except below the laterally flattened tail where it becomes deep orange. In southwestern New England, I noted specimens from upland areas tended to be boldly patterned with well defined black lines bordering a bright yellow dorsal band. Specimens from lowland, sandy, and coastal areas were more darkly pigmented. Some isolated populations on the Narragansett Bay Islands (RI) approached a charcoal gray coloration.

The larvae are quite large, often 60-70 mm long, with a pattern of dorsal spots and mottling. They are frequently mistaken for larval Desmognathus fuscus, from which they are distinguished by their larger size and delicate, equally proportioned limbs. Eurycea bislineata have a lengthy larval period spanning several breeding seasons. Therefore, in contrast to Desmognathus fuscus, larvae occur in various size classes within a stream. Larval Desmognathus fuscus transform before the following year's larvae hatch, therefore only one size class is found.

DISTRIBUTION:

The four closely related subspecies of Eurycea bislineata have a wide distribution east of the Mississippi River extending into southern Canada. They are absent from peninsular Florida, northern Ohio, northern Indiana, and Michigan. Mittleman (1949, 1966) discussed the distribution of these subspecies. Jacobs (1987) biochemically examined geographic variation within Eurycea bislineata ssp. He elevated three subspecies to specific status, but unfortunately did not examine any specimens from New England or Long Island in his detailed study.

Eurycea b. bislineata is found from Virginia and West Virginia north through Pennsylvania, New York, and New England (Mittleman, 1966). In Canada, its range encompasses portions of Ontario, Quebec, New Brunswick (Mittleman, 1966), and Labrador (Cook and Preston, 1979).

In southwestern New England this salamander is abundant and widespread, from sea level to high elevations. In Connecticut, it is common statewide. Likewise, in Massachusetts it is widespread except on Cape Cod, where Lazell (1976) documented it at a single site on the Sandwich moraine, and cited an unconfirmed report from Falmouth. Lazell (1976) confirmed the identity of the two Eurycea bislineata deposited at the ANSP (Academy of Natural Sciences, Philadelphia) from Nantucket, cited in Dunn's (1926:304) monograph. However, he did not consider these two old specimens with partially illegible collection data sufficient evidence of their natural occurrence upon Nantucket. Lazell (1976) raised the possibility that the label with collection data affixed to the Eurycea jar may have belonged to a jar of Nantucket Plethodon cinereus, from which it was detached during a flood at the ANSP. I agree with Lazell's deletion of Eurycea bislineata from Nantucket's fauna, based on the confusion surrounding these specimens coupled with Lazell's intensive, albeit futile, efforts to locate Eurycea on Nantucket. Ignoring their occurrence on Long Island (NY), Lazell (1976) attributed their rarity on Cape Cod to this species' preference for the "solid bedrock foundation" of New England. In Rhode Island, they are common throughout the state, including coastal areas (Raithel, pers. comm.). I collected them in springs and brooks on Aquidneck, Conanicut, and Prudence islands in Narragansett Bay.

In New York, Eurycea bislineata is widespread on the mainland. Their distribution on Long Island may provide the key to understanding their occurrence on Cape Cod. All Long Island collection sites documented with specimens (AMNH) or cited in the literature (Dunn 1926:298,305; Bishop 1941:293-296) are along the Harbor Hill Recessional Moraine on Long Island's north shore. Eurycea bislineata is absent from the central and southern portions of Long Island, including the Ronkonkoma Terminal Moraine. Goldsmith (1987) illustrated the Ronkonkoma Terminal Moraine comprising the south fork of eastern Long Island, Block Island (RI) as well as Martha's Vineyard and Nantucket (MA). He illustrated the Harbor Hill Recessional Moraine comprising Long Island's north fork, Plum Island and Fisher's Island (NY), as well as the

Charlestown Moraine on Rhode Island's south shore, and Cape Cod's Buzzards Bay (which includes the Elizabeth Islands) and Sandwich moraines.

I hypothesize that in New England and New York, Eurycea bislineata ranges south to, but not beyond, the Harbor Hill Recessional Moraine. Specimens from Long Island's north shore, Rhode Island's Charlestown Moraine, and Cape Cod's Sandwich Moraine as well as Lazell's (1976) unconfirmed report from Falmouth, which is located on the Buzzards Bay Moraine, would fit this distributional scenario. These sites are all located along the southern edge of the Wisconsin ice sheet's "retreatal stage" illustrated by Wilson (1906:Plate 2b). This map, with Eurycea localities plotted, is reproduced at the end of this species account. Along the Harbor Hill Moraine, Eurycea bislineata is quite localized, confined to springs and streams percolating out of the moraine. Additional confirmation of my hypothesis would be the discovery of Eurycea in springs on Plum Island, Fisher's Island, or the Elizabeth Islands, as well as additional sites on Cape Cod's Sandwich and Buzzards Bay moraines. My hypothesis would be refuted by the discovery of Eurycea on Long Island's south shore, Block Island (RI), Martha's Vineyard (MA), or Nantucket (MA). Although the mainland and large islands have been inventoried, many of the smaller islands (Plum, Fisher's, and the Elizabeth archipelago) have never been comprehensively studied.

LIFE HISTORY AND ECOLOGY:

Eurycea bislineata was collected in a wide variety of habitats. Although undisturbed and rural sites were favored, 9% of the collections I made in Connecticut were from urbanized areas. I found Eurycea in swift flowing, high gradient mountain brooks, muddy meandering flood plain rivers and wooded swamps, springs and seepage areas, edges of vernal pools, and damp moist woodland, often several hundred feet from the nearest stream. In Connecticut, Babbitt (1937) found them 200 feet from water. They appear to move much further from water than Desmognathus fuscus.

I collected Eurycea as early as February and as late as November. Between 1975-1986, I made 144 collections in Connecticut distributed as follows: February (1), March (5), April (19), May (17), June (16), July (11), August (18), September (34), October (20), November (3). The increase in collecting success during September and October may result from low water levels in streams which facilitated collection.

Various authors studied the reproductive habits of Eurycea bislineata. Noble (1929b) found that secondary sexual characteristics of male Eurycea were most pronounced from October through May. The male's enlarged head was often discernable in my collections. Noble (1929b) described both spermatophore deposition and courtship behavior. Wilder (1924) studied a population at Mount Toby (Franklin Co., MA). Although she found eggs in early developmental stages as late as the first week of June, egg laying generally occurred in May. Wilder reported that "Dr. E.R. Dunn has records of eggs from a brook in Northampton in the latter part of April". In Connecticut, Babbitt (1937) found eggs from April through August. In New York, Bishop (1941:283) reported that eggs were laid between April 11 and June 25. Wilder found the number of eggs varied from 12-36 with the average being 18. These were fastened by a slender stalk of jelly to the underside of a submerged stone under which water ran freely. On May 20, I found a clutch of eggs attached to the underside of a flat stone in a swiftly flowing brook at Monterey (MA). Hatchlings which averaged 14 mm were found in June and early July, approximately one month after the eggs were laid (Wilder, 1924). Between June 27 and July 15, Johnson and Goldberg (1975) collected newly hatched larvae at Amherst (MA). I found several size classes in my New England collections, indicating a prolonged larval period with several cohorts. Wilder reported that larvae took two to three years to develop, varying from 43-76 mm at transformation.

Bishop (1941:291) cited various sources who reported that Eurycea bislineata fed on insects, annelids, arachnids, sowbugs, mites, and an occasional salamander.

Eurycea bislineata is secure in southwestern New England, occurring in most state parks and forests, as well as on private sanctuaries and undeveloped land. It appears more tolerant of urbanization than Desmognathus fuscus remaining widespread near New York City. For example, in Westchester County (NY) and adjacent Fairfield County (CT), where Desmognathus is now rare, Eurycea is common. Eurycea may have increased as Desmognathus became extirpated in urbanized areas. In 1988, Eurycea (AMNH 127985) was collected at Alley Pond Park (Queens Co.), within the New York City limits. At present, the only populations of conservation concern may be those located along the recessional moraine on western Long Island, which is becoming increasingly degraded. The Cape Cod site at Sandwich is of concern as it is represents the only known Eurycea site on Cape Cod (Lazell, 1976).

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=62): AMNH 13082-87, 76118, 77008+8, 77009+4, 107586-92, 108077-78, 114111-18, 116004, 117815-33, 121449-50, 125188, 133441

Hartford Co. (n=33): AMNH 107576, 107593-96, 108079, 117834-42, 121451-55, 125189-200, 128771

Litchfield Co. (n=47): AMNH 16802, 99300-04, 108080-84, 114119-23, 116005, 117843-46, 121456-67, 125201-06, 128772-73, 131695-700

Middlesex Co. (n=23): AMNH 107597-98, 114124-28, 116006-07, 117847-51, 121468-72, 131768-71

New Haven Co. (n=13): AMNH 108085-86, 114129-30, 116008-09, 117852, 125207-12

New London Co. (n=36): AMNH 107599-600, 108087, 114131-32, 116010, 117853-70, 121473-77, 125213-14, 128774-75, 131701, 131772-73

Tolland Co. (n=5): AMNH 107601, 116011, 117871-72, 131774

Windham Co. (n=16): AMNH 107602-05, 117873-82, 125215-16

Massachusetts

Berkshire Co. (n=110): AMNH 3875, 13944, 11403, 14408-09, 121679-705, 125391-94, 125802-04, 128885-90, 131920-49, 132288-322

Franklin Co. (n=10): AMNH 54699-701, 103729-31, 132323-24, 133213-14

Hampden Co. (n=24): AMNH 125395-404, 131950-58, 132325-29

Hampshire Co. (n=1): AMNH 132330

Rhode Island

Kent Co. (n=4): AMNH 132524, 133289-91

Newport Co. (n=57): AMNH 124563-67, 125012-22, 128693-97, 132600-35

Providence Co. (n=18): AMNH 125023-34, 128698-99, 132636-39

Washington Co. (n=16): AMNH 124576-77, 125035-45, 128578-80

New York

Columbia Co. (n=7): AMNH 40433, 121822, 125520-24

Dutchess Co. (n=39): AMNH 52786-88+2, 57883-84+2, 57885-91+2, 68422+1, 81642, 115870-76, 116409-10, 127979-81, 129948-49, 132771-74

Putnam Co. (n=6): AMNH 63775, 118044-47

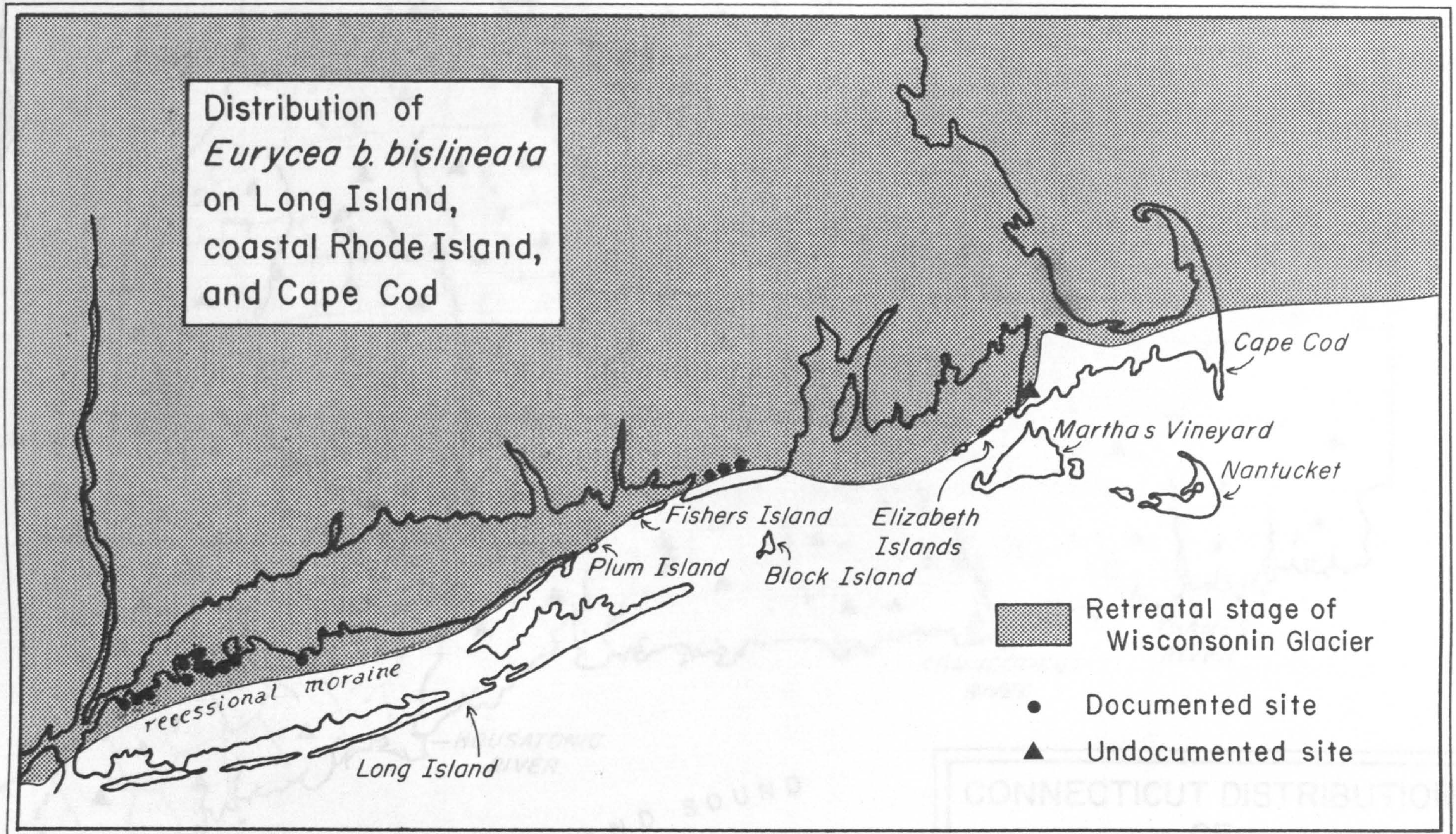
Westchester Co. (n=17): AMNH 33028, 36043, 108388-89, 115866-69, 116423, 125533-36, 129168-69, 129468, 132689

New York: Long Island

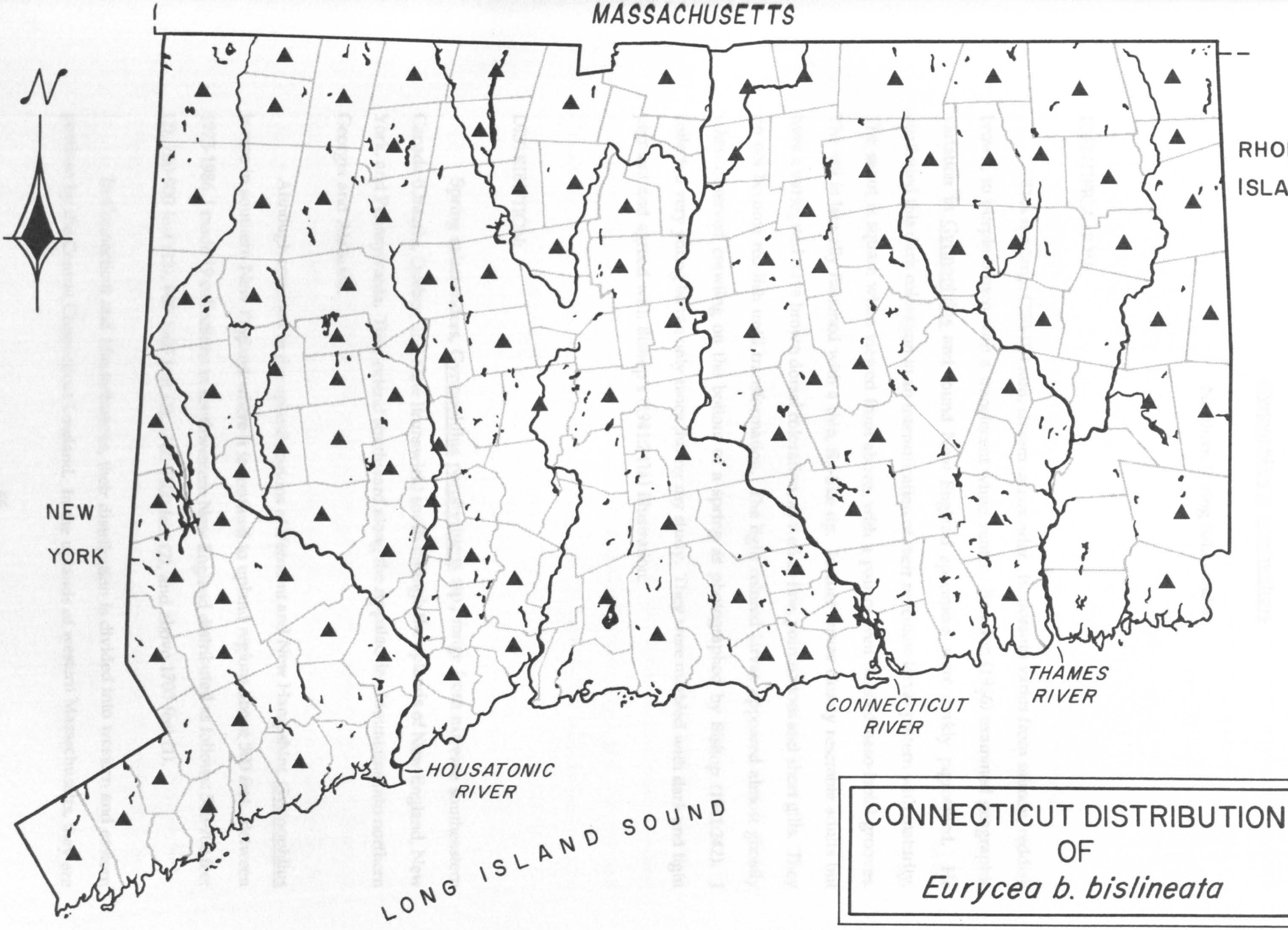
Nassau Co. (n=14): AMNH 3744-45, 72550-51, 75112, 121817-21, 133001-04

Queens Co. (n=112): AMNH 13088, 33271-305, 33307, 33336-85, 33392-98, 35531-45, 41372-73, 127985

Suffolk Co. (n=2): 60567, 81383



Distribution of
Eurycea b. bislineata
on Long Island,
coastal Rhode Island,
and Cape Cod
Cape Cod
Martha s Vineyard
Nantucket
Elizabeth
Islands
Fishers Island
Block Island
Plum Island
recessional moraine
Long Island
Retreatal stage of
Wisconsonin Glacier
Documented site
Undocumented site



CONNECTICUT DISTRIBUTION OF *Eurycea b. bislineata*

Gyrinophilus p. porphyriticus

Northern Spring Salamander

IDENTIFICATION:

This is a large (120-190 mm) stream salamander. Its dorsum varies from salmon, reddish brown, to purple brown with a translucent white venter. Brandon (1966) examined geographic variation in Gyrinophilus and found New England specimens were darkly pigmented. He attributed this dark coloration to an intensification of their reticulate larval pattern with maturity. The snout is square when viewed from above, with a pair of well defined naso-labial grooves. The tail is laterally flattened with a thin, fin-like tip. Mature larvae closely resemble adults but have a variegated olive brown dorsal coloration, as well as fine, pointed toes and short gills. They do not become reddish until transformation. The light colored larvae appeared almost ghostly when observed crawling on the bottom of a spring as photographed by Bishop (1941:242). I collected very young larvae only twice during my study. They were marbled with dark and light pigment and agreed with Bishop's (1941:241a) illustration.

DISTRIBUTION:

Spring salamanders, Gyrinophilus porphyriticus ssp., range from extreme southeastern Canada (Ontario, Quebec, and New Brunswick) south through the uplands of New England, New York, and Pennsylvania. They extend southward along the Appalachian Mountains into northern Georgia and Alabama.

Although common in the upland regions of Vermont and New Hampshire, Gyrinophilus is rare in southern New England where it is confined to upland regions above 500 feet. Between 1975-1986, I made 19 collections in southwestern New England distributed as follows: 500-700 feet (2), 700-900 feet (13), 900-1100 feet (1), 1100-1300 feet (2), and above 1700 feet (1).

In Connecticut and Massachusetts, their distribution is divided into western and eastern portions by the Central Connecticut Lowland. In the uplands of western Massachusetts, they are locally common both in surface runoff (streams and brooks) as well as in springs and seeps. They are rare and localized in the adjoining portions of northern Litchfield County (CT). I made a single collection from New York's Columbia County, on the west side of the Taconic Uplift, bordering Mount Washington (MA). I anticipate they will be found in areas of Dutchess County (NY) bordering the Taconic Uplift such as Brace Mountain.

On the eastern side of the Central Connecticut Lowland, all but one of my collections have been from within spring houses or wells. In Connecticut, I collected spring salamanders at Staffordville (Tolland Co.). A specimen (USNM 27746) was found at Storrs (Tolland Co.) in 1900. I have no records from Windham County (CT), but anticipate they may be found there as Lazell and Raithel (1986) recently discovered them just east of the Connecticut state line in Rhode Island (Providence Co.).

I am aware of a handful of scattered records from the uplands of eastern Massachusetts. I collected a specimen at New Salem (Franklin Co.), Lazell (1972) reported spring salamanders from Wachusett Mountain (Worcester County) and the Holyoke Range (Hampshire Co.), Graham and Stevens (1982) found a specimen at Holden (Worcester Co.), Mirick (pers. comm.) observed specimens at Petersham (Worcester Co.), and Lazell and Raithel (1986) reported them at Palmer (Hampden Co.). They appear much rarer and more localized on the eastern side of the Central Connecticut Lowland. However, their subterranean habits in eastern New England renders their collection extremely fortuitous.

LIFE HISTORY AND ECOLOGY:

Gyrinophilus requires clean, cold, well oxygenated water. Steep, rocky, heavily forested hemlock ravines are favored habitats. They appear intolerant of disturbance as evidenced by the collections I made. Thirteen collections were from undisturbed sites, the remaining six from rural areas with a mosaic of land uses.

I collected Gyrinophilus in steep, rocky, high gradient ravines, brooks, seepage areas, springs, and below ground in spring pipes and wells. Springs and brooks percolating from hillsides below perched swamps were productive sites for Gyrinophilus, as were east and north facing ravines. In certain brooks they were quite abundant, while at other sites several hours were required to locate a single specimen. I was unable to find them in many seemingly ideal habitats. At other sites a single specimen was collected and none observed on subsequent visits. For example, in a spring where I regularly draw water at Egremont (MA), I collected a single Gyrinophilus in 1987. To date, I have not observed any others there. The steep, rocky slope at this site is comprised of loose soil mixed with exfoliating rock sheets and is peppered with seepage areas. I imagine additional Gyrinophilus would be found if the hillside were excavated. Dunn (1926:264) reported a specimen dug up from three feet below the ground surface during road repairs in Vermont.

The following account will provide further evidence of difficulties I encountered while trying to document this species' presence. I received a reliable report of Gyrinophilus from Campbell Falls on the Connecticut-Massachusetts state line. The habitat appears excellent, including a steep hemlock ravine with many cold, spring fed seepage areas. Despite several day long field trips accompanied by several assistants, I was unable to find a single Gyrinophilus at Campbell Falls. Therefore, I do not consider my inability to find Gyrinophilus necessarily proof of their absence.

I collected Gyrinophilus from March through November. Nineteen collections from southwestern New England were distributed as follows: March (1), May (3), June (5), July (1), August (4), September (1), October (3), November (1). I have little reproductive data on this species. Dunn (1926:264) reported a clutch size of fifteen eggs. I collected a recently hatched larva (AMNH 131964) on June 14 at Egremont (MA) which measured 31 mm. A larva (AMNH 128700) completing its first year of growth was collected on March 23 at Foster (RI) and measured 40 mm. Near Albany (NY), Bishop (1941:248) found recently hatched larvae in April and July which measured between 26-28 mm. I found larvae in various size classes which indicated their larval period extended over several years in southwestern New England. Bishop (1941:250) reported a three year larval period near Albany.

Bishop (1941:252-53) cited several sources who included insects, worms, spiders, millipedes, snails, crustaceans, and other salamanders (Desmognathus and Gyrinophilus) in the diet of Gyrinophilus. Dunn (1926:264) reported that wild caught Gyrinophilus fed on Desmognathus fuscus and Eurycea bislineata, while a captive specimen consumed Hemidactylium scutatum and young Rana sylvatica. A one year old larva (AMNH 128700) which I collected at

Foster (RI) regurgitated an immature mayfly and a fairy shrimp. A large larval Gyrinophilus consumed a smaller conspecific while I was transporting them in a water filled plastic bag.

Gyrinophilus is secure in the uplands of western Massachusetts where they occur in large state forests and parks. In Connecticut, most Litchfield County sites are on private watershed properties owned by the Metropolitan District Commission. The greatest threats to Gyrinophilus come from pollution of their cool, clean aquatic habitats. Pollution of aquatic sites may be caused by pesticides, fertilizers, road run-off, and industrial chemicals. Potentially, ground water pollution may be the most serious threat to Gyrinophilus east of the Central Connecticut Lowland (eastern Connecticut, western Rhode Island, and eastern Massachusetts) where they are largely confined to springs and subterranean water. Accelerated siltation from erosion caused by poor forestry practices such as clear cutting, as well as construction and agriculture, degrades clear, high quality streams. Thermal pollution and reduced oxygenation are major threats. Gyrinophilus is rarely found in streams that are dammed, as impoundments usually increase water temperature and reduce oxygenation. Gyrinophilus may have been more widespread prior to the impounding of many New England streams during the 1800's. Large scale logging may threaten Gyrinophilus by removing forest canopy and thereby raising water temperatures in nearby brooks. Pollution or logging of perched swamps which are the headwaters of many Gyrinophilus habitats may adversely affect an entire population.

SPECIMENS EXAMINED

Connecticut

Hartford Co. (n=14): AMNH 121478-88; UCS 3540, 4086, 6593

Litchfield Co. (n=13): AMNH 121489, 125217-21, 128776; UCS 2123, 4320, 4995, 5213, 6393, 6551

Tolland Co. (n=4): AMNH 117883, 121490; UCS 8260; USNM 27746

Massachusetts

Berkshire Co. (n=27): AMNH 45090-92, 121706-08, 131961-69, 132343-54

Franklin Co. (n=5): AMNH 132355, 133215-18

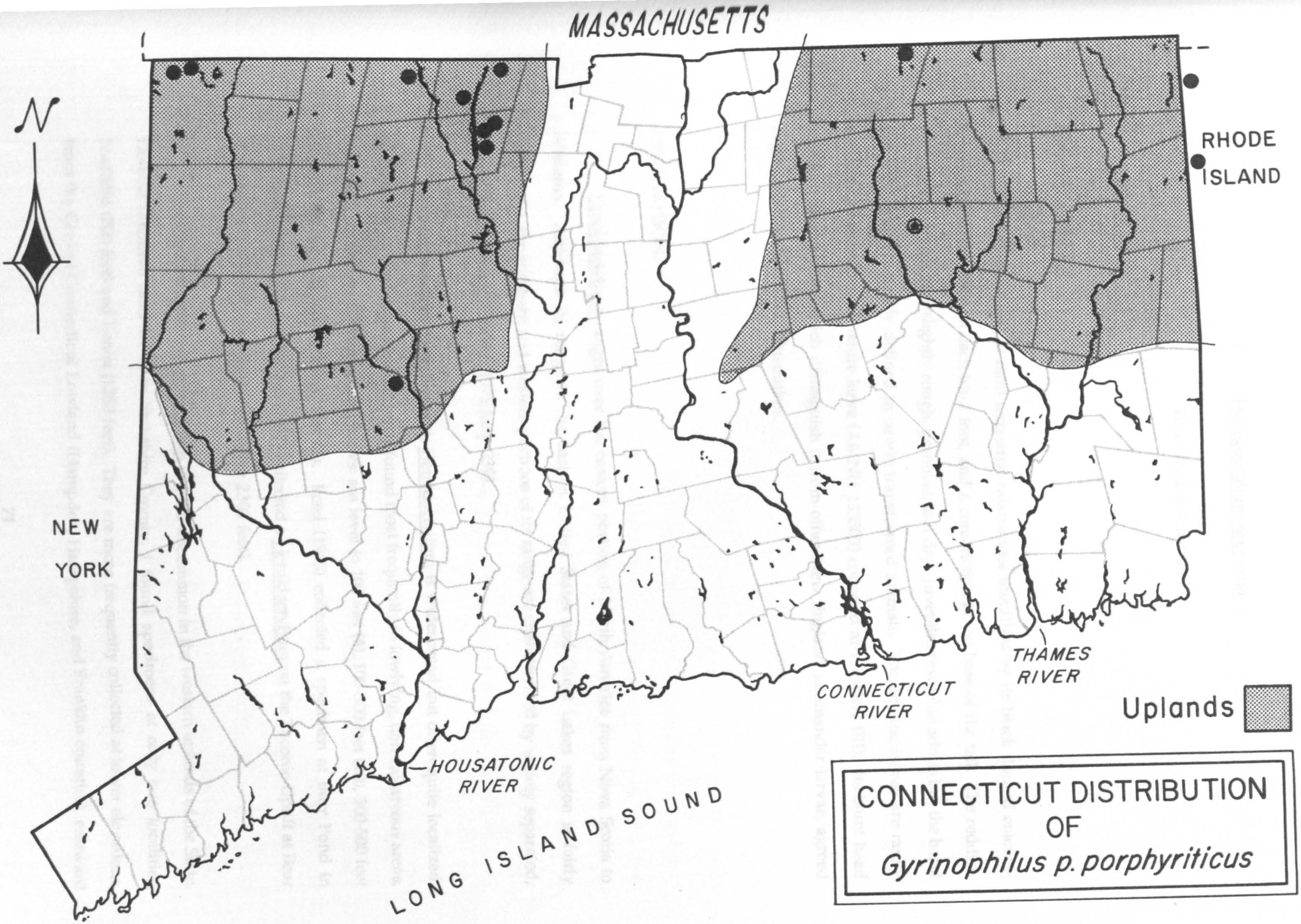
Hampden Co. (n=2): AMNH 125405-06

Rhode Island

Providence Co. (n=3): AMNH 125046, 128581, 128700

New York

Columbia Co. (n=1): AMNH 121823


MASSACHUSETTS
RHODE
ISLAND
N
NEW
YORK
HOUSATONIC
RIVER
CONNECTICUT
RIVER
THAMES
RIVER
LONG ISLAND SOUND
Uplands
CONNECTICUT DISTRIBUTION
OF
Gyrinophilus p. porphyriticus

Hemidactylium scutatum

Four Toed Salamander

IDENTIFICATION:

This is a small (50-90 mm) terrestrial salamander identified by its black flecked enamel-white venter, four toes on each hind foot, and a constriction at the base of the tail. The reddish brown dorsum appears slightly rough, granular, and dry. Juveniles resemble adults but the basal tail constriction is poorly defined in newly transformed animals. The aquatic larvae are rarely collected. I examined a mature larva (AMNH 133503) collected at Westerly (RI). Its blunt head and long bushy gills, which distinguish it from other New England salamander larvae, agreed with Bishop's (1941:179c) illustration.

DISTRIBUTION:

Hemidactylium ranges over the eastern portion of North America from Nova Scotia to Alabama. Although its range in the eastern United States and Great Lakes region is fairly continuous, the southern and western portions of its range are characterized by widely separated, disjunct populations (Conant, 1975:Map 239).

In southwestern New England, Hemidactylium is widespread but often quite localized. In Connecticut, it occurs statewide, but is found most frequently in lowlying, non-calcareous areas. I made 23 collections distributed as follows: sea level to 100 feet (4), 100-300 feet (10), 300-500 feet (5), 500-700 feet (2), and 700-900 feet (2). Reed (1955) collected a specimen at Burr Pond in Torrington (1000 feet) and Babbitt (1937) collected a Hemidactylium on the Taconic Uplift at Bear Mountain in Salisbury (maximum elevation 2300 feet).

In Massachusetts, Hemidactylium is quite uncommon in the western uplands of the State. Despite intensive field work in Berkshire County, I found specimens at only two localities, Sheffield (700 feet) and Lenox (1250 feet). They are more frequently collected at lower elevations, from the Central Connecticut Lowland (Hampden, Hampshire, and Franklin counties), eastward through Worcester County to the coast. Lazell (1976) reported Hemidactylium from Cape Cod and two nearby islands, Martha's Vineyard and Naushon.

Raithel (pers. comm.) found Hemidactylium throughout Rhode Island, including Conanicut and Prudence Islands in Narragansett Bay. In New York, they occur on Long Island and Staten Island, as well as the mainland. In Westchester County, Deckert (1914) reported Hemidactylium from Silver Lake near White Plains and I collected specimens at Lewisboro, North Salem, Ossining, and Ward Pound Ridge Reservation. In Putnam County, E. Kanze (pers. comm.) found them near Croft's Corners. In Dutchess County, Bishop (1941:194) reported them at Red Hook, Kiviat found a specimen at Clinton Hollow, and I collected specimens at Wappinger, Hyde Park, and Staatsburg. I have no records from Columbia County, but anticipate that additional field work will reveal their presence.

LIFE HISTORY AND ECOLOGY:

I collected Hemidactylium under rocks, logs, and debris both in moist and dry woodland, as well as in wooded swamps. Sandy, acidic deciduous woodland adjoining red maple swamps were favored sites. Specimens were collected around the edges of swamps as well as on hummocks surrounded by water. Sphagnum moss was usually present in the general vicinity of collection sites, but often in small amounts. The majority (70%) of my collections were from rural areas with a mosaic of land usages, while 13% were from undisturbed sites, and 17% from disturbed, suburban and urban areas.

I found Hemidactylium from March through October, with most collections made in spring (March-April) and autumn (September-October). Gravid Hemidactylium and Ambystoma maculatum were observed migrating at the same time. I collected gravid Hemidactylium migrating into swamps on March 17 at Ridgefield (CT) and March 30 at Sharon (CT). My data differ from Blanchard (1934a) who found Hemidactylium in southern Michigan emerged "many days, perhaps three weeks, after the spotted salamanders have mated and laid their eggs". Bishop's (1941:180) earliest migration date near Albany (NY) was April 8.

Blanchard (1933a) reported that Hemidactylium mated in the autumn. I noted a resurgence of Hemidactylium surface activity in September and October which may indicate a breeding period similar to Blanchard's (1933a) report. He found the breeding season in southern Michigan running "from at least the middle of September to the latter part of October". Blanchard (1933b) found pre-hibernating aggregations of Hemidactylium in November, including one aggregation of close to 200 individuals scattered over several square feet. The salamanders were grouped together under leaves in depressions and cavities on the forest floor. He also found individuals near the ground surface as late as December 1.

Blanchard (1933b) also described a post-hibernation aggregation of nineteen Hemidactylium collected on April 20. These salamanders were of varying sizes and were lying "quietly" in small groups under leaves near the entrance to a small hole. I noted a similar aggregation on April 3 at Lenox (MA). Ten torpid subadult Hemidactylium (AMNH 132356-65) and a juvenile Plethodon c. cinereus (AMNH 132366) were collected under an automobile tire resting on a wooded hillside. This site was laced with rodent tunnels and root cavities and was located above a wooded swamp and marsh.

On October 21, I collected six Hemidactylium (AMNH-MWK 7998-8003) at Southwick (MA) under branches and leaves bordering a wooded swamp. Three of these were adults and three were very small individuals which had transformed several months previously. Blanchard and Blanchard (1931) examined a large series of 352 Hemidactylium collected between October 10-12, 1924 at Hamburg township in southern Michigan. They divided this series into three size classes: juveniles which had transformed during the previous summer, juveniles ending their second season of growth, and mature adults which were at least three seasons old. Apparently the intermediate size classes were not represented in my Southwick collection. Blanchard (1935a) examined the sex ratio of the juveniles in the Hamburg township sample. He excluded sexually mature adults to avoid any collection bias due to seasonality or differential habitat preferences. Of 260 juveniles, 148 (57%) were females and 112 (43%) were males. I have no data on sex ratios of Hemidactylium from my study area.

Blanchard (1933c) recorded egg laying dates in southern Michigan. He concluded that "The time at which the first eggs of Hemidactylium may be expected is definitely the middle of April. It is evident that the egg-laying is accomplished in a very brief period--the last half of April; the collections show no females with unlaid eggs after April 29." Bishop (1941:183) observed egg deposition on April 13 and April 28 at New Salem (NY). Blanchard (1935b) examined the number of eggs produced by Hemidactylium. He counted both eggs found in nests and those dissected from the oviducts of gravid females. He concluded that southern Michigan Hemidactylium usually produced between 18-41 eggs per female, with the minimum count found in 217 specimens being six and the maximum 46. He concluded that a natural nest containing fewer than 41 eggs was probably the product of a single female, while nests with more than 46 eggs probably resulted from two or more females nesting communally. Between May 19 and June 2, Gilbert (1941) examined 32 nests near Ithaca (NY). He found that the number of eggs per nest varied between 12-68. He considered only two of these nests, which contained more than 40 eggs, as communal. Breitenbach (1982) reported communal nesting in 12% of 109 nests examined in Michigan. Harris and Gill (1980) studied Hemidactylium in Virginia. They reported that nests which were abandoned by the attendant female had reduced embryonic survival.

Six Hemidactylium nests were examined during my study. On April 23, a nest containing eggs and three salamanders was found in a moss covered rotten stump located in the center of a small shrub swamp at Hyde Park (NY). A nest containing eggs and three salamanders was found on May 12 at Lisbon (CT). Four nests containing eggs and a single salamander were found, two on May 12 at Lebanon (CT) and two on May 17 at Andover (CT). Dunn (1926:202) found a female with 19 eggs on May 23 near Northampton (MA). Blanchard (1934b) noted "that female Hemidactylium usually stays with her eggs until they hatch unless her nest is closely associated with one or more other nests. In the latter event it is usual for all but one of the females to desert the nest." I did not count eggs in the six nests I examined. Therefore I can only conclude that the two nests with three females present, (Hyde Park and Lisbon), were communal. The four nests from Lebanon and Andover may have been either single clutches or communal nests from which the additional female(s) had departed.

Hemidactylium eggs are deposited in a variety of mosses as well as in rotten wood. Wallace (1984) reviewed literature and concluded that the use of Sphagnum sp. varied from area to area. Wallace hypothesized that nesting in sphagnum moss may produce a favorable microclimate, ample aeration, and reduced egg spoilage due to fungistatic and bacteriostatic properties of Sphagnum sp. Of the six nests I examined, only one (Hyde Park) was not deposited in sphagnum moss. Blanchard (1923) gave a detailed description of eggs hatching in the field on May 27. The larvae wriggled out of the egg, and then with great effort wriggled down the side of nest and flopped into the water below. Blanchard (1923) reported that the period from egg deposition to hatching is about five weeks, followed by an aquatic larval life of about six weeks. Based on Blanchard's (1933c) data which limited egg deposition to the latter half of April, one may conclude that hatching will occur in late May or very early June, and transformation should follow by mid July. However, Bishop (1941:184) reported natural incubation periods as long as 62 days at New Salem (NY). My data from southwestern New England indicates that Hemidactylium migrates earlier, (i.e. often contemporaneously with Ambystoma maculatum), than in southern Michigan. The six nests found between April 23 and May 17 fit Blanchard's data. However, the well developed larva collected at Westerly (RI) on June 20 should have transformed in late June or early July, several weeks earlier than in Michigan. Additional field work is needed to determine if the breeding period of Hemidactylium in southwestern New England differs significantly from southern Michigan.

There is little data on food habits of Hemidactylium. Bishop (1941:189) listed spiders, springtails, drosophilid flies, homopterous bugs, staphylinid beetles, and microlepidoptera larvae as food items. Hemidactylium has tail autonomy similar to that found in Gekkonid lizards. If the salamander's tail is roughly handled or grabbed, it detaches at the basal constriction. After detaching, the tail vigorously wriggles, thereby distracting potential predators while the salamander crawls away. I noted when uncovering Hemidactylium, they frequently curled up and turned upon their backs, exposing their bright white venter. This may serve to frighten small predators such as shrews. Although Bishop (1941:188) reported Hemidactylium curling up when disturbed, to my knowledge, the behavioral sequence of curling up and turning over to expose the venter has not been reported.

Hemidactylium has been considered rare in southwestern New England. It was listed in Dowhan and Craig's (1976) monograph on Connecticut's rare and endangered species and is currently protected in Massachusetts as a "species of special concern". My survey demonstrated that Hemidactylium is widely distributed in southwestern New England. I consider it secure within the region, occurring on protected land, but also flourishing in many moderately developed and semi-rural areas. Road mortality does not appear substantial when compared to Ambystoma sp.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=7): AMNH 108088, 114133-34, 116012, 117884; AMNH-MWK 8006-07

Hartford Co. (n=12): AMNH 108089-90, 116013, 121491-93; AMNH-MWK 7961, 7950-52, 8004; UCS 4894

Litchfield Co. (n=9): AMNH 114135-37, 125222, 131702; UCS 7743-46

Middlesex Co. (n=2): UCS 7187-88

New Haven Co. (n=12): AMNH 121494-96, 125223; SCSC 20; YPM 62, 192-93, 269-70, 2073-74

New London Co. (n=25): AMNH 117885-90, 121497, 125224-30; AMNH-MWK 7828, 7858-59, 7861-62, 7968, 7970; MCZ 100512-13; UCS 2971, 8343

Tolland Co. (n=9): AMNH 116014; AMNH-MWK 7864-65; UCS 2117-18, 2465, 4895, 7724, 8275

Windham Co. (n=8): AMNH 121498, 131703-06; UCS 2642, 6540, 7529

Massachusetts

Berkshire Co. (n=11): AMNH 132356-65; AMNH-MWK 8010

Hampden Co. (n=14): AMNH 131970-74; AMNH-MWK 7988-90, 7998-8003

Rhode Island

Kent Co. (n=5): AMNH 132525-26, 133308-10

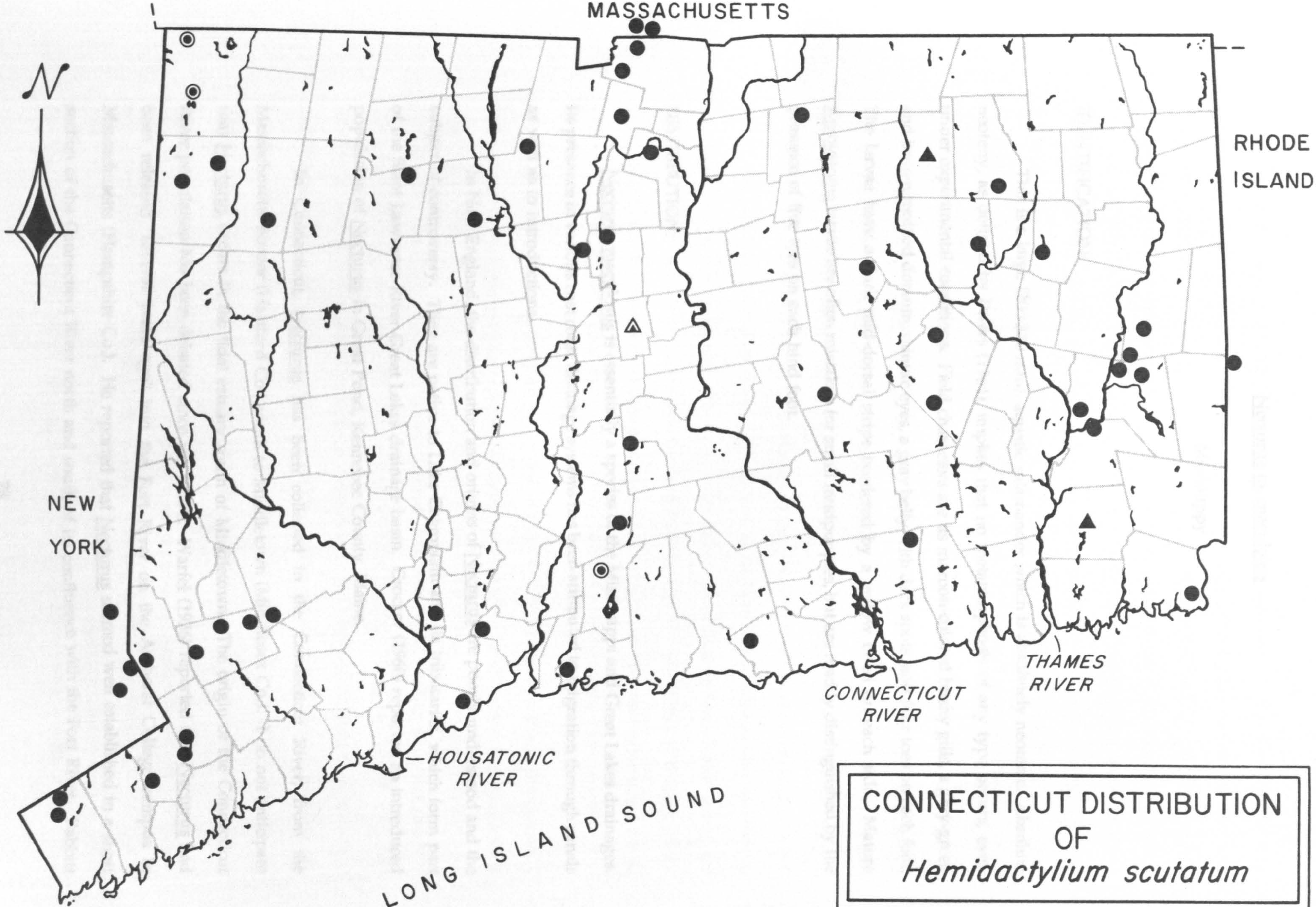
Providence Co. (n=10): AMNH 128583-84, 133312-14, 133495-97, 133500, 133502

Washington Co. (n=3): AMNH 133315-16, 133503

New York

Dutchess Co. (n=11): AMNH 68421, 132775-84

Westchester Co. (n=5): AMNH 125537-38, 129170-72



CONNECTICUT DISTRIBUTION
OF
Hemidactylium scutatum

Necturus m. maculosus

Mudpuppy

IDENTIFICATION:

This is a large (200-330 mm), aquatic salamander which is absolutely neotenic. Absolute neoteny, as defined by Peters (1964), implies that no metamorphosis of any type occurs, even under experimental conditions. Field characters are its maroon-colored bushy gills, a gray-green and brown mottled dorsum, minute eyes, a gray belly with dark spots, and four toes on each foot. The larvae have a dark mid-dorsal stripe bordered by a yellow band on each side. Mature Ambystoma larvae are often mistaken for small mudpuppies, but are readily distinguished by the presence of five toes on each hind foot.

DISTRIBUTION:

Necturus maculosus is essentially a species of the Mississippi and Great Lakes drainages. Its presence in various east coast drainage systems has been attributed to migration through canals as well as to introductions.

In New England, the distribution and origins of Necturus are poorly understood and the subject of controversy. They are native to Lake Champlain and its tributaries, which form part of the Saint Lawrence River-Great Lakes drainage basin. Crocker (1960) reported an introduced population of Necturus in Great Pond, Kennebec County, Maine.

In Connecticut, Necturus has been collected in the Connecticut River, from the Massachusetts border (Hartford Co.) south to Middletown (Middlesex Co.). I do not anticipate that Necturus occurs in the tidal estuary south of Middletown. The origin of the Connecticut River population has been debated since the 1930's. Warfel (1936) reported that Necturus had been released "several years ago" into the Fort River on the Amherst College campus in Massachusetts (Hampshire Co.). He reported that Necturus seemed well established in a short section of the Connecticut River north and south of its confluence with the Fort River. Babbitt

(1932) found two specimens in the Farmington River (a tributary to the Connecticut) near Simsbury (Hartford Co.) in June, 1921. He described these as "probably escapes or discards from the laboratories of the many schools and colleges along the Connecticut valley." In his Amphibia of Connecticut, Babbitt (1937) did not mention the Simsbury record, but cited specimens collected between 1933-1936 in the Connecticut River at East Hartford and Windsor (Hartford Co.), and included (Plate 1a) a photograph of a Windsor specimen. Babbitt (1937) also stated that "One was reported taken on a hook by a fisherman, in the Shepaug River, about fifteen years ago." The Shepaug is a tributary to the Housatonic River. Babbitt (1937) considered the mudpuppy an introduced species.

Dowhan and Craig (1976) stated that as the mudpuppy "is common and native to the nearby Hudson River system, it is not improbable that it is indigenous to Connecticut." However, they ignored Bishop (1941:34-35) who reported that Necturus probably migrated into the Hudson and Mohawk rivers during the early nineteenth century via the Erie Canal. The canal between Lake Champlain and the Hudson River may also have served as a dispersal route into the Hudson drainage. Craig (1979) deleted the mudpuppy from Connecticut's fauna, attributing the Connecticut River population to the introductions described by Warfel (1936) and Babbitt (1937). Craig stated that "the possibility that mudpuppies had been present before the introductions is very unlikely, as intensive previous use of the river had not resulted in any discoveries."

Although I was unable to clarify the origin of the Connecticut River population, I determined that mudpuppies were present in the Connecticut River well before the introductions reported by Warfel (1936). A specimen (USNM 131851) was collected at Middletown (Middlesex Co.) in 1875. The Hartford Times reported that two fishermen caught a mudpuppy at Cromwell (Middlesex Co.) on March 31, 1922. On April 14, 1922 the Hartford Times reported that another mudpuppy was netted by an eel collector at Bissell's ferry in Windsor (Hartford Co.). On April 23, 1922 the Waterbury Herald reported that the Cromwell mudpuppy had been on exhibit in the window of Moore's fish market on Church Street in New Britain. The Waterbury Herald also reported that the Cromwell mudpuppy had been captured in a net with shad and alewives.

There are several recent records of mudpuppies from the Connecticut River. In 1954, a specimen (UCS 1069) was collected in an eel pot at Windsor. In 1956, a specimen (UCS 1071) was collected by hook and line at East Windsor (Hartford Co.). The Hartford Courant (July 24, 1983) reported that two mudpuppies were captured in mid April (1983) just above the Enfield dam

(Hartford Co.). This newspaper article was accompanied by a photograph of one the mudpuppies which had been mounted by a taxidermist!

Although well documented from the Connecticut River, the status of Necturus in the Housatonic River needs to be investigated. Babbitt (1937) gave a vague report, previously quoted, from the Shepaug River. The renowned popular nature writer, Hal Borland, lived beside the Housatonic River at Salisbury (Litchfield Co.). In his Book of Days, which chronicled natural events at his home, Borland wrote (1976:142) "Once in a while too, I find a salamander down along the river, and now and then I hook one when I am fishing in a shallow, murky cove. This fellow is called a mud puppy." I have unconfirmed reports of Necturus from Lake Garfield (Berkshire Co., MA). Lake Garfield drains into the Konkapot River which joins the Housatonic River at Ashley Falls (MA), just north of the Connecticut state line. Neither Babbitt nor Borland's statements, or the undocumented Lake Garfield report, are detailed enough to merit adding the Housatonic River to the range of Necturus.

In Massachusetts, D. Smith (pers. comm.) reported "we have many specimens of mudpuppy from the Connecticut River." Warfel (1936) reported them from Northampton, Hadley, South Hadley, South Hadley Falls, and North Hadley (Hampshire Co.). In Rhode Island, Vinegar and Friedman (1967) reported an introduced population of Necturus at the Scituate Reservoir (Providence Co.). In southeastern New York, Bishop (1941:35-36) reported Necturus from the Hudson River at Albany (Albany Co.), Kingston (Ulster Co.), and Poughkeepsie (Dutchess Co.). He considered these specimens representative of populations that had become established during the early nineteenth century.

LIFE HISTORY AND ECOLOGY:

I did not collect any field data on Necturus, therefore I have drawn heavily upon Bishop (1941) as well as other authors for the following life history information. Bishop (1941:33) found mudpuppies under the most "diverse conditions" including deep, clear cold water as well as muddy and weed choked streams, backwaters, polluted canals, stagnant reservoirs, and drainage ditches.

Hecht and Walters (1955) reported that mudpuppies were most active during the winter, as 90% of the adults they examined in museums were collected between December and April. The Connecticut specimens reported by various newspapers were collected between March 31 and mid April. However, the four specimens from East Hartford and Windsor (Babbitt, 1937) were collected between September and mid October while the two Simsbury specimens (Babbitt, 1932) were collected in June.

In western New York, Bishop (1941:22) reported that the male seeks out and mates with the female. During September and October, he found males with enlarged testes and swollen cloacal glands gathered with females under cover on the bottom of streams and ponds. He observed mated females with spermatophores in their vents on October 14 in Salmon Creek (Monroe Co., NY). The eggs are deposited the following summer in nests excavated under stones, planks, and other debris to which the eggs are singly attached. Clutch size varies from as few as 18 to well over 100 (Bishop, 1941:25). Bishop (1941:27) reported finding freshly laid eggs as early as May 12 and as late as June 11. The dates of egg laying and their subsequent incubation periods are dependent upon water temperature, therefore considerable variation may be expected between habitats, and from year to year in the same area. Bishop (1941:27) reported an incubation period as short as 38 days in a shallow, warm creek, but generally found incubation to take close to two months. Bishop (1941:31) found that sexual maturity is usually attained in their sixth year, at a length of 200 mm.

Bishop (1941:32-33) listed fish, fish eggs, crayfish, aquatic insects and insect larvae, mollusks, snails, worms, leeches, spiders, sowbugs, as well as plant material as food items. He reported four species of salamanders were eaten: Desmognathus fuscus, Eurycea bislineata, and Notophthalmus viridescens, and eggs of Necturus maculosus. Lagler and Goellner (1941) examined the stomach contents of 105 mudpuppies collected between April 27-28 at Evans Lake in southern Michigan. They measured the volume as well as the frequency of seven food items. Insects made up 49.3% of the total volume and were found in 92.4% of the specimens. Earthworms ranked second, making up 20% of the total volume and occurring in 34.3% of the specimens. Fishes, crustaceans, and snails were also important food items. Bones of a small, unidentified frog were found in one specimen. Two mudpuppies contained the remains of musk turtles, Sternotherus odoratus which consisted of a piece of hind leg skin and an entire 23 mm long turtle. Lagler and Goellner (1939) addressed the problem of whether mudpuppies posed a threat to sport fisheries. They concluded that although mudpuppies may compete with fish for food, they were not significant predators upon fish. They reported that the significance of mudpuppy-fish competition was dependent upon the abundance of food and that any analysis of their impact should take into account that young mudpuppies are eaten by fish. They concluded that large scale destruction of mudpuppies to control purported predation on fish was unwarranted.

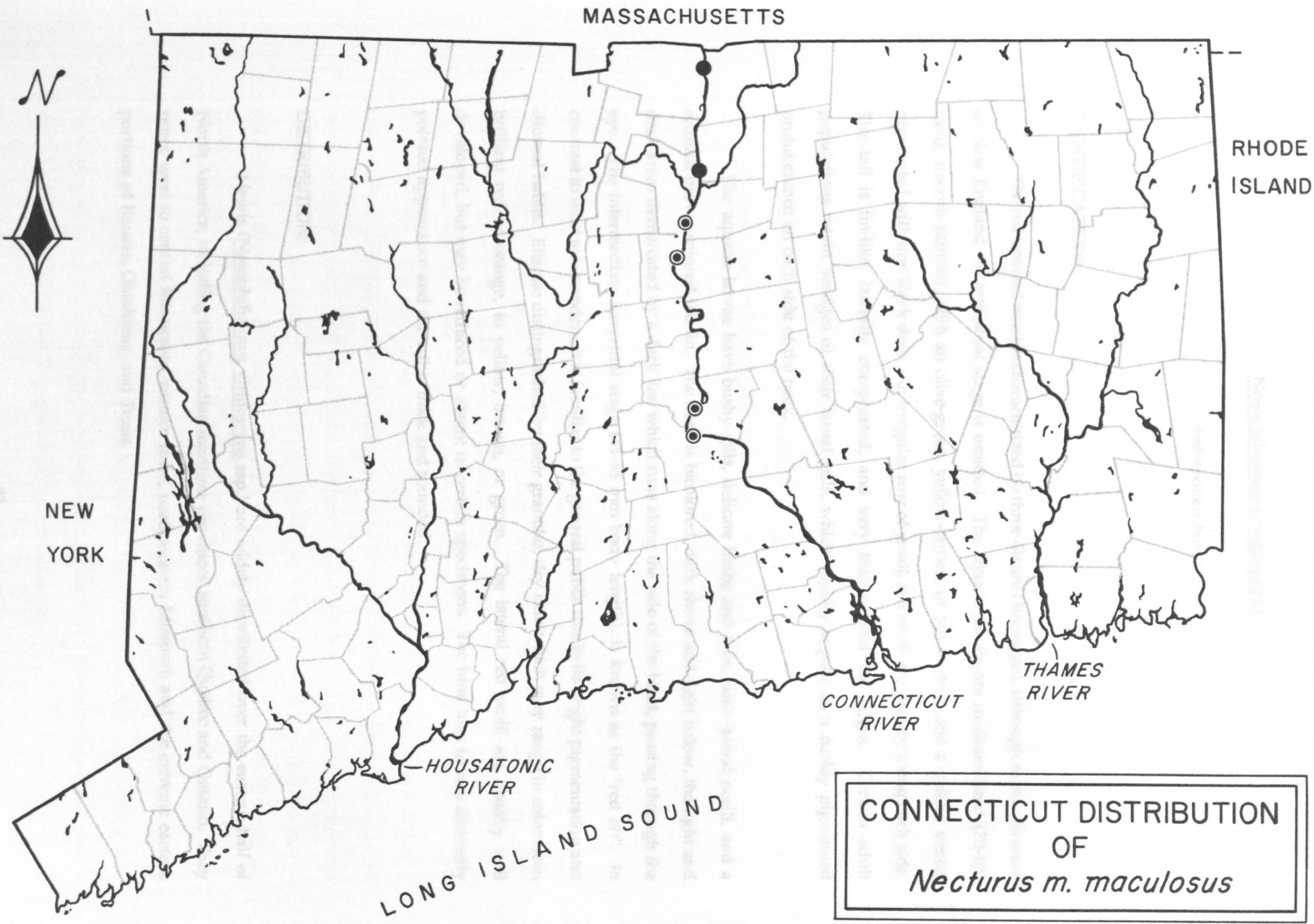
The mudpuppy is generally assumed to be introduced into southwestern New England. If this is the case, the only conservation concern need be its potential impact upon native species. However, additional survey work is required to determine the extent of its occurrence in southwestern New England, with the Housatonic drainage a top priority. One of Warfel's (1936) prime arguments for the introduction of Necturus was their presence in both the Hudson and Connecticut rivers coupled with their absence in the intervening Housatonic drainage. If mudpuppies are found in the Housatonic River, the entire question of their natural occurrence in southwestern New England would have to be reexamined. Biochemical techniques may be helpful in clarifying the relationships of Necturus in eastern New York and New England.

SPECIMENS EXAMINED

Connecticut

Hartford Co. (n=2): UCS 1069, 1071

Middlesex Co. (n=1): USNM 131851


N
MASSACHUSETTS
RHODE
ISLAND
NEW
YORK
HOUSATONIC
RIVER
CONNECTICUT
RIVER
THAMES
RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION
OF
Necturus m. maculosus

Notophthalmus v. viridescens

Red-spotted Newt

IDENTIFICATION:

The red-spotted newt is characterized by three distinct life stages, although in certain areas of New England the terrestrial stage is omitted. The aquatic adults are medium-sized (70-100 mm), smooth skinned, with an olive-green, yellow-brown, or tan dorsum and a yellow venter pigmented with fine black dots. An irregular row of small, red ocelli are present along each side. The tail is fin-like, laterally compressed, and very thin around the edges. Certain adult populations retain vestiges of their larval gills, which usually appear as a darkly pigmented protuberance on each side of the neck.

The aquatic larvae have bushy gills, delicate limbs and toes, faint lateral ocelli, and a reddish-brown colored tail fin. The head is bicolored, dark above and light below, the light and dark areas demarcated by a dark line which runs along the side of the head, passing through the eye. The intermediate terrestrial stage (35-85 mm body length), is known as the "red eft". In contrast to most salamanders, it is familiar to the general public due to its bright pigmentation and diurnal habits. Efts are distinguished by their granular, dry skin which may range in color from brilliant red or orange, to yellow, brown, or green. The lateral red ocelli are usually well developed, but may be reduced or absent in certain specimens. The hind toes have a distinctly pointed appearance and the tail is thick and rounded.

DISTRIBUTION:

Newts (Notophthalmus viridescens ssp.) are widely distributed over the eastern half of North America, including the Canadian maritime provinces, southern Quebec and Ontario. They range west to central Minnesota, eastern Iowa, northwestern Missouri, and the extreme eastern portions of Kansas, Oklahoma, and Texas.

Red-spotted newts, Notophthalmus v. viridescens, are widely distributed over southwestern New England. Although quite localized along the coast, they are ubiquitous in upland areas. In Connecticut, I found red-spotted newts abundant in the western part of the State, particularly Litchfield County. In the Central Connecticut Lowland, I found them with regularity on the chain of basalt ridges which run from New Haven into Massachusetts. They are scattered and localized in eastern Connecticut with most of my records from the upland areas of Tolland and Windham counties.

In Massachusetts, red-spotted newts are ubiquitous in the western uplands. They become increasingly localized in the central and eastern parts of the State. They occur on Cape Cod and Martha's Vineyard (Lazell, 1976). In Rhode Island, they are very localized and uncommon (Raithel, pers. comm.). To date, Raithel has not found red-spotted newts on any of the Narragansett Bay Islands, but in 1988 discovered a population on Block Island (AMNH 133508-09). In New York, they are widely distributed on the mainland and have been reported from both Long Island and Staten Island (Bishop, 1941:75-82).

LIFE HISTORY AND ECOLOGY:

I collected adult and larval red-spotted newts in a wide variety of aquatic habitats. Sunny, weed-choked, shallow, still or slow moving water were favored habitats. In such areas, large numbers of red-spotted newts were collected in a few sweeps of a dip net. Collection sites included meandering rivers, margins of reservoirs and lakes, impoundments, pasture ponds, marshes, beaver ponds and meadows, bogs, drainage ditches, as well as factory and mill ponds. Lower density populations of red-spotted newts were found in cool and shaded habitats such as vernal pools, permanent woodland ponds, fire ponds, wooded swamps, high gradient mountain brooks, and springs. Efts were collected in both deciduous and coniferous woodland as well as open canopy areas bordering woodland including pastures and meadows. Surficial soil conditions of eft habitats varied from dry and crumbly to muddy and waterlogged.

Between 1975-1986, I made 156 collections of Notophthalmus in Connecticut distributed as follows: February (1), March (9), April (16), May (36), June (32), July (18), August (15), September (22), and October (7). Noble (1926) collected active red-spotted newts at Greenwich (CT) on November 20 and Northampton (MA) on November 26.

Sexual dimorphism is marked during the breeding season with males distinguished by their enlarged tail fin and black, cornified areas on the inner surfaces of the hind limbs. I observed mating red-spotted newts on March 20 (CT:Sharon), April 10 (MA:New Salem), and May 3 (CT:Union). Raithel (pers. comm.) found a mating pair on April 19 at Little Compton (RI). Bishop (1941:64) found that egg laying near Albany (NY) commenced in the middle of April and continued through May. However, he stated (1941:62) that "the mating antics of the male may be continued at intervals throughout the winter but actual mating and egg laying begins in the spring." Bishop (1941:64) reported that the egg laying period is a long, drawn out process, with a small number of eggs being deposited each day. Females dissected by Bishop often contained several hundred eggs, however he found "little evidence to support the view that all may be deposited" in a single season. Bishop (1941:65) found eggs in the field on May 7. He stated that under natural conditions the incubation period extended from 20 to 35 days.

I collected larvae on June 14 (MA:Great Barrington), June 20 (RI:Westerly), June 21 (MA:Egremont Plain), July 11 (CT:Redding), July 15 (CT:East Windsor), July 21 (NY:Pound Ridge), August 2 (MA:South Egremont), August 6 (MA:Becket), August 9 (CT:Pawcatuck), August 11 (NY:Hillsdale), and September 5 (CT:Lisbon). I found newly metamorphosed red-spotted newts (=efts) on September 19 (CT:Windsor) and October 1 (MA:Holyoke). Dunn (1930) found metamorphs leaving a pond at Mount Toby (MA) on September 23. Bishop's (1941:68) earliest date of transformation was August 17 and he reported transformation occurring as late as September 15. Hurlbert (1970) found that post-larval migrations of young Notophthalmus (28-47 mm) occurred from July through November near Ithaca (NY).

Efts were collected more frequently than the other life stages of Notophthalmus. Between 1975-1986, I made a total of 156 collections from Connecticut, of which 5 were larvae, 66 aquatic adults, and 85 terrestrial efts. Efts were active during the daytime as well as at night. Cool, damp, rainy, or overcast weather stimulated eft activity. During the daytime, they moved boldly across the forest floor with little fear of predation due to the toxicity of their bright red skin. Huheey and Brandon (1974) gave a detailed discussion of the bright red warning coloration exhibited by terrestrial stage Notophthalmus. They reported that Notophthalmus viridescens served as a model for two Batesian mimics, the red salamander (Pseudotriton ruber) and the mud salamander (Pseudotriton montanus).

I noted that efts from upland areas were brilliantly colored red or orange while those from lowland and sandy areas were dull orange, yellow, or dark carmine. Bishop (1941:59) reported that efts from Long Island were not as vividly pigmented as those from cooler, damper areas. Huheey and Brandon (1974) hypothesized that the bright coloration of upland populations evolved in response to cool, montane conditions which favored dense, terrestrial populations of Notophthalmus. In such populations bright warning coloration would be adaptive. However, in coastal plain habitats not conducive to terrestrial behavior, Notophthalmus exhibited reduced eft population densities, minimized the duration of the eft stage, and adopted cryptic coloration and behavior.

I noted that efts occurred in several size classes and that when mature, they turned yellow and green prior to returning to the water. Bishop (1941:57-59) noted changes in coloration with the onset of maturity as well as variation in the length of the terrestrial period within and between populations. He reported that efts returned to the water at the end of their second or third year on land. In contrast, Healy (1974) reported that efts found at inland sites in Massachusetts remained on land from three to as long as seven years.

However, in coastal plain areas of New England and New York, the life history strategies of Notophthalmus are quite variable. On Cape Cod and Long Island red-spotted newts exhibiting various degrees of neoteny have been collected. In certain populations the eft stage is skipped, while in others the aquatic adult stage is eliminated, with reproduction being carried out by the terrestrial efts who migrate to breeding ponds in a manner similar to Ambystoma. Detailed discussions of this problem can be found in Noble (1926, 1929a), Healy (1970, 1973, 1974), and Lazell (1976). In summary, there is considerable variation in the life history strategies of red-spotted newts on the coastal plain, which may be an adaptation to the harsh conditions found in these areas including salt spray, frequent drying of ponds, and limited terrestrial habitat. Neoteny would enable red-spotted newts to utilize deep, salt free ponds without having to move out onto potentially inhospitable terrain for their eft stage. Conversely, the ability to live on land as an adult would be adaptive in areas where freshwater ponds regularly dry up or become saline due to a seasonally lowered water table.

Bishop (1941:70-71) cited various sources on the food habits of Notophthalmus. Adults feed on worms, insects, insect larvae, small amphibians, leeches, small crustaceans, mollusks, small fish, and amphibian eggs. Efts feed on insects, spiders, mites, worms, and mollusks while larvae feed on Entomostraca, small worms, insect larvae, and minute mollusks. Morgan and Grierson (1932) found adult red-spotted newts fed throughout the winter in Massachusetts. Matheson and Hinman (1929) reported that red-spotted newts were beneficial because they consumed mosquito larvae.

Notophthalmus is secure in southwestern New England, where it occurs in a wide variety of habitats, both pristine as well as disturbed. They are found in state parks, forests, county parks, private sanctuaries, as well as on private land. The only conservation concerns may be some of the geographically isolated and/or neotenic populations found on the coastal plain. For example, although there are several hundred freshwater ponds on Block Island, Notophthalmus has been found in just one of them. I consider these populations quite important in terms of regional biodiversity and suggest that these sites be monitored to ensure they are not damaged by changing land usages.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=50): AMNH 17063-65, 17857-68, 70369, 72563-64, 107606-09, 108091-93, 114171-72, 114174-75, 116036-43, 117922-23, 125231-36, 128791-94, 133444

Hartford Co. (n=29): AMNH 107610-11, 116044, 117924, 121520, 125237-44, 128795-805, 131718, 131777-80

Litchfield Co. (n=86): AMNH 99312-44, 108094-108, 114176-80, 114793-94, 116045-49, 117925-31, 121521-32, 125245-50, 131781

Middlesex Co. (n=4): AMNH 114181-82, 116050-51

New Haven Co. (n=18): AMNH 107612-13, 114183, 117932, 121533-36, 125251-58, 128806-07

New London Co. (n=12): AMNH 108109, 114184, 117933-34, 121537-40, 128808, 131719-20, 131782

Tolland Co. (n=5): AMNH 108110-13, 128809

Windham Co. (n=10): AMNH 117935, 121541-46, 125259, 128810; AMNH-FS 9958

Massachusetts

Berkshire Co. (n=72): AMNH 3878, 13950, 121732-41, 125421-37, 128926-28, 132015-46, 132410-17

Franklin Co. (n=36): AMNH 103736-38, 116434, 125438-49, 132418-27, 133219-28

Hampden Co. (n=38): AMNH 125450-59, 132047-53, 132428-48

Hampshire Co. (n=6): AMNH 78411, 125460-62, 132449-50

Rhode Island

Kent Co. (n=18): AMNH 132540-51, 133323-27, 133504

Providence Co. (n=6): AMNH 133330-34, 133507

Washington Co. (n=17): AMNH 125079, 133335-39, 133508-18

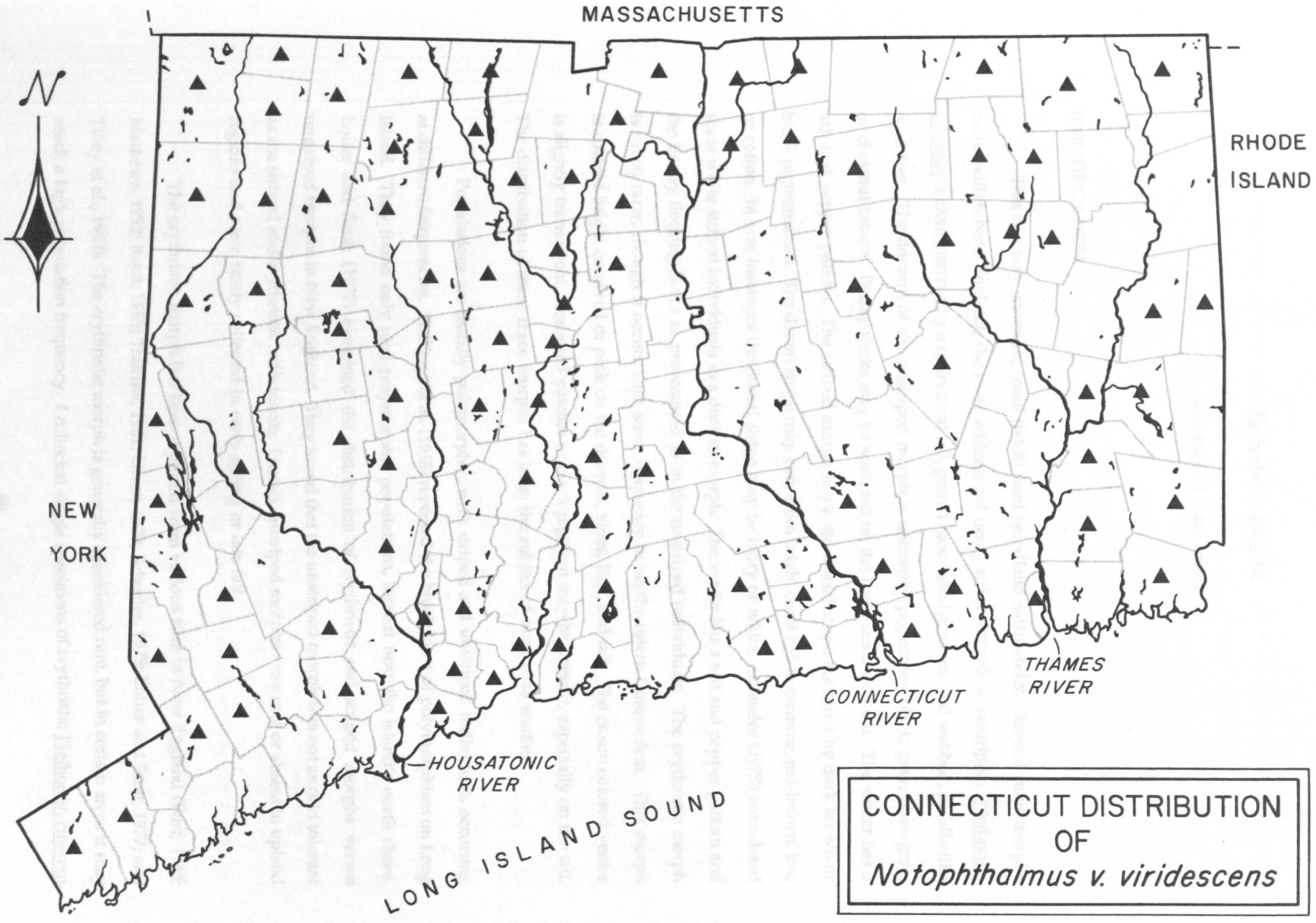
New York

Columbia Co. (n=4): AMNH 125564-65, 130145, 132702

Dutchess Co. (n=34): AMNH 118060, 121833-34, 132835-65

Putnam Co. (n=6): AMNH 121835-40

Westchester Co. (n=12): AMNH 125571-79, 130196-98


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
HOUSATONIC RIVER
CONNECTICUT RIVER
THAMES RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION
OF
Notophthalmus v. viridescens

Plethodon c. cinereus

Red-backed Salamander

IDENTIFICATION:

This is a very common, small (60-90 mm) woodland salamander. Several color morphs occur within New England, the most widespread being either striped or unstriped. Plethodon cinereus is characterized by a cylindrical tail, paired naso-labial grooves, and webbed, paddle-like hind feet. The dorsum of the unstriped morph is uniformly pigmented black, gray, olive-gray, or chestnut-brown. Brassy flecks may be scattered on the back, sides, and tail. The venter has a salt and pepper pattern. The striped morph has a red dorsal stripe bordered by dark brown or black pigmentation. The dorsal stripe may vary from bright coral red to carmine, red-brown, tan, or coffee. In rare instances the dorsal stripe may be ivory or white. Schueler (1975) considered these white striped individuals as a distinct morph. The venter has a salt and pepper pattern and the brassy flecking is not as pronounced as in the unstriped individuals. The erythristic morph is much rarer, though it occurs with some frequency in northwestern Connecticut. This morph is colored bright coral red or pink on the dorsum, sides, legs, and tail. The cream colored venter is slightly translucent. Scattered patches of black pigment may be present, especially on the tail. The distribution of these three morphs has been the subject of numerous studies.

Populations are usually polymorphic, with striped and unstriped individuals occurring at different frequencies. Williams et al. (1968) reported the breakdown of polymorphism on Long Island. They found only nine polymorphic populations, located near the island's north shore. Lotter and Scott (1977) examined the distribution of erythristic and striped morphs versus unstriped morphs in New England. They found that the unstriped morph was not as cold tolerant as the striped and erythristic individuals. I noted unstriped morphs were rare or absent in upland regions and were rarely collected in early spring or late fall.

The erythristic morph has been reported from various sites in New England (Burt, 1945; Mathews, 1952; Reed, 1955; Thurow, 1961; Greer, 1973; Schueler, 1975; Lotter and Scott, 1977; and Tilley et al., 1982). The erythristic morph is generally considered rare, but in certain areas it may reach a high population frequency. I collected single specimens of erythristic Plethodon cinereus at the following sites: Connecticut (Hartland, AMNH 121500), Massachusetts (Richmond, AMNH 121716; Dighton, AMNH 125408), New Hampshire (Alstead, AMNH 125641), and Rhode Island (Little Compton, AMNH 132533). I found erythristic Plethodon cinereus with frequency at several sites in two contiguous towns in northwestern Connecticut (Colebrook and Winchester). Mathews (1952) found that erythristic salamanders comprised 22.9% of the Plethodon population at North Colebrook and Reed (1955) found 14.7% of the Plethodon that he collected at Winchester's Highland Lake were erythristic.

Thurow (1961) attempted to correlate the distribution of the erythristic morph with glacial advances and retreats during substages of the Wisconsin epoch. He hypothesized that the erythristic morph became established in a small area of northwestern Connecticut, isolated by two long lakes formed by the retreat of the Cary glacier. He plotted reported localities of erythristic Plethodon in an east-west band, bounded on the north by the Mankato glacial maxima and the south by the Cary glacial maxima. Subsequent data has refuted his hypothesis that the erythristic morph is restricted to the area between the glacial maximae of the Cary and Mankato substages. I collected specimens considerably south of the Cary maxima at Dighton (MA) and Little Compton (RI) as did Lotter and Scott (1977) at Cohasset (MA), Scituate (MA), and Norton (MA). Tilley et al. (1982) found erythristic salamanders restricted to sites located between 41-47 degrees N latitude. All my collections of erythristic Plethodon fall into this latitudinal range. Brodie and Brodie (1980) considered this erythristic morph a Batesian mimic of the toxic, aposematic eft stage of the red-spotted newt, Notophthalmus v. viridescens. They found that free-ranging avian predators significantly avoided the erythristic morph while feeding upon the striped morph.

DISTRIBUTION:

Plethodon c. cinereus has a wide distribution over the northeastern United States and southern Canada. It extends south to northern and western North Carolina, extreme eastern Tennessee, and the Virginias. Further west, its range is bordered on the south by the Ohio River, extending to the Indiana-Illinois border. Around the Great Lakes it is found from Michigan to eastern Minnesota. Disjunct populations have been reported from southern North Carolina, Missouri, Illinois, and western Minnesota (Conant, 1975:Map 233).

In New England, Plethodon cinereus is the most widely distributed member of the herpetofauna. On the mainland, it is found wherever a small patch of woodland remains, from sea level to high elevations, from pristine natural areas to urban parks. It has been reported from the following Massachusetts islands: Nantucket, Martha's Vineyard, and the Elizabeth Islands (Lazell, 1976). In Rhode Island, I collected them on the three large Narragansett Bay Islands (Conanicut, Prudence, and Aquidneck) and Raithel has found them on Dutch Island. I was unable to find them either on Block Island (RI) or Chimon Island (CT).

LIFE HISTORY AND ECOLOGY:

I found Plethodon cinereus under cover in a wide variety of terrestrial habitats, usually in or near deciduous or coniferous woodland. Both mature forest and recent second growth were inhabited. Salamanders were also found under cover in open areas, but usually not far from a patch of woodland. Salamanders were also observed crossing roads at night during wet weather. Habitats varied considerably in amount of moisture, slope, canopy closure, and disturbance. Although no attempt was made to census populations, large numbers could be collected in a relatively short time. Burton and Likens (1975) reported that Plethodon cinereus comprised 93.5% of the salamander biomass in a New Hampshire forest. They found that the salamander biomass in their study area was two times as great as that of the avifauna and approximately equal to that of mice and shrews. Taub (1961) found that the surface litter is only a minor portion of the habitat of Plethodon cinereus since salamanders were distributed at least 12 inches below the ground surface.

Between 1975-1986, I made 244 collections of Plethodon cinereus in Connecticut as follows: March (11), April (47), May (49), June (30), July (18), August (19), September (44), October (22), November (2), and December (2). In southern Michigan, Blanchard (1928) found Plethodon cinereus active as early as March 25 and as late as December 9. In February, Hoff (1977) collected 87 Plethodon cinereus located 30-36 inches below the ground surface in the roots of decaying tree stumps in Plymouth County (MA). Plethodon cinereus lays its eggs on land. These hatch into fully developed juveniles which are exact replicas of the adults. I observed young salamanders as well as eggs under rotten logs and in cavities below imbedded rocks. A salamander was observed brooding a clutch of eggs with well developed embryos on August 14 at Bridgewater

(CT). I found this nest under a flat stone which was lying in a hemlock grove. In Michigan, Test and Heatwole (1962) found nests beneath logs, stones, and inside decaying logs, as well as in tunnels dug by vertebrates and invertebrates.

In Maryland, Plethodon cinereus attained maturity after two years of growth (Sayler, 1966). Therefore, Maryland salamanders matured at the end of their third season, as they do in southern Michigan (Blanchard, 1928). Sayler (1966) reported that mating occurred from October through April, oviposition in June, and hatching by September. She found that it took two years for the eggs to develop within the female. In southern Michigan, Blanchard (1928) found ten females containing spermatophores between October 31 and December 9 and reported clutch sizes of between five and thirteen eggs. Highton and Savage (1961) found that embryos removed from the brooding female had less than one third the survival rate to hatching as those attended by the parent. In addition, incubated hatchlings averaged 6.6 mm longer than non-incubated young.

Burton (1976) found that New Hampshire Plethodon cinereus fed on primarily on mites and insects. Heatwole and Test (1961) examined the stomach contents of 317 wild caught specimens from Michigan and found two instances of cannibalism. I dissected Plethodon cinereus from the stomachs of Diadophis punctatus, Thamnophis sauritus, and Thamnophis sirtalis.

Plethodon cinereus is secure in southwestern New England, remaining common even in heavily developed areas. Wyman and Hawksley-Lescault (1987) reported that Plethodon cinereus favored soils of neutral pH. They found that salamanders were excluded from 27% of their study area in Delaware County (NY) due to low soil pH. Although lacking baseline pH data on forest soils, they questioned whether increasing acid precipitation over the last few decades may have accelerated the rate of soil acidification. In conclusion, they stated that "the influence of soil pH on salamander distribution might fundamentally change the forest floor decomposer food web of which P. cinereus is an upper-level consumer."

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=60): AMNH 13080-81, 71449-52+8, 72565+5, 83829, 107614-28, 108114-21, 114138-39, 116015-17, 117891-94, 125260-61, 128777-79, 133442-43

Hartford Co. (n=44): AMNH 107634-41, 108122-27, 114140, 116018-19, 117895-97, 121499-502, 125262-76, 128780-84

Litchfield Co. (n=30): AMNH 2673, 107629-33, 108128-36, 114141-46, 116020-23, 121503-04, 125277-79

Middlesex Co. (n=22): AMNH 107642-45, 114147-58, 116024-25, 121505-08

New Haven Co. (n=29): AMNH 107661-74, 108137-38, 114159-60, 116026-27, 117904-08, 121509-10, 125280-81

New London Co. (n=57): AMNH 107646-60, 108139-46, 114161-69, 116028-29, 117898-903, 121511-12, 125282-84, 128785-87, 131707-14, 131775

Tolland Co. (n=32): AMNH 107675-93, 108147-49, 114170, 116030-32, 117909-10, 121513-14, 131715-16

Windham Co. (n=18): AMNH 107694-96, 116033-34, 117911-16, 121515-19, 131717, 131776

Massachusetts

Berkshire Co. (n=43): AMNH 3876, 11402, 14410, 104810, 121709-31, 131980-89, 132366-71

Bristol Co. (n=2): AMNH 125407-08

Franklin Co. (n=22): AMNH 103732-35, 132372-84, 133229-33

Hampden Co. (n=33): AMNH 125409-19, 131990-2000, 132385-90; AMNH-MWK 7991-95

Hampshire Co. (n=3): AMNH 125420, 132391-92

New Hampshire

Cheshire Co. (n=3): 125639-41

Rhode Island

Kent Co. (n=11): AMNH 125047-50, 128590-91, 128701-02, 133349-50, 133521

Newport Co. (n=7): AMNH 132527-33

Providence Co. (n=9): AMNH 124610, 125070-71, 128594, 132649, 133357, 133527-29

Washington Co. (n=18): AMNH 115881-82, 124611-12, 125072-75, 125077-78, 128595-602

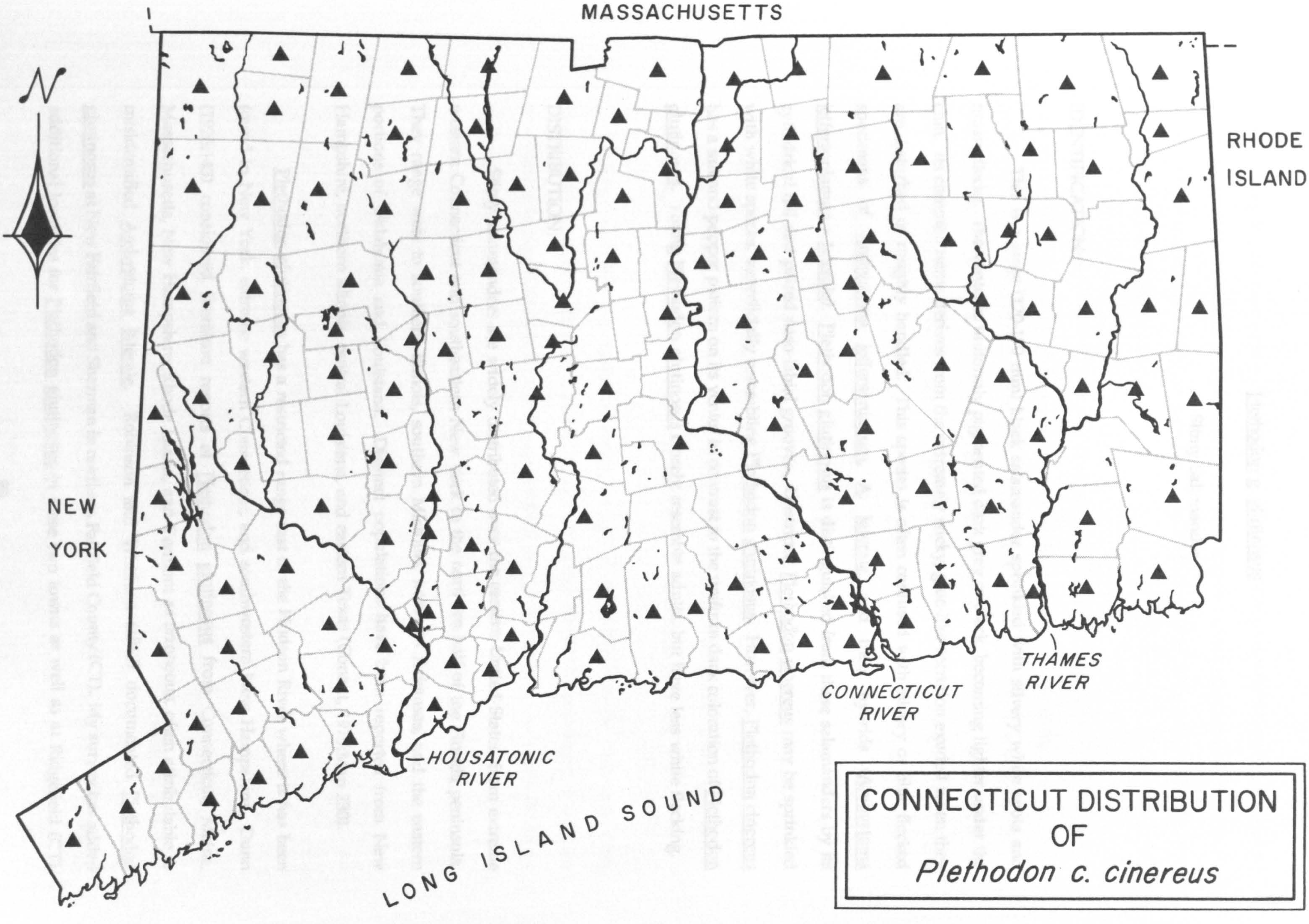
New York

Columbia Co. (n=2): AMNH 114726-27

Dutchess Co. (n=39): AMNH 108390-92, 115877-78, 116431-33, 116457-59, 132785-812

Putnam Co. (n=6): AMNH 133005-10

Westchester Co. (n=22): AMNH 108393, 118056-58, 125539-54, 127976-77



CONNECTICUT DISTRIBUTION OF *Plethodon c. cinereus*

Plethodon g. glutinosus

Slimy Salamander

IDENTIFICATION:

This is a large (120-170 mm) black salamander sprinkled with silvery white spots and brassy flecks. The venter is uniformly pigmented dark gray or black, becoming lighter under the chin. Its common name derives from the extremely sticky, glue-like secretion exuded when they are disturbed or roughly handled. This species is often confused with silvery or blue flecked specimens of Ambystoma jeffersonianum, A. laterale, and their hybrids (Ambystoma jeffersonianum x laterale). Plethodon glutinosus is distinguished from these salamanders by its cylindrical tail and paired naso-labial grooves. Unstriped Plethodon cinereus may be sprinkled with white specks, superficially resembling Plethodon glutinosus. However, Plethodon cinereus has a salt and pepper pattern on its venter in contrast to the uniform dark coloration of Plethodon glutinosus. Young Plethodon glutinosus closely resemble adults, but have less white flecking.

DISTRIBUTION:

Slimy salamanders are widely distributed over the eastern United States, from extreme western Connecticut and southeastern New York to the northern half of the Florida peninsula. They range west to southern Illinois, southern Missouri, northern Arkansas, and the eastern portions of Oklahoma and Louisiana. Disjunct populations have been reported from New Hampshire, northern Illinois, central Louisiana, and eastern Texas (Conant, 1975:Map 230).

Plethodon glutinosus has a restricted range east of the Hudson River where is has been found in New York, extreme western Connecticut, and southwestern New Hampshire. Dunn (1926:143) considered literature reports of Plethodon glutinosus from Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont as erroneous, often attributable to misidentified Ambystoma laterale. Robinson and Whitham (1960) documented Plethodon glutinosus at New Fairfield and Sherman in northern Fairfield County (CT). My survey has added additional localities for Plethodon glutinosus in these two towns as well as at Ridgefield (CT).

These sites are located in a band of rugged upland terrain which is part of the Hudson Highlands and Manhattan Prong which extends from New York into western Connecticut (Prucha et al., 1968). My six Connecticut collections were distributed as follows: 300-500 feet (1), 500-700 feet (1), 700-900 feet (3), and 900-1100 feet (1).

In New York, Deckert (1914) found Plethodon glutinosus "fairly abundant" in Westchester County and Bishop (1941:231) reported specimens from Fishkill and Wappinger Falls in southwestern Dutchess County. I found this species quite uncommon and localized east of the Hudson River in New York. The majority of my collections were either in or near the Hudson Valley as indicated by the following sites: Ossining and Peekskill (Westchester Co.), Wappinger, Hyde Park, and Red Hook (Dutchess Co.). This species becomes progressively rarer east of the Hudson Valley. In eastern Westchester County, I collected specimens at Lake Oscaleta near Ridgefield (CT) and received an unconfirmed report (Soltesz, pers. comm.) from Ward Pound Ridge Reservation. In Dutchess County, Kiviat collected a specimen at Clinton Hollow in Dutchess County and provided an unconfirmed report from Cat Rocks in Dover, within a few miles of the Connecticut state line. I have no records from either Putnam or Columbia counties, but anticipate that they occur at least in the western portions of these counties.

Highton (1963) reported two specimens (MCZ 36758-59) from southwestern New Hampshire collected by a Harvard University student in a ravine near Hubbard Pond, three miles northeast of Rindge (Cheshire Co.). Highton reported that these specimens extended the range of Plethodon glutinosus 90 miles east of Albany (NY) and 120 miles NE of the Connecticut sites previously mentioned. Although disjunct populations of Plethodon glutinosus have been mapped by Conant (1975:Map 230), the locality data accompanying MCZ 36758-59 may be suspect as no additional specimens have been found in southwestern New Hampshire.

LIFE HISTORY AND ECOLOGY:

This species appears to have very narrow habitat requirements at its range limit in eastern Westchester County (NY) and western Connecticut. At these sites, I found Plethodon glutinosus restricted to mature second growth deciduous or hemlock forest located on steep, often rocky slopes, covered with a thick duff layer and rotten logs. I noted a striking example of their ecological specialization in New Fairfield's Pootatuck State Forest. A small patch of mature forest was located on a steep, rocky, duff covered slope. This mature forest had not been logged for some time, possibly due to the rugged terrain. It was surrounded by much younger forest with a very thin duff layer. A nearby clear-cut area was in the process of reforestation, primarily from saplings growing up from the stumps of cut trees. Although Plethodon glutinosus was readily collected in the patch of mature forest, intensive searching of both the young forest and clear-cut area did not yield any specimens, although both Plethodon cinereus and Notophthalmus viridescens were found in all three habitats.

In the Hudson Valley, Plethodon glutinosus seems to have a wider habitat tolerance when compared with my Connecticut sites. I collected specimens under slabs of exposed, exfoliating graywacke (a shale-like, fragmental, sedimentary rock) along roadside banks at Hyde Park (NY). These microhabitats were often quite dry. Additional specimens were collected on graywacke talus slopes in young deciduous woodland at Wappinger (NY) and Hyde Park. These graywacke sites closely resemble Bishop's (1941:222) photograph of a shale bank Plethodon glutinosus habitat in western New York. I also collected specimens under debris in disturbed habitats at Hyde Park which included a powerline cut and a pile of construction debris at the edge of a field.

Although I collected all my Connecticut specimens in June, I found specimens active in New York on the following dates: April 5 (New Scotland, Albany Co.), April 15 (Wappinger, Dutchess Co.), and April 22 (Hyde Park, Dutchess Co.). I have no reproductive data on Plethodon glutinosus from southwestern New England. Highton (1962) compared this species' life history parameters at various parts of its range. He found that salamanders from Maryland and Pennsylvania (the closest sites he examined to New York) probably mate in both the autumn and spring. He reported that salamanders from the northern part of the range deposited eggs in late spring, therefore the first young would probably appear in late summer. Highton (1962) found that salamanders took five years to mature in the north (Maryland and Pennsylvania) compared to three years in the south (Florida) and that northern females bred only every second year. He also reported that salamanders in the northern portion of the range attained larger maximum adult sizes than their southern counterparts. Highton (1962) found the mean number of ovarian eggs in 23 gravid females collected near Centerville (Pennsylvania) was 16.7 (range 13-25), while the mean of ten specimens from Cunningham Falls State Park, (Maryland) was 26.1 (range 16-34).

Bishop (1941:221-222) cited various sources concerning food habits of Plethodon glutinosus which included earthworms, snails, slugs, sowbugs, spiders, centipedes, millipedes, as well as larval and adult insects. A Plethodon glutinosus was dissected from the stomach of a Thamnophis sirtalis which I collected in Virginia (Pulaski Co.).

Plethodon glutinosus is at its northeastern range limit in southwestern New England. The populations in Fairfield County (CT) and adjacent Westchester County (NY) appear tied to stable, mature forest ecosystems. Although much of their range in Connecticut lies within the Pootatuck State Forest, this does not ensure protection since state forests may be harvested for timber. Areas of the Pootatuck State Forest containing populations of Plethodon glutinosus should be declared natural areas with specific prohibitions against timber harvesting. Contiguous areas of young second growth forest should be included in these natural areas to serve as buffer zones. As these buffer zones mature, they may provide additional Plethodon glutinosus habitat, thereby increasing the potential carrying capacity for this species.

In the Hudson Valley, this salamander is more widespread, exploiting a variety of transitional and disturbed habitats. At Hyde Park (NY), it is protected on two National Historic Sites (Franklin and Eleanor Roosevelt). Additional survey work is urgently needed to determine the extent of this species range, its abundance, and its habitat requirements in southwestern New England.

SPECIMENS EXAMINED

Connecticut

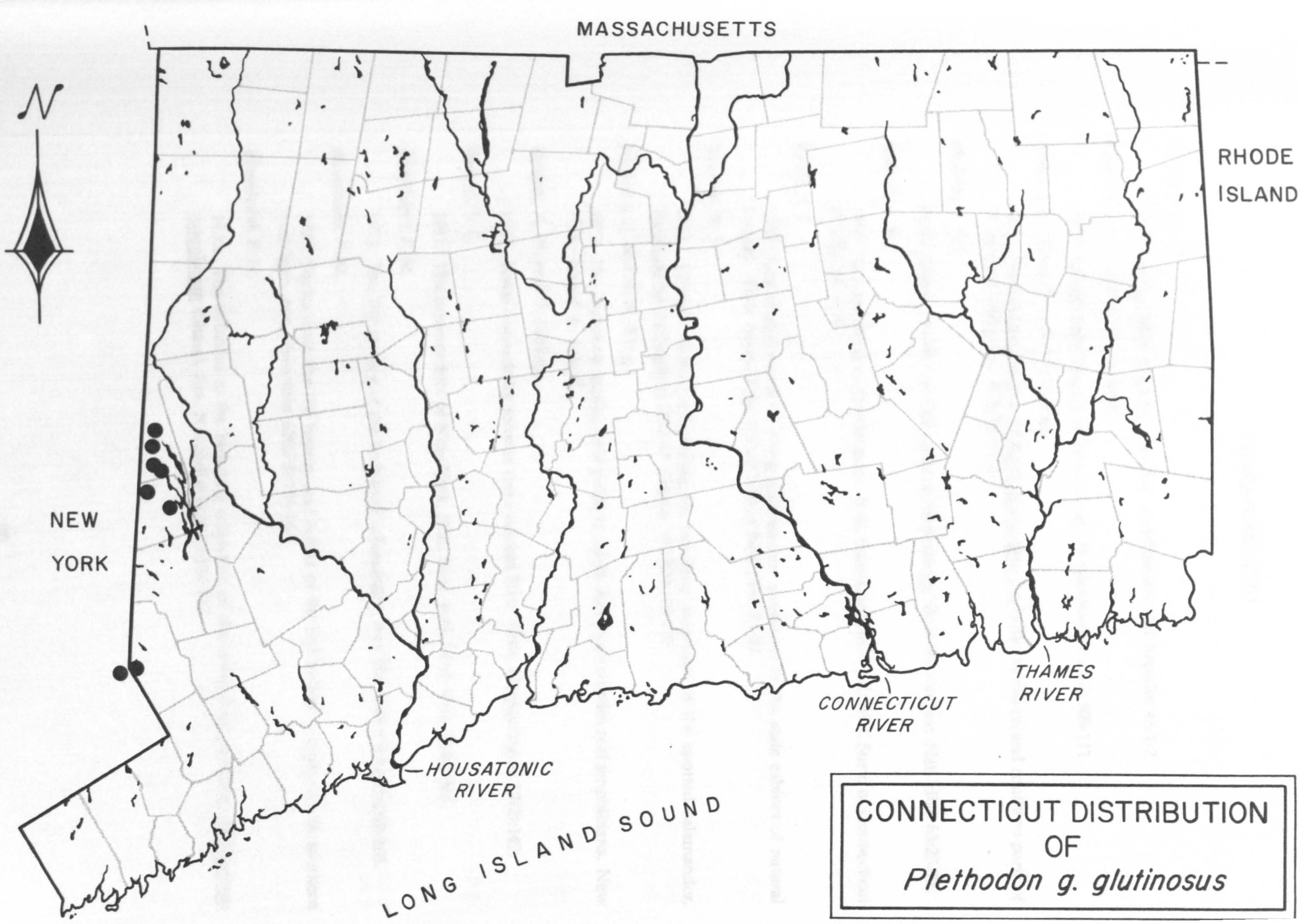
Fairfield Co. (n=14): AMNH 59216, 64468, 64625, 117917-21, 125285-86, 128788-90; UCS 8359

New York

Albany Co. (n=1): AMNH 132697

Dutchess Co. (n=24): AMNH 73562, 108356, 132813-34

Westchester Co. (n=9): AMNH 125555-62, 130199



CONNECTICUT DISTRIBUTION
OF
Plethodon g. glutinosus

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CHAPTER FOUR: ANURA

INTRODUCTION

Frogs are represented in southwestern New England by ten species in four families (Bufonidae, Hylidae, Pelobatidae, and Ranidae). These are individually treated in detail in the following chapter.

Three extralimital species, Acris crepitans, Pseudacris triseriata, and Rana septentrionalis were included in Babbitt's (1937) Amphibia of Connecticut. The inclusion of Rana septentrionalis is puzzling, as Babbitt stated "none are found in this State [Connecticut]" and "this frog is a strictly northern amphibian found in the cold regions even as far north as Hudson Bay, Canada". This species should be eliminated from the herpetofauna of southwestern New England.

Pseudacris triseriata was included in Connecticut's fauna based on a generalized range description contained in Dickerson (1906:158) who stated that it had been reported from every state, except northern New England, northern New York, Michigan, Arizona, California, Oregon and Washington. Pseudacris triseriata kalmi, the New Jersey chorus frog, is found on the coastal plain of Staten Island (NY) southward to the southern tip of the Delmarva Peninsula. It intergrades with the upland chorus frog, Pseudacris triseriata feriarum, in northern New Jersey and eastern Pennsylvania (Conant, 1975:328). The western chorus frog, Pseudacris t. triseriata, ranges from the Midwest eastward along the north and south sides of the Great Lakes into northern New York and extreme southern Quebec (Conant, 1975:Map 289). DesMeules and Fichtel (1988) reported Pseudacris triseriata from extreme northern Vermont on Lake Champlain's Alburg Peninsula, part of the Saint Lawrence River drainage which also includes the Great Lakes. This Vermont record is the only substantiated occurrence of this species in New England. The New England range of Pseudacris triseriata is limited to the Champlain lowlands of northwestern Vermont, therefore this species should be eliminated from southwestern New England's herpetofauna.

Acris crepitans, the cricket frog, was reported by Babbitt as occurring in Connecticut based on the following citation "Cope places its northern limit at New Haven, Conn." However, in his Batrachia of North America, Cope (1889:325) stated it ranged "as far northeastwardly as New

York". Dickerson (1906:154) wrote that "on the Atlantic coast it has not been reported north of southern New York and Connecticut". Cricket frogs have been documented from Long Island (NY) and the west side of the Hudson River. Presently, they are very rare in New York having disappeared from most (if not all) of Long Island, but still found upstate in Orange and Ulster counties. Their distribution parallels the southern leopard frog, (Rana utricularia), a coastal plain species with a northward range extension along the west side of the Hudson River. Porter (1967:52) provided the only report of this frog's occurrence within the southwestern New England biogeographic region as quoted: "In New York State the northern cricket frog is reputedly limited to Long Island. However, in April of 1963, while peeper hunting in Westchester County I heard the familiar clicking call, and spent the rest of the day trying to disprove my ears. After several hours of swamp wading I finally found a small colony of cricket frogs, which I was able to observe before they further proved their identity by zigzagging away. For the past three springs I have revisited the area to see whether these pioneers have been able to establish themselves in this outlying land. Although they were still there in the spring of 1966, I am not confident about their future, for the colony has apparently not increased." Based on Porter's report there is a remote possibility that Acris crepitans may have occurred in southwestern Connecticut. This frog appears intolerant of urbanization, therefore I would not expect it to still be present in this heavily populated region.

As a group, frogs are adapted to cool, mesic environments. Therefore, in marked contrast to reptiles, high elevations are not a major factor limiting their distribution. Noteworthy exceptions are two southern species, Fowler's toad (Bufo woodhousii fowleri) and spadefoot toad (Scaphiopus h. holbrooki), which dispersed northward to New England along the coastal plain, and subsequently inland via river valleys. I usually found these two species along the coast and within low lying river valleys. Although frogs are conspicuous in most aquatic habitats, continual loss of wetland habitats and pollution, especially acid rain, potentially threaten their survival. Heavy road mortality may have long term deleterious effects upon the population structure of some species.

Bufo a. americanus

American Toad

IDENTIFICATION:

This is a robust, chunky terrestrial frog usually between 50-90 mm long characterized by its dry, warty skin. The hind legs and tympanic region are often spinous and the white belly is mottled with black pigment. The dorsum is spotted varying shades of carmine, brown, yellow, or grey with one or two warts in each of the largest dorsal spots. Fowler's toad, (Bufo woodhousii fowleri), has a more variable dorsal pattern tending toward green and white markings, a distinct vertebral stripe, more than two warts in each of the largest dorsal spots, and an immaculate white belly. Hybrids between these toads occur in southwestern New England and are frequently difficult to identify. The diagnostic adult characteristics of Bufo americanus are poorly developed in juveniles making their identification difficult. Tadpoles of Bufo americanus are black with red and golden metallic flecking and a distinctly bicolored tail. They are not easily distinguishable from Fowler's toads.

DISTRIBUTION:

The american toad is widely distributed over the eastern half of North America, but absent from Florida and the coastal plain of the southeastern United States. Closely related subspecies occur in the Ozark region (Arkansas, southern Missouri, eastern Oklahoma) and in Canada, north to Hudson's Bay.

In southwestern New England this is an abundant, widespread species. I collected american toads from sea level to elevations over 2000 feet in the Berkshire Mountains (MA).

LIFE HISTORY AND ECOLOGY:

American toads utilize a wide variety of terrestrial habitats. I collected them at the edge of salt marshes, in dry deciduous woods, on powerline cuts, trails, and railroad beds, in sand and gravel pits, agricultural fields and barnyards, talus slopes and quarries, wooded swamps, wet meadows, as well as suburban and urban gardens. They occur in severely disturbed and scarified sites as well as stable, mature woodland.

I collected american toads from mid March through October. Between 1975-1986, I made 199 collections of Bufo americanus in Connecticut distributed as follows: March (4), April (25), May (51), June (43), July (23), August (24), September (24), and October (5). Bufo americanus were most active on rainy nights when large numbers (both living and dead) were observed on roads. Daytime activity was usually confined to mornings or late afternoons, although rainy, cool, or overcast weather resulted in activity throughout the day. Adult toads were usually collected foraging on the ground surface at night or buried under cover during the day. Juveniles were most frequently collected hopping about during the daytime.

American toads move to breeding sites during the first warm rains of spring in late March and early April. The males arrive at these wetlands prior to the females and begin their melodious trilling. Adult males are on average roughly half the size of adult females. During the breeding season the males's nuptial pads (patches of dark, rough skin on the front digits) are pronounced. These assist him in grasping the female during amplexus. Eggs are laid in thin strings wrapped around submerged vegetation and sticks.

I heard breeding choruses of american toads on the following dates: April 19 (CT:Greenwich), April 20 (NY:Pound Ridge), April 21 (CT:Bethel; NY:Southeast), April 22 (CT:Plainfield), April 24 (CT:Orange), April 29 (NY:Hyde Park), April 30 (RI:Quonochontaug; NY:Hyde Park), May 7 (NY:Hyde Park), May 12 (CT:Southbury), May 16 (NY:Washington), May 17 (MA:West Stockbridge), May 18 (CT:Ellington), and May 19 (MA:New Marlborough).

Toads were observed in amplexus on: April 19 (CT:Greenwich), April 20 (NY:Pound Ridge), April 30 (RI:Quonochontaug; NY:Hyde Park), May 1 (RI:Quonochontaug), May 12 (CT:Southbury), and May 24 (MA:Mount Washington). Wright and Wright (1949:142) reported american toads breeding from April 5 to July 25 with peak activity around April 30.

Bufo americanus utilized a wide variety of aquatic habitats for breeding including the backwaters of rivers and impoundments, flooded meadows, marshes, gravel pit ponds, water-filled ruts in dirt roads, and pasture ponds. At Quonochontaug (RI) I collected Bufo americanus in amplexus in a brackish tidal meadow. While dip netting toads I also collected sticklebacks, killifish, and small eels, all indicators of partially saline water. Kiviat and Stapleton (1983) observed mating toads in tidal creeks feeding into the lower Hudson River estuary at Iona Marsh (Rockland Co., NY).

Usually the breeding wetlands have an open canopy, which allows the water to receive a large amount of sunlight. The black Bufo tadpoles bask in the shallow, sunny water which raises their body temperature, increasing their metabolic rate and accelerating development. I observed eggs hatching on May 5 at Somers (CT) as well as large schools of Bufo tadpoles basking or feeding in shallow water at several localities.

I observed metamorphosing Bufo americanus on: June 10 (CT:West Haven), June 15 (MA:Sheffield), June 21 (CT:North Stonington), June 30 (CT:Cornwall), July 1 (CT:Weston), July 4 (CT:Joyceville), and August 11 (CT:Hartland). Wright and Wright (1949:143) reported Bufo americanus metamorphosing on June 8-12 at Ithaca (NY).

American toads eat many types of invertebrates. I observed this species eating ants and at Waterville Valley (NH) watched a large toad feasting upon dead insects falling below an electric bug "zapper". Gruner (pers. comm.) observed Bufo americanus feeding on moths and insects attracted to a house light at Andover (CT). Babbitt (1937) watched a Massachusetts toad eat 51 gypsy moth and tent caterpillars in an hour. He included butterflies, moths, and wasps as food items eaten by New England toads. Toads are extremely beneficial, consuming large quantities of injurious insects.

The enlarged paratoid glands and warty skin produce a noxious toxin which affords this species protection against many mammalian predators, although certain species are able to feed on toads. Groves (1980) reported mass predation of american toads by striped skunks (Mephitis mephitis), but the skunks did not consume the most toxic portions (dorsum and paratoid glands) of their prey. Schaaf and Garton (1970) reported raccoons feeding on american toads. I dissected Bufo americanus from the stomachs of three snake species, Heterodon platyrhinos, Nerodia s. sipedon, Thamnophis s. sirtalis. Toads are a key dietary item of Heterodon.

Thousands upon thousands of toads are killed on roads each year. The long term effects of sustained high road mortality upon the population structure of New England amphibians is unknown. In Europe, declines of Bufo bufo and other amphibians have been attributed to road mortality. Conservation action in the form of "toad tunnels" have been constructed at key crossing points to minimize these losses (Langton, 1989). Pesticides may kill toads and are especially injurious if applied on or near their breeding ponds. I received reliable reports of local extinctions of several species of frogs on Long Island following intensive DDT spraying to control mosquitoes.

Despite localized extinctions and high road mortality american toads are ubiquitous in southwestern New England found in parks, state forests, and private sanctuaries. Presently, they are secure within the region.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=24): AMNH 70351-53, 107697-704, 108150, 114185-91, 117936, 117951, 121547, 128811, 133445

Hartford Co. (n=30): AMNH 107713-16, 114192-93, 116052, 117937, 121548-55, 125287-95, 128812-14, 131783-84

Litchfield Co. (n=34): AMNH 107705-12, 108151-62, 114194-201, 116053-56, 121556, 131721

Middlesex Co. (n=28): AMNH 52867-68, 52870, 114202-06, 116057, 117938-39, 121557-63, 125296-300, 128815-18, 131785

New Haven Co. (n=20): AMNH 107722-24, 108163-64, 116058, 117940-41, 121564-68, 125301-06, 128819

New London Co. (n=20): AMNH 51527, 107717-21, 108165-66, 114207, 116059-60, 117942-44, 121569, 128820-22, 131722-23

Tolland Co. (n=17): AMNH 107725, 108167, 117945-47, 121570-71, 128823-27, 131724-25, 131786-88

Windham Co. (n=14): AMNH 107726-29, 116061, 117948-50, 121572-74, 131726-27, 132943

Massachusetts

Berkshire Co. (n=28): AMNH 115917, 121742-47, 125463-64, 128930-34, 132055-68

Franklin Co. (n=2): AMNH 103728, 132451

Hampden Co. (n=8): AMNH 132069-76

Rhode Island

Kent Co. (n=8): AMNH 124624-29, 124648, 125080

Providence Co. (n=6): AMNH 76128, 124647, 125084-87

Washington Co. (n=15): AMNH 118087-90, 124638-43, 124645-46, 125088, 128616, 132554

New York

Columbia Co. (n=3): AMNH 114728, 132703, 132866

Dutchess Co. (n=17): AMNH 108360, 116467-73, 132704, 132867-74

Putnam Co. (n=3): AMNH 118064, 121842-43

Westchester Co. (n=11): AMNH 108396-98, 118065, 125583-88, 130200

HYBRIDS

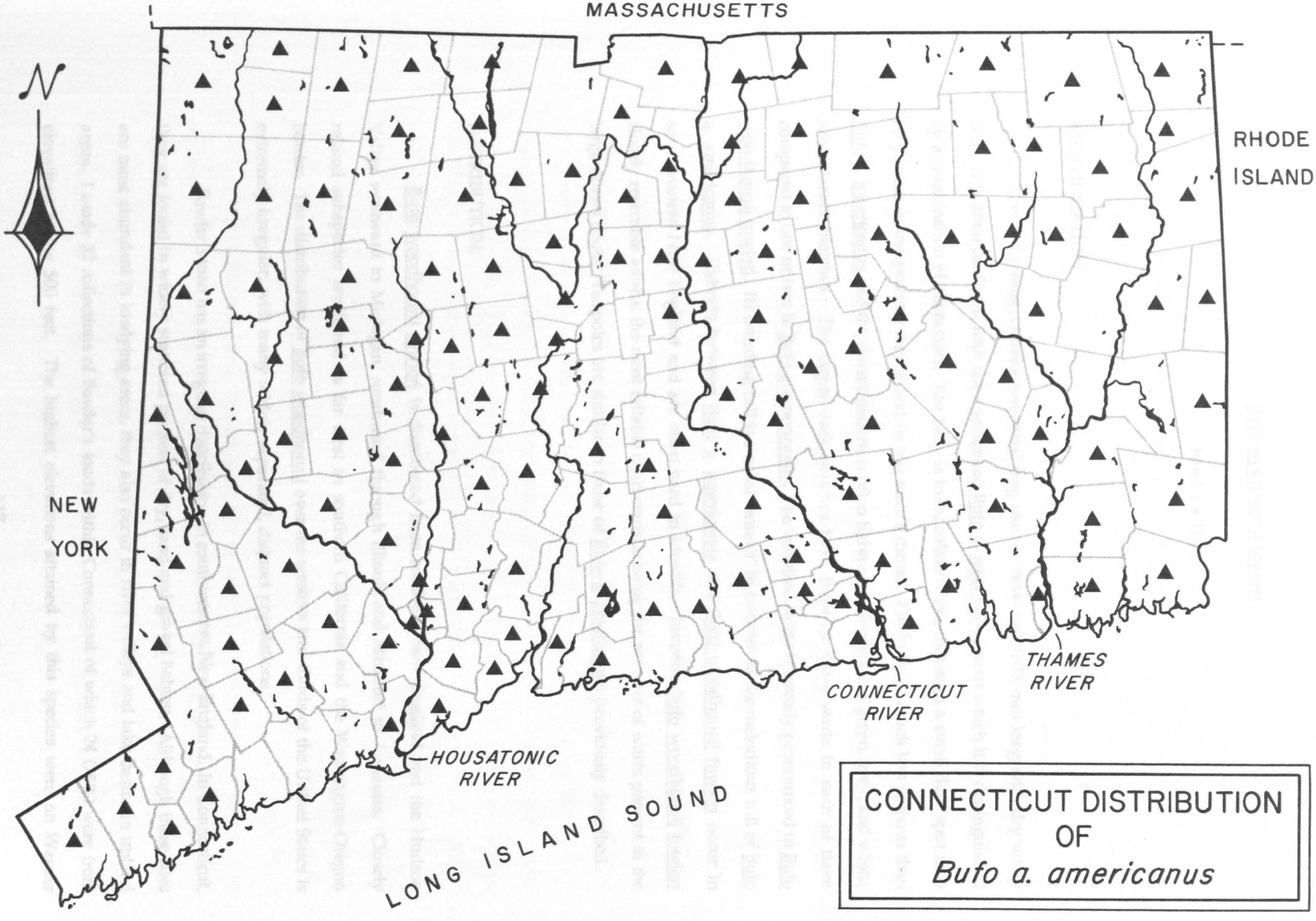
(Bufo a. americanus x woodhousii fowleri)

Connecticut

New Haven Co. (n=2): AMNH 114208-09

Tolland Co. (n=2): AMNH 117952-53

Windham Co. (n=2): AMNH 117954-55


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
THAMES RIVER
CONNECTICUT RIVER
HOUSATONIC RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION OF *Bufo a. americanus*

Bufo woodhousii fowleri

Fowler's Toad

IDENTIFICATION:

This is a robust, chunky terrestrial frog usually between 50-75 mm long with dry warty skin. It is often confused with the widespread Bufo a. americanus from which it is distinguished by a combination of characters. The belly is immaculate white, although a small dark spot may be present in the pectoral region and on the male's throat. The body is much less spinous than Bufo a. americanus and the dorsal pattern is often lighter tending toward green, grey, and white, with darker blotches. The larger dark blotches have three or more warts in each of them compared to one or two in Bufo a. americanus. The vertebral stripe is usually pronounced in Bufo woodhousii fowleri. Its breeding call is a nasal "waaah" in contrast to the melodious trill of Bufo a. americanus. Hybrids between Bufo a. americanus and Bufo woodhousii fowleri occur in southwestern New England and are often hard to identify. Juvenile Bufo woodhousii fowleri closely resemble adults, the most reliable characteristic being the number of warts present in the large dorsal spots. Tadpoles are similar to those of Bufo a. americanus previously described.

DISTRIBUTION:

Bufo woodhousii fowleri is distributed from southern New England and the Hudson Valley westward to Michigan, southward through Illinois and Missouri to Arkansas. Closely related subspecies are found as far west as southern California and the Washington-Oregon border. The distribution of Bufo woodhousii over the western two-thirds of the United States is extremely irregular, with many widely separated, disjunct populations.

Fowler's toad has an irregular distribution in southwestern New England. In Connecticut, they are found in widely scattered pockets of dry, sand and gravel habitat. Although these sites are most abundant in lowlying areas, they also occur in river valleys and lake basins in upland areas. I made 32 collections of Fowler's toads within Connecticut of which 24 (75%) were from elevations below 500 feet. The highest elevations attained by this species were on Wanzer

Mountain in Sherman where I found Bufo woodhousii fowleri on Pine Ledge (800-900 feet) and at the summit (1150 feet).

In Massachusetts, Fowler's toads are widely distributed along the coastal plain from southeastern New Hampshire through Cape Cod and its islands to Narragansett Bay (RI). Hoopes (1930) illustrated the distribution of Bufo woodhousii fowleri in New England. All but two of her records were from the coastal plain of eastern Massachusetts and Rhode Island. Fowler's toads are found in the sand and alluvium deposits of the Central Connecticut Lowland. Dunn (1930) considered them "not rare" in the vicinity of Northampton (Hampshire Co.) and Hoopes (1930) reported them from Chicopee (Hampden Co.) and Greenfield (Franklin Co.). Barker and Caduto (1984) reported Fowler's toads at White River Junction in the Connecticut River Valley of Vermont (the northward extension of the Central Connecticut Lowland of Massachusetts). Although not yet recorded from Berkshire County in western Massachusetts, I strongly suspect their presence in the extensive glacial sand and gravel deposits at Sheffield, as they occur in similar habitat a few miles south at Taconic (CT).

Raithel (pers. comm.) has found populations of Fowler's toads scattered throughout Rhode Island. In New York, they are the only species of Bufo native to Long Island. They have a restricted distribution on the New York mainland, primarily confined to the Hudson River Valley as far north as the Albany Pine Bush (Stewart and Rossi, 1981). I examined specimens from several sites in the Hudson River Valley of both Westchester and Dutchess counties. Inland, these toads are much rarer. I received reliable reports from Pound Ridge and Lewisboro in eastern Westchester County and examined specimens from Hopewell Junction in the central valley of Dutchess County. I have no reports from either Putnam or Columbia counties.

LIFE HISTORY AND ECOLOGY:

I found Fowler's toads utilizing a variety of habitats. These sites were always well drained and often quite xeric. Scarified, rocky, and poorly vegetated areas were inhabited as were dry, sandy deciduous woodland. When found sympatrically with Bufo a. americanus, the two species favored different microhabitats. For example, on Wanzer Mountain at Sherman (CT), I collected Fowler's toads on dry, sunny rock ledges while american toads were found in the adjacent moister, shady deciduous woodland.

I found Bufo woodhousii fowleri from May through September. They appeared to have a shorter annual activity season than most amphibians, including Bufo a. americanus. I made 32 collections of Fowler's toads within Connecticut distributed as follows: May (9) June (4), July (7), August (7), and September (5). Babbitt (1937) gave collection dates only from late May and June for Hartford County (CT) Bufo woodhousii fowleri. I found adults and juveniles actively moving about on the ground surface, often during hot and sunny weather. Adults were also collected at night foraging during warm rains.

Fowler's toads emerge from hibernation later and begin breeding several weeks after american toads (Hoopes, 1930; Babbitt, 1937; Wright and Wright, 1949:212). The presence of hybrids indicates their breeding seasons may overlap. Clarke (1974a) reported toads dormant for "at least seven months of the year" at New Haven (CT). He heard choruses of Fowler's toads from May 11 through June 30, although occasional calls were heard as late as August 17. He did not find Fowler's toads active prior to the commencement of calling by the males, which suggested they begin to breed upon emergence from hibernation. Babbitt (1937) reported breeding from May 15 through August in Connecticut.

In Massachusetts, near Northampton, Dunn (1930) found them still hibernating on May 6, one toad active on May 10, and calling on May 12. Harper (1928) reported breeding choruses on June 13 and June 22 at Natick (MA). Near Albany (NY) Wright and Wright (1949:212-13) reported males calling on May 13 through July 2.

Eggs resemble those of american toads but are sometimes laid in double strings. I observed metamorphosing Fowler's toads on July 12 at Wilton (CT). Wright and Wright (1949:213) reported metamorphosis on July 1-2 near Albany (NY). Clarke (1974b) found postmetamorphic growth of Fowler's toad at New Haven (CT) rapid with an average 6.58-fold length increase in the first year after metamorphosis. Clarke (1974c) examined the stomach contents of 108 juvenile and adult Fowler's toads from New Haven (CT) with ants and beetles comprising 81% of all the food items eaten.

Mortality factors for Fowler's toads are similar to american toads. Lazell (1972) attributed extinctions of this species on Nantucket (MA) to insecticides. Fowler's toad is secure in southwestern New England with the exception of the Hudson River Valley and adjacent areas of southeastern New York. In this area populations are few and scattered and may therefore be quite vulnerable to localized extinctions.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=25): AMNH 70356-57, 108168, 114212-14, 116062-63, 128828-30, 133446; UCS 5047-48, 5058-59, 5073, 5126, 5132-35, 5164, 5180, 5197

Hartford Co. (n=18): AMNH 107730, 108169, 116064-65, 121575, 131728; AMNH-MWK 7905-06; UCS 1010, 1012, 2161, 6412-15, 6517, 6537-38

Litchfield Co. (n=26): AMNH 44339; CMNH 19192 (6 specimens); TCWC 24690-93, 24699-703; UCS 3028, 3069, 3147, 3210, 4173, 4188-90, 4493; UIMNH 4716

Middlesex Co. (n=10): AMNH 52866, 52869, 107884-86, 116066-67; UCS 1022, 6478, 7090

New Haven Co. (n=20): AMNH 114210-11, 125307; SCSC 42-43; TCWC 24704-05; UCS 2162, 7139-47, 7423, 8379; YPM 4874

New London Co. (n=35): AMNH 51523, 107731-34, 116068-77, 121576-78, 130238-39, 131729-38, 131789-90; UCS 784-85, 7278

Tolland Co. (n=27): AMNH 107737, 108170; MVZ 141379-81; TCWC 24694-98; UCS 775-82, 1009, 1013-18, 1020, 5349, 5335, 5353, 6491-93

Windham Co. (n=22): AMNH 117956-70, 130236-37, 131791; AMNH-MWK 7831; UCS 783, 2165, 8378

Massachusetts

Hampden Co. (n=2): AMNH 128938, 132077

Hampshire Co. (n=1): AMNH 121748

Rhode Island

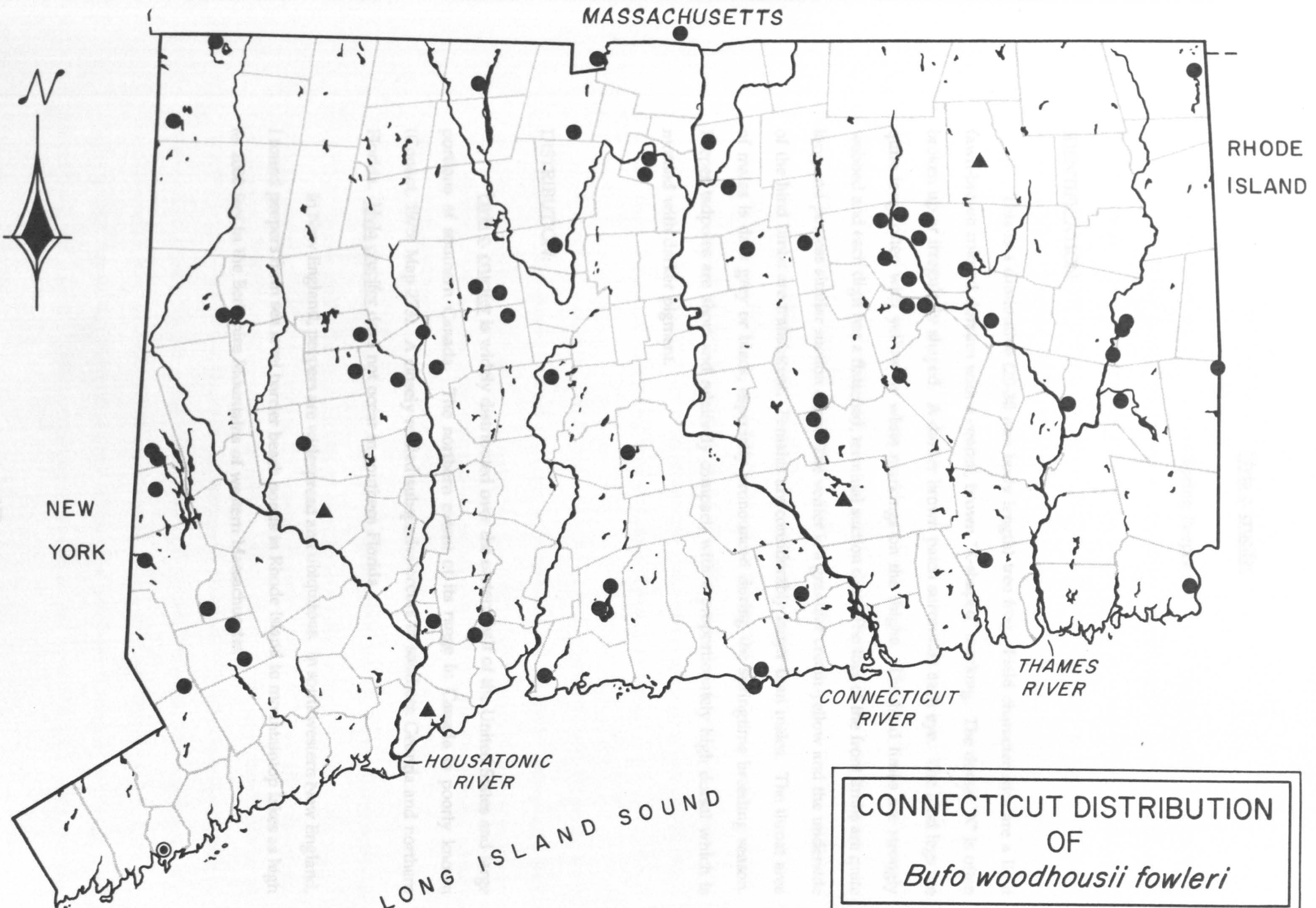
Kent Co. (n=11): AMNH 124650, 125089-98

Washington Co. (n=3): AMNH 124656-58

New York

Dutchess Co. (n=2): AMNH 14368, 71461

Westchester Co. (n=6): AMNH 945, 960-63, 18768



CONNECTICUT DISTRIBUTION OF *Bufo woodhousii fowleri*

Hyla c. crucifer

Spring Peeper

IDENTIFICATION:

This is a diminutive (20-30 mm body length) tree frog. Field characteristics are a light fawn-brown colored dorsum with a central, brown "X-shaped" marking. The dorsal "X" is often broken up or irregularly shaped. A darker brown patch surrounds each eye. The hind legs are quite long, often with yellow or white markings on the thighs. The hind limbs are strongly webbed and each digit has a flattened, terminal suction disc. The toes of the front limbs are quite long and possess similar suction discs. The venter is a granular cream-yellow and the underside of the hind limbs are translucent. Females are considerably larger than males. The throat area of males is dark grey or black, especially pronounced during the springtime breeding season. Peeper tadpoles are short and relatively compact, with a proportionately high dorsal which is mottled with darker pigment.

DISTRIBUTION:

Hyla c. crucifer is widely distributed over the eastern half of the United States and large portions of southern Canada. The northern extent of its range in Canada is poorly known (Conant, 1975: Map 273). A closely related subspecies occurs in southern Georgia and northern Florida. Hyla crucifer does not occur in southern Florida.

In New England, peepers are widespread and ubiquitous. In southwestern New England, I found peepers from sea level barrier beach ponds in Rhode Island to mountaintop lakes as high as 2000 feet in the Berkshire Mountains of western Massachusetts.

LIFE HISTORY AND ECOLOGY:

I found peepers in a wide range of habitats. Their preferred habitat was in and near moist deciduous woods but peepers were collected in coniferous forest, grassy meadows and fields, gardens, sandy coastal and pine barren habitats. Peepers tolerate a wide range of ecological disturbance and were found in mature second growth forests as well as highly disturbed urbanized areas. Peepers still occur within many of the Northeast's largest cities including New York.

My collections of peepers were bimodal with most records occurring in the early spring with a secondary, smaller peak in early autumn. Between 1975-1986 I made 118 collections of peepers in Connecticut as follows: March (26), April (38), May (15), June (6), July (7), August (6), September (14), and October (6). The large March-May collections were a function of breeding activity and the September collections resulted from increased activity coupled with the onset of cool, moist autumn weather. I found peepers active at night, on the ground or in low vegetation. Rain or high humidity increased nocturnal activity while wind or near freezing temperatures curtailed it. Daytime activity occurred in damp, shaded forest or when vegetation was moist from rain or dew. Cloudy, damp, and cool weather increased daytime activity.

Peepers are among the first amphibians to breed in southwestern New England. Their choruses have been likened to sleigh bells, but the individual's call is a harsh "peep-peep". They are often referred to as the "harbinger of spring" in New England and while most people recognize their choruses, few have actually seen the diminutive frog. In the autumn, I heard solitary peepers calling during the day in cool, damp weather.

I heard choruses or observed peepers in breeding pools on the following dates: March 17 (NY:Rye), March 20 (CT:Guilford), March 21 (CT:Danbury, Killingworth), March 23 (NY:Pound Ridge), March 24 (CT:Bozrah, Danbury; NY:Freedom Plains), March 25 (CT:Danbury, Wallingford; NY:Armonk; MA:Wilbraham), March 26 (MA:Holyoke), March 27 (MA:Egremont), March 28 (MA:Sheffield; NY:Hillsdale), March 29 (CT:Mansfield), March 30 (CT:Bethel; MA:South Hadley), March 31 (MA:Gill; NY:Clinton Hollow), April 1 (CT: Darien, Mansfield; NY:Stanford), April 2 (CT:Greenwich; MA:Egremont; NY:Travis Corners), April 4 (CT:Danbury), April 5 (CT:Somers, Wallingford), April 6 (CT:Ashford), April 7 (CT:Somers; MA:Great Barrington, Sheffield), April 9 (CT:Colebrook), April 10 (MA:New Salem; NY:Pound Ridge); April 12 (CT:Plainfield, Stafford;

MA:Monson; RI:Summit); April 13 (RI:Exeter); April 14 (RI:Coventry, Hopkinton), April 20 (NY:Pound Ridge); April 21 (CT:Bethel), April 22 (NY:Hyde Park); April 24 (NY:Hyde Park); April 28 (CT:Woodbridge); April 29 (NY:Hyde Park), April 30 (NY:Hyde Park; RI:Quonochontaug), May 6 (NY:Hyde Park), May 8 (CT:Windsor), May 12 (MA:Mount Everett), May 17 (MA:West Stockbridge; NY:Hyde Park), May 18 (NY:Hyde Park), May 19 (MA:New Marlborough), and May 24 (MA:Mount Washington). Babbitt (1937) reported that choruses (in Connecticut) "usually start in late February or early March if the weather is mild". Wright and Wright (1949:314) stated that "they breed from April 1 to June 15". My data indicate choruses commence in mid March and continue through the end of May.

Peepers were observed in amplexus on March 25 (NY:Armonk), April 4 (CT:Danbury), April 7 (MA:Great Barrington), April 10 (MA:New Salem), April 12 (RI:Summit), and May 23 (MA:Egremont). Wright and Wright (1949:314) observed a pair in amplexus of March 29 near Ithaca (NY), contradicting their previous statement of breeding "from April 1 to June 15" by several days.

Peepers utilize a wide range of aquatic habitats for breeding. I observed peepers breeding in woodland vernal pools, red maple wooded swamps, shrub swamps, swamps and marshes fringing lakes and reservoirs, wet meadows, fens, pasture ponds, bogs, quarry and sand pit ponds, brackish water lagoons behind barrier beaches, water filled ruts on dirt roads, and in flooded pastures. Their eggs are laid singly upon the bottom of the wetland or attached to vegetation.

I observed metamorphosing peepers on June 8 (CT:East Granby), July 12 (CT:Wilton), and August 10 (MA:Sheffield). Wright and Wright (1949:315) observed transforming peepers on July 14 and August 2 at Ithaca (NY).

Peepers feed on small invertebrates and are fed on by a wide variety of vertebrates. Large carnivorous aquatic invertebrates feed on their tadpoles and an occasional adult. Peepers are one of the most common frogs in southwestern New England and are secure, occurring in most wetlands surrounded by some type of forest.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=20): AMNH 107738, 108171-73, 114215-23, 116078-81, 117971, 128831, 133447

Hartford Co. (n=14): AMNH 107741-42, 108175, 114224-25, 116082, 125308-09, 128832-33, 131792-95

Litchfield Co. (n=12): AMNH 107739-40, 108176-79, 114226-29, 116083-84

Middlesex Co. (n=4): AMNH 114230, 117972, 121579-80

New Haven Co. (n=4): AMNH 114231-32, 117973-74

New London Co. (n=22): AMNH 107743-53, 116085, 121581, 128640-44, 128834-37

Tolland Co. (n=7): AMNH 117975-76, 121582-83, 128838, 131739-40

Windham Co. (n=4): AMNH 125310, 128839-40, 131741

Massachusetts

Berkshire Co. (n=36): AMNH 118076-84, 121749, 125465-79, 128942-43, 132078-86

Franklin Co. (n=2): AMNH 132452-53

Hampden Co. (n=11): AMNH 125480, 132087-93, 132454-56

Hampshire Co. (n=5): AMNH 84796-98, 125481-82

Rhode Island

Kent Co. (n=8): AMNH 125100, 132555-61

Washington Co. (n=18): 118091-96 125101-06, 128632-36, 128730

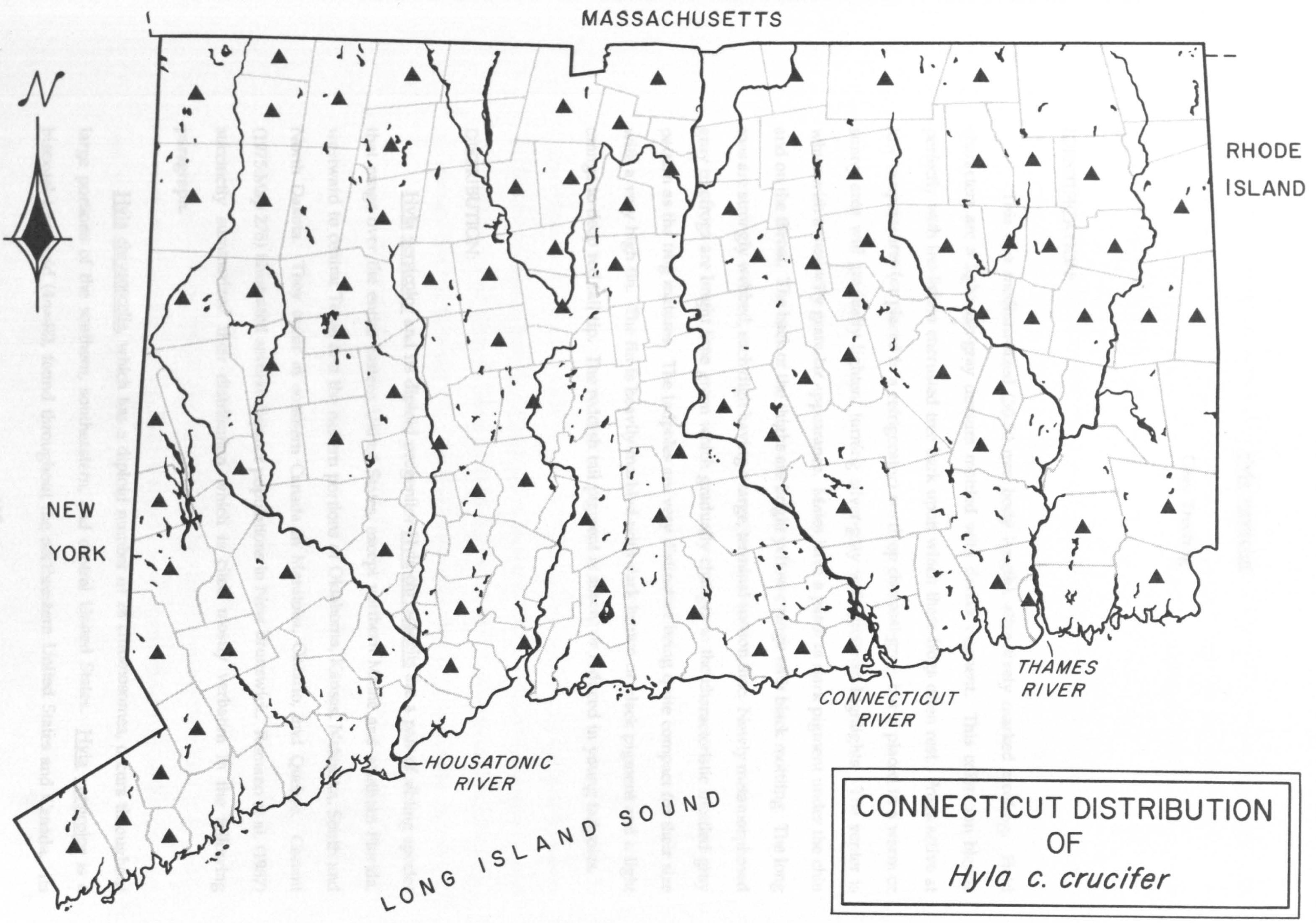
New York

Columbia Co. (n=9): AMNH 114729-37

Dutchess Co.(n=16): AMNH 116474, 129176-77, 132713-17, 132875-82

Putnam Co.(n=2): AMNH 121859-60

Westchester Co.(n=8): AMNH 108401-05, 125590, 129178-79



CONNECTICUT DISTRIBUTION OF *Hyla c. crucifer*

Hyla versicolor

Gray Treefrog

IDENTIFICATION:

This is a medium-sized (30-50 mm body length), attractively marked treefrog. Field characters are a light ash-gray dorsum mottled with darker pigment. This coloration blends perfectly with the lichen encrusted tree bark upon which these frogs often rest. Frogs active at low temperatures (or placed in a refrigerator) are deep charcoal-gray, but if placed in a warm or sunny area will gradually lighten, turning silver-gray with greenish highlights. The venter is white with a distinctly granular appearance. Males have a patch of dark pigment under the chin and on the throat. The back of the thighs are bright yellow-orange with black mottling. The long toes are strongly webbed, each digit having a large, terminal suction disc. Newly metamorphosed gray treefrogs are bright lime green which gradually changes to the characteristic mottled gray pattern as the frog matures. The tadpoles are very distinctive being quite compact for their size with a very high fin. The fin is heavily marbled with dark brown or black pigment and a light orange to deep red tail tip. The reddish tail pigment is absent or reduced in young tadpoles.

DISTRIBUTION:

Hyla versicolor and its diploid progenitor Hyla chrysoscelis are a pair of sibling species that range over the entire eastern United States, except northern Maine and southern Florida, westward to central Texas and the eastern portions of Oklahoma, Kansas, Nebraska, South and North Dakota. They occur in southern Canada in Manitoba, Ontario, and Quebec. Conant (1975:Map 278) illustrated several disjunct populations in New Brunswick. Romano et al. (1987) succinctly summarized their distribution which is cited mostly verbatim in the following paragraph.

Hyla chrysoscelis, which has a diploid number of 24 chromosomes, occurs throughout large portions of the southern, southeastern, and central United States. Hyla versicolor is a bisexual tetraploid (4n=48), found throughout the northeastern United States and Canada. Its range extends southward into eastern and central Texas and apparently divides Hyla chrysoscelis into western (central Texas north to Minnesota) and eastern populations. Although the two species are largely allopatric, numerous contact zones in a variety of habitats are broadly distributed throughout North America.

In southwestern New England, Hyla versicolor is widely distributed, but quite cryptic and rarely collected. I collected Hyla versicolor from near sea level to 1700 feet on Mount Washington in the Berkshire Mountains of western Massachusetts. They probably occur at even higher elevations if suitable habitat is present.

LIFE HISTORY AND ECOLOGY:

Gray treefrogs favor moist, deciduous woodland with pools of standing water for breeding. Shrub swamps are favored habitats with frogs often hiding in wet pockets formed at the branch axils of red maples. I collected gray treefrogs in sandy, xeric pine barren habitats at coastal and inland locations. They were active during early spring rains, but most prevalent in May and June. Between 1975-1986 I made 38 observations of Hyla versicolor in Connecticut as follows: March (1), May (13), June (11), July (9), August (3), September (1). On October 20 (1989), I collected two adults on a wet road near Liberty Hill (CT), thereby extending their activity season well into the autumn. Adult Hyla versicolor are nocturnal. The few found during the day were asleep, tightly pressed against a tree trunk or wedged into a crevice under loose bark, their large, conspicuous eyes tightly closed. Tadpoles and metamorphs were active during the daytime.

Gray treefrogs have a truncated breeding season compared to many amphibians in my study area. The paucity of specimens in my collections resulted from their annual terrestrial activities being primarily confined to a few wet nights in late May or early June. During the remainder of the activity season they were arboreal, effectively camouflaged by their cryptic coloration. Fortunately, males emitted their distinctive trilling call from the forest canopy throughout the warm, humid summer months. By carefully noting these calls and making concerted efforts to collect their distinctive tadpoles, I ascertained these frogs were much more widely distributed than indicated by my collections.

I heard breeding choruses or observed frogs at pools on: May 8 (CT:Windsor), May 23 (MA:Egremont), May 24 (MA:Mount Washington), May 25 (MA:Sheffield), May 27 (NY:Hyde Park), May 28 (CT:East Haddam, Salem), May 29 (MA:Sheffield), May 30 (CT:Voluntown), June 1 (CT:Canaan), June 12 (CT:Canaan), and June 13 (CT:Andover). Babbitt (1937) reported that breeding occurred in Connecticut from May 1 through July. Dunn (1930) reported frogs calling on May 12 followed by egg deposition on May 20 near Northampton (MA). Wright and Wright (1949:347) reported breeding choruses commencing on June 16 near Ithaca (NY). On June 19 they found a pair in amplexus and on June 21 found packets of 15-35 eggs attached to vegetation on the pond's surface, with some eggs already hatching.

I found Hyla versicolor utilizing a variety of sites for breeding. Shrub and red maple swamps were favorite sites, but tadpoles were collected in grassy pasture ponds, as well as disturbed sites such as quarry and sand pit ponds and wetlands surrounded by manicured lawns and housing developments. They even utilized abandoned swimming pools for breeding at North Canaan (CT) and Hyde Park (NY).

Although Wright and Wright (1949:347) reported tadpoles transforming from June 27 through August, I found tadpoles in pools as late as September 5 at Lisbon (CT). Although some of these were near metamorphosis, others had not begun to develop limbs. I found a metamorph on July 31 at Bethany (CT). On August 2 at Bridgehampton (Long Island, NY), I found Hyla versicolor in various developmental stages in and near a small pond. These included young tadpoles without red tails, mature tadpoles with bright red tails and limb buds, and newly metamorphosed froglets. These data indicated two distinct cohorts of young were present in this pond. Whether adults bred twice at this site, or different frogs bred at different times is an interesting question for future research.

Babbitt (1937) fed young specimens house flies, aphids, small crickets, moths, and termites. He listed moths, tree crickets, ants, flies, grasshoppers, and beetles as part of the adult diet. He found treefrogs frequenting apple orchards, apparently attracted by the wide variety of insects found on apple trees. These frogs serve as food for various vertebrates and tadpoles are preyed upon by aquatic invertebrates. Road mortality occurred but was usually minimal when compared to other amphibians.

Gray treefrogs have disappeared or greatly declined in areas that have been built up or severely polluted. Fifty years ago, Babbitt (1937) found them becoming scarce in western Hartford County (Simsbury, Bloomfield, and Canton), due to development accompanied by destruction of wetlands and natural vegetation. Although populations occur in many suburban areas, they are most numerous in rural sections. The present distribution of Hyla versicolor indicating widespread geographical occurrence may be misleading as the actual number of breeding sites (and individuals) is declining. Fortunately, documented breeding sites for these frogs occur on various protected land including federal, state, and county parks, state forests, and private sanctuaries.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=5): AMNH 114233-34, 116086-87, 131742

Hartford Co. (n=3): AMNH 116088-89, 131743

Litchfield Co. (n=6): AMNH 114235-36, 116090, 117977-79

Middlesex Co. (n=1): AMNH 121584

New Haven Co. (n=3): AMNH 117980, 125311-12

New London Co. (n=7): AMNH 131796-99, 132944; AMNH-MWK 7827, 7852

Tolland Co. (n=4): AMNH 128841, 131744-46

Windham Co. (n=5): AMNH-FS 9866-69; AMNH-MWK 7856

Massachusetts

Berkshire Co. (n=15): AMNH 128954-57, 132100-10

Hampden Co. (n=1): AMNH 132457

Rhode Island

Kent Co. (n=1): AMNH 124661

Washington Co. (n=5): AMNH 124662-65, 132562

New York

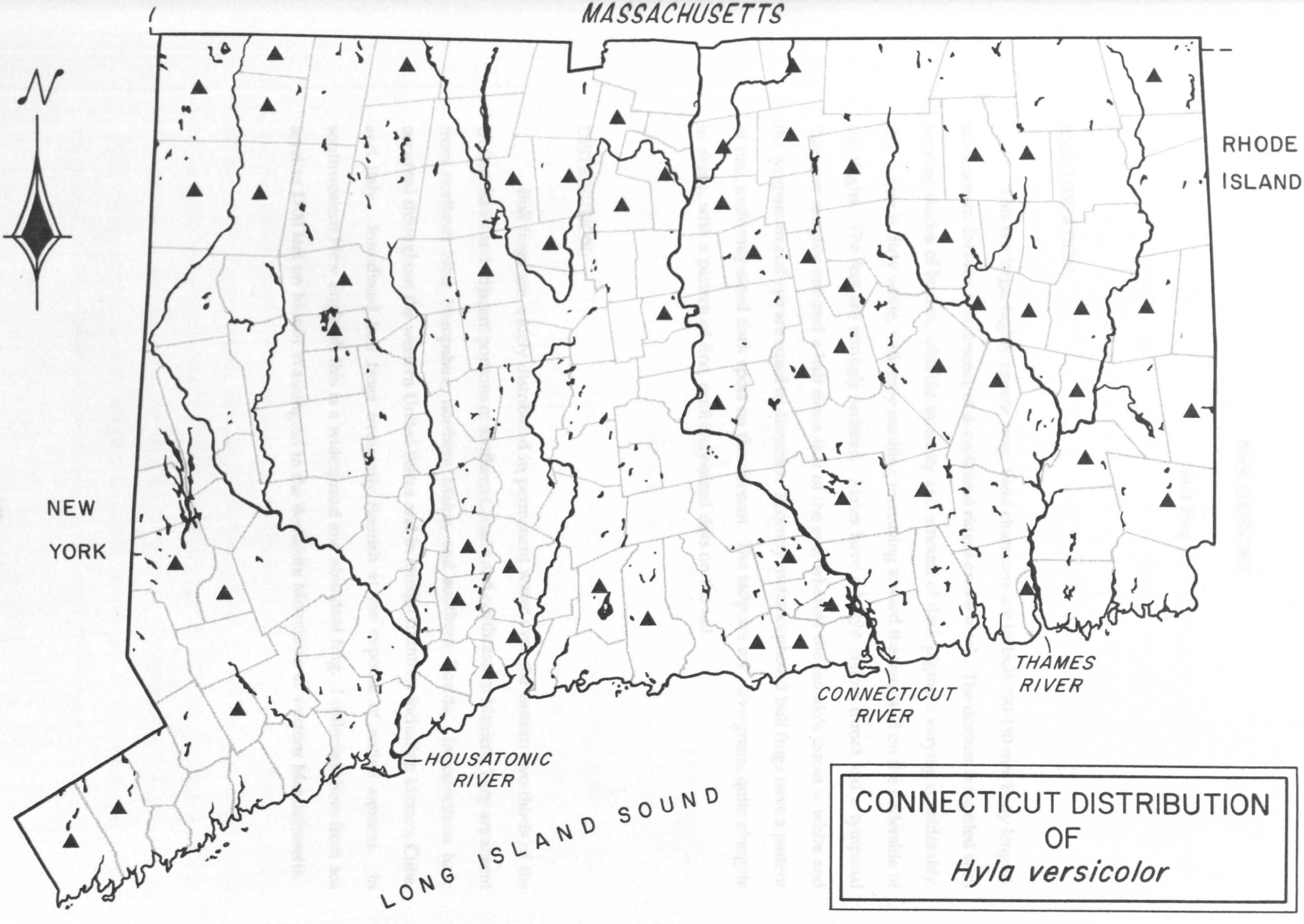
Columbia Co. (n=3): AMNH 92810-12

Dutchess Co. (n=17): AMNH 68430, 71463+4, 116477-80, 132883-89

Putnam Co. (n=2): AMNH 57659, 95730

New York: Long Island

Suffolk Co. (n=4): AMNH-MWK 7888-89, 7893-94


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
HOUSATONIC RIVER
CONNECTICUT RIVER
THAMES RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION OF *Hyla versicolor*

Rana catesbeiana

Bull Frog

IDENTIFICATION:

This is a large, highly aquatic frog. Field characters are its bulk (90-150 mm body length), olive-brown dorsum, and absence of dorsolateral ridges on the trunk. The dorsum is mottled with varying shades of brown, with the intensity and amount of dark pigment varying considerably. The venter is dirty white, with grey mottling increasing toward the vent and on the underside of the thighs. The feet are strongly webbed. Males have a bright yellow throat and a tympanal diameter roughly one and a half times that of the eye, whereas the female's throat is white and the tympanum and eye are equal in diameter. Recently metamorphosed bull frogs have a pattern of fine, uniformly-sized dark spots on the dorsum. The tadpoles are olive-green, quite elongate in shape, with a pattern of fine, uniformly-sized dots on the tail.

DISTRIBUTION:

Bull frogs are widely distributed in permanent water over the eastern two-thirds of the United States and adjacent portions of southern Canada and northeastern Mexico. They are absent from northern New Hampshire, northern Maine, and southern Florida. Introductions have occurred throughout the western United States and in foreign countries including Mexico, Cuba, and Italy. Introduced bull frogs frequently flourish at the expense of native anurans. In southwestern New England, this is a widespread and abundant frog. I collected them from sea level to 1700 feet on Mount Washington in the Berkshire Mountains of western Massachusetts.

LIFE HISTORY AND ECOLOGY:

Bull frogs utilized a wide variety of aquatic situations with populations occurring in most permanent water bodies. I collected them in lakes, ponds, reservoirs, rivers, stock ponds, marshes, woodland pools, floodplain swamps, bogs, factory and mill ponds, sand pit and quarry ponds, as well as golf course and ornamental ponds. A viable population is well established in New York City's Central Park.

Juveniles are more transient than adults, frequently moving between wetlands in rainy weather. In addition to the aforementioned habitats, juveniles were found in ephemeral and shallow water habitats (such as vernal pools and small, steep gradient brooks) generally shunned by adults. I collected a juvenile in salt marsh tidal ditch at Leetes Island in Guilford (CT).

I found bull frogs active from late March through October. Between 1975-1986 I made 175 collections in Connecticut as follows: March (1), April (9), May (46), June (34), July (27), August (21), September (26), and October (11). Dunn (1930) found them active near Northampton (MA) as early as April 11. These data differ markedly from Babbitt (1937) who reported Connecticut Rana catesbeiana come out of hibernation in late May.

Rana catesbeiana breeds from late May through early July. I heard their distinctive deep, hoarse breeding call on May 24 (CT:Wilton), May 31 (CT:New London), June 3 (CT:Greenwich), June 4 (CT:Colebrook), June 13 (NY:Millbrook), and July 4 (CT:Manchester). My data differ from Wright and Wright (1949:446) and Bury and Whelan (1984) who reported the New York breeding season from late June through late July. Large numbers of eggs are laid in mats which float upon the water's surface.

I found two distinct sizes of tadpoles present at most sites and overwintering tadpoles in many areas. These data point to a minimal two year larval period in southwestern New England. Tadpoles take two to three years to mature in New York (Wright and Wright, 1949:446; Bury and Whelan, 1984). Metamorphosis occurs from mid June through the end of August as evidenced by specimens collected on June 17 (CT:New Fairfield), June 29 (CT:Bridgewater), July 10 and August 4 (CT:Thompson), and August 28 (CT:New Fairfield). The specimen collected on August 28 had five legs (AMNH 108180). Wright and Wright (1949:446) gave transformation dates of July 1 to August 15 in "the North" which is a narrower time frame than my data indicate.

Rana catesbeiana are preyed upon by various vertebrate predators. They are economically important, serving as the primary source of frog legs in the United States. This has resulted in numerous introductions into areas where they do not naturally occur. Bull frogs are voracious, eating any moving prey they are able to swallow. The literature is replete with accounts of prodigious eating feats of Rana catesbeiana, summarized by Whelan and Bury (1984). I observed an instance of cannibalism at Thompson (CT), as a Rana catesbeiana captured and swallowed a newly metamorphosed conspecific. Gruner (pers. comm.) reported bull frogs attacking fishing lures.

Bull frogs are secure in southwestern New England. They are highly successful flourishing in areas where other frogs have disappeared. Bury and Whelan (1984) found hunting to be a problem in many parts of their range, resulting in excessive losses of adult breeding stock. This is not the case in my study area where collection of frog legs appears minimal and without detriment to local populations.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=12): AMNH 1834, 107754-60, 108180, 114237-39

Hartford Co. (n=10): AMNH 107762-64, 108181-82, 117981-82, 121585, 128842-43

Litchfield Co. (n=28): AMNH 438, 487-93, 99345-48, 107761, 108183-93, 114240, 114795, 116091, 117983

Middlesex Co. (n=6): AMNH 108194, 114241-42, 116092-93, 121586

New Haven Co. (n=6): AMNH 107766, 108195-96, 114243, 121587, 125313

New London Co. (n=11): AMNH 107765, 108197-200, 114244, 116094-95, 117984-86

Tolland Co. (n=9): AMNH 107767-71, 108201, 117987-89

Windham Co. (n=8): AMNH 107772-74, 117990-92, 121588; AMNH-FS 9960

Massachusetts

Berkshire Co. (n=17): AMNH 121750-54, 128960, 132111-16, 132458-62

Franklin Co. (n=3): AMNH 103729, 132463-64

Hampden Co. (n=2): AMNH 121755, 132117

Hampshire Co. (n=4): AMNH 7517-18, 133237-38

Rhode Island

Kent Co. (n=1): AMNH 132563

Providence Co. (n=1): AMNH 125107

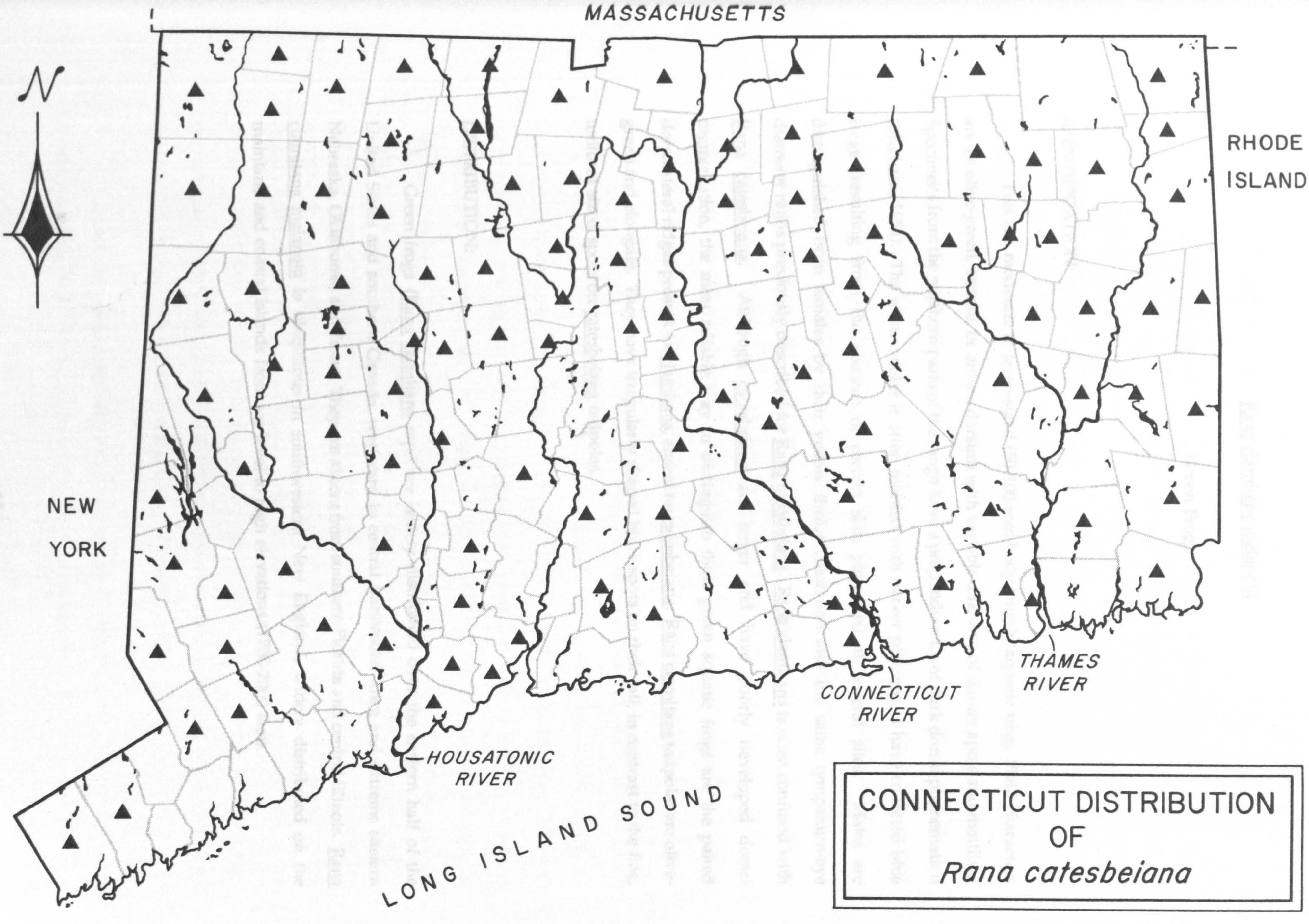
Washington Co. (n=3): AMNH 124666, 128654, 128731

New York

Columbia Co. (n=1): AMNH 121844

Dutchess Co. (n=5): AMNH 116435, 132890-93

Westchester Co. (n=5): AMNH 108406-08, 125592, 127978



CONNECTICUT DISTRIBUTION
OF
Rana catesbeiana

Rana clamitans melanota

Green Frog

IDENTIFICATION:

This is a moderate to large-sized (50-100 mm body length) aquatic frog. Field characters are an olive-green, bronze, or brown dorsum with variable amounts of darker spots and mottling. Specimens from the northern parts of the range have a preponderance of dark dorsal pigmentation (Mecham, 1954). The white venter is often mottled with darker pigment. I have collected blue frogs (resulting from the absence of certain skin pigments) at several sites. Males are distinguished from females by their yellow throat coloration and the same tympanum-eye diameter ratios previously described for Rana catesbeiana. Rana clamitans is often confused with Rana catesbeiana. Although catesbeiana are larger and have poorly developed dorsal pigmentation, the most reliable way to distinguish these green aquatic frogs are the paired dorsolateral ridges present on clamitans, absent on catesbeiana. Rana clamitans tadpoles are olive-green and elongate. They have irregularly shaped black spots on their tail, in contrast to the fine, uniform sized spots on catesbeiana tadpoles.

DISTRIBUTION:

Green frogs (Rana clamitans ssp.) are widely distributed over the eastern half of the United States and southern Canada, westward to central Minnesota, Iowa and extreme eastern Nebraska, Oklahoma, and Texas. They are absent from southern Florida and central Illinois. Rana clamitans melanota is ubiquitous in southwestern New England, widely distributed on the mainland and coastal islands from sea level to high elevations (1700-2000 feet).

LIFE HISTORY AND ECOLOGY:

Rana clamitans utilize a wide variety of aquatic habitats, both permanent and temporary, pristine and disturbed. The use of such a broad range of wetlands contributes to its abundance. I collected Rana clamitans around the margins of lakes, reservoirs, and ponds, on floodplains, in rivers, streams, springs, wooded swamps, vernal pools, fens, bogs, wet meadows, tidal creeks and meadows, flooded quarries and sand pits, mill and factory ponds, as well as ornamental and golf course ponds, and swimming pools.

Rana clamitans are active from March through October. They are among the first amphibians to become active in the spring. Between 1975-1986, I made 219 collections of Rana clamitans in Connecticut distributed as follows: March (6), April (15), May (55), June (32), July (25), August (25), September (46), October (14), November (11). Babbitt (1937) found Connecticut Rana clamitans active on warm days during the winter and frogs feeding from early March through late fall. Dunn (1930) gave March 28-April 17 as early activity dates at Northampton (MA). He found a hibernating specimen on October 22. My data indicate a longer activity season than reported by Dunn, but shorter than that of Babbitt, since I observed no winter activity.

Rana clamitans breeds in late May. Males produce advertisement calls to attract females to their territories which they vigorously defend against other males. I heard males calling on May 17 (NY:Hyde Park), May 24 (CT:Wilton), May 26 (NY:Hyde Park), May 28 (CT:Salem; NY:Hyde Park), and May 31 (CT:New London). In Connecticut, Babbitt (1937) reported the breeding season begins on May 15. Wright and Wright (1949:451-52) reported that breeding in "the North" occurred from the end of May to mid-August. They reported amplexus and egg laying on June 16 at Ithaca (NY). Dunn (1930) reported mating on May 22 at Northampton (MA). The large number of eggs are laid in a film upon the water's surface. Wells (1976) reported ten instances of Rana clamitans depositing two egg clutches in a single season at Ithaca (NY) with elapsed time between clutches varying from 15-46 days. I found well developed tadpoles active in vernal pools and wooded swamps in early spring (March-April), which indicated they overwintered. Wright and Wright (1949:452) reported one winter is spent in the tadpole stage. Babbitt (1937) reported occasional specimens may overwinter twice.

I found metamorphosing specimens on: June 10 (CT:West Haven), June 21 (CT:North Stonington), June 23 (CT:Pomfret), June 29 (CT:Bridgewater), July 4 (CT:Manchester), July 10

(CT:Thompson), July 21 (NY:Pound Ridge), September 2 (CT:Bethel), September 5 (CT:Lisbon), and September 23 (CT:Salisbury). In Connecticut, Babbitt (1937) reported metamorphosis from July to early September. My data indicate metamorphosis occurs from early June through late September.

Rana clamitans feed on a wide variety of invertebrates and small vertebrates. Hamilton (1948) examined the stomachs of over 400 New York specimens and found that Coleoptera, Diptera, Orthoptera, caterpillars, and arachnids were major dietary components, both in frequency and bulk. Vertebrate prey included frogs and fish. Vergeer (1948) reported a jumping mouse (Zapus hudsonius) consumed by a Rana clamitans. These frogs are fed on by a wide variety of vertebrate predators including wading birds, fish, turtles, snakes, raccoons, and other frogs. Although, like Rana catesbeiana, their legs are edible, they are too small to make harvesting commercially viable. Rana clamitans is secure throughout my study area, disappearing only when wetlands are drained, filled, or heavily polluted.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=16): AMNH 60488-89, 70362, 107775-77, 108202-04, 114245-47, 116096-97, 117993, 133448

Hartford Co. (n=14): AMNH 107778, 108174, 108205-07, 116098, 121589-91, 125314-16, 128844, 131800

Litchfield Co. (n=28): AMNH 99349-58, 99651-52, 107779-81, 108208-17, 114248-49, 116099

Middlesex Co. (n=14): AMNH 52871, 107782-83, 108218-20, 114250-52, 116100, 117994-95, 121592-93

New Haven Co. (n=7): AMNH 107786, 108221-22, 114253, 116101, 121594, 125317

New London Co. (n=24): AMNH 107784-85, 108223-26, 114254-57, 117996-98, 121595-96, 128663-64, 128845, 131747-48, 131801-04

Tolland Co. (n=11): AMNH 107787-90, 108227, 117999-803, 128846

Windham Co. (n=9): AMNH 107791-94, 116102, 118004-06, 121597

Massachusetts

Berkshire Co. (n=33): AMNH 108412, 121756-59, 125483-84, 128966-69, 132118-30, 132466-74

Franklin Co. (n=7): AMNH 103740, 116437, 132475-76, 133234-36

Hampden Co. (n=4): AMNH 121760, 125485, 132131, 132477

Hampshire Co. (n=7): AMNH 7519-22, 51055, 85298, 132478

Rhode Island

Kent Co. (n=4): AMNH 125108, 128658, 132566-67

Providence Co. (n=5): AMNH 124668-69, 125110, 128732, 132659

Washington Co. (n=23): AMNH 118097-98, 124670-72, 124675-79, 125111-23

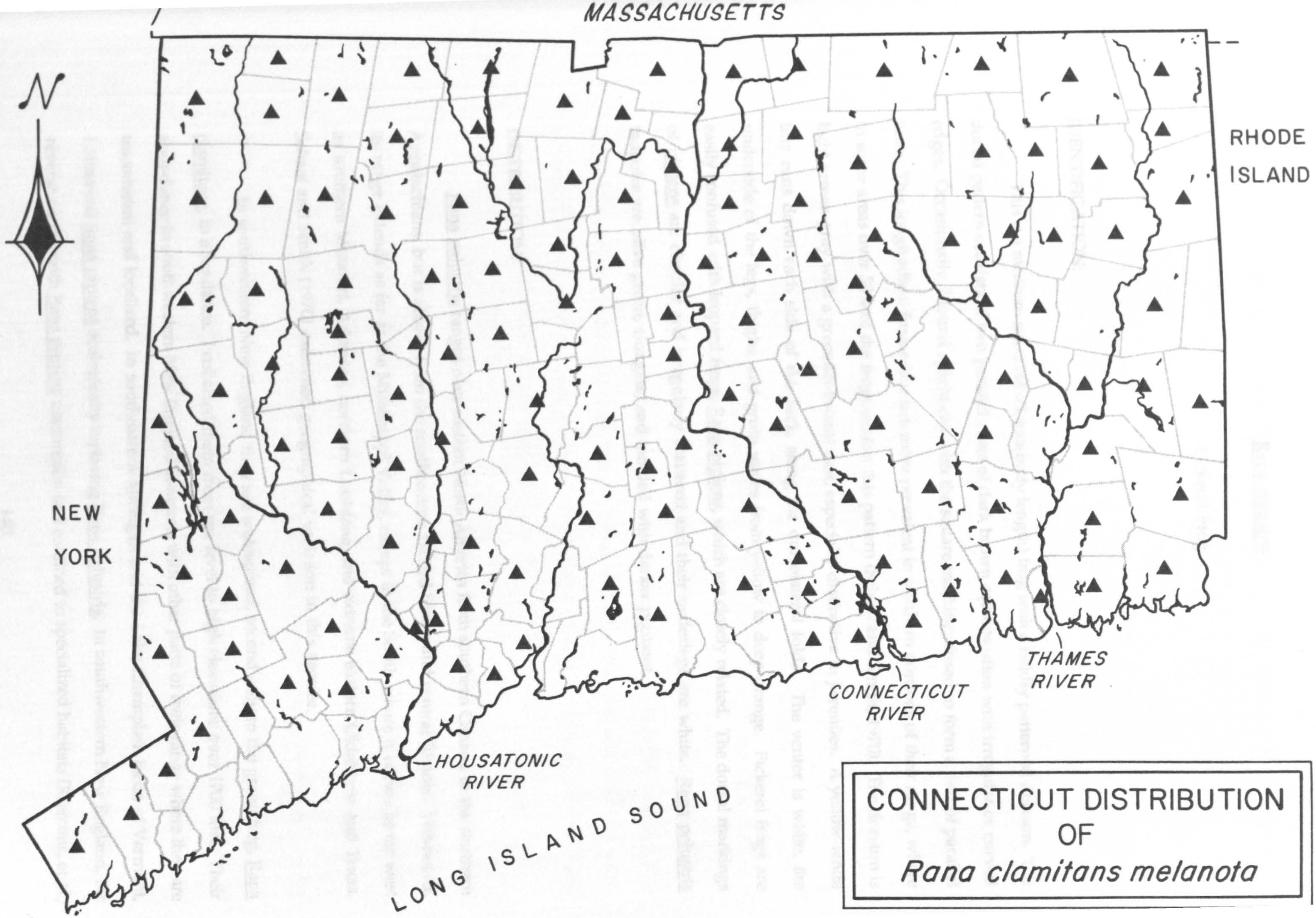
New York

Columbia Co. (n=3): AMNH 114738, 125593, 132894

Dutchess Co. (n=24): AMNH 116436, 116481-88, 132895-909

Putnam Co. (n=2): AMNH 118068, 121845

Westchester Co. (n=1) AMNH 125595


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
HOUSATONIC RIVER
CONNECTICUT RIVER
THAMES RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION OF *Rana clamitans melanota*

Rana palustris

Pickerel Frog

IDENTIFICATION:

This is a medium sized (45-75 mm body length) frog with a boldly patterned dorsum. The dorsal pattern consists of two parallel rows of dark brown squares often with irregular or curved edges. Occasionally, I found specimens with the square markings fused to form a pair of parallel lines. This longitudinal fusion is much more prevalent in southern portions of their range, where in some areas over 50% of the frogs exhibit this pattern (Schaaf and Smith, 1970). The dorsum is light brown-gray with a greenish-bronze cast, especially distinctive in juveniles. A yellow-white line runs down each side of the back, along the dorsolateral folds. The venter is white, the underside of the legs, thighs, and groin varies from yellow to deep orange. Pickerel frogs are easily confused with leopard frogs, Rana pipiens, which are closely related. The dorsal markings of pipiens are circular and irregularly scattered and their underlegs are white. Rana palustris tadpoles are olive green, elongate, and mottled with darker pigment.

DISTRIBUTION:

Rana palustris ranges over eastern North America from southern Canada to the southern Appalachians, but is absent from the southeastern United States and central Illinois. Westward, its range extends as far as the Mississippi Valley, except in the South where it occurs as far west as southern Missouri, Arkansas, northern Louisiana, and extreme eastern Oklahoma and Texas. Schaaf and Smith (1970) examined geographical variation in this species.

In southwestern New England they are widespread, second only to the green frog, Rana clamitans, in abundance. I collected them from sea level to high elevations over 1700 feet. Their abundance in southwestern New England contrasts with other parts of their range where they are uncommon and localized. In southeastern Michigan and the Lake Champlain basin of Vermont, I observed Rana pipiens ecologically replacing Rana palustris. In southwestern New England, the reverse occurs with Rana pipiens uncommon and confined to specialized habitats (Klemens, et al., 1987). In the Appalachian Mountains of southern Virginia (Pulaski, Giles, and Wythe counties), I observed Rana palustris confined to narrow corridors of riparian habitat.

LIFE HISTORY AND ECOLOGY:

I found Rana palustris in a wide assortment of moist habitats, both pristine and disturbed. Favored habitats were in or near shallow water, with at least a partially open canopy, and a thick layer of herbaceous vegetation. However, in mountainous areas they frequented shaded streams and rocky ravines, which lacked herbaceous ground cover. I collected Rana palustris at the margins of lakes, ponds, and reservoirs, in wet meadows, marshes, fens, bogs, vernal pools, springs, shrub and red maple swamps, sand pit and quarry ponds, and along the banks and floodplains of brooks, streams, and rivers. Similar to Rana clamitans, both permanent and ephemeral water habitats were utilized. Immature frogs were often collected in damp terrestrial situations where they were most noticeable during rainy or cool weather and early in the day.

I found Rana palustris active from March through November. Between 1975-1986 I made 216 collections in Connecticut distributed as follows: March (2), April (13), May (55), June (36), July (21), August (26), September (51), October (11), November (1). My collecting success was bimodal, peaking in May-June and again in September. These data may indicate reduced activity during the hot and dry months of July and August.

Babbitt (1937) found Rana palustris active throughout the year in Connecticut, even during winter warm spells (December-February). Dunn (1930) reported early activity between April 15-22 and hibernation commencing on October 22 at Northampton (MA). My data indicate a longer activity season than reported by Dunn, but shorter than reported by Babbitt.

Their breeding call resembles a low pitched snore. Apparently the sound does not carry well, as I heard calls of this common frog only twice, on April 4 (CT:Danbury) and May 7 (NY:Hyde Park). Babbitt (1937) found Connecticut frogs breeding from April 20 to May 20. At Northampton (MA), Dunn (1930) reported frogs calling on April 16 and May 14, frogs in amplexus on April 22 and 24, and eggs on April 27 and May 7. Near Ithaca (NY), they breed from April 23 through May 15 (Wright and Wright, 1949:479). These authors found frogs in amplexus on April 28 near Ithaca. My data indicate breeding commences in early April instead of mid April as reported by Babbitt (1937), Dunn (1930), and Wright and Wright (1949). Several thousand eggs are deposited in a globular mass attached to submerged twigs or vegetation (Wright and Wright, 1949:479-80).

Development is completed in the same season as the eggs are deposited. I found metamorphosis occurring on July 17 (NY: West Point), July 19 (CT:East Hartford) and August 4 (CT:Thompson) and tadpoles with well developed hind limbs on August 6 (MA:Becket). A recently transformed specimen (AMNH 114265) collected on September 7 at Stafford (CT) had a cluster of three left front legs. My data indicate metamorphosis occurs as early as mid July and continues through early September. Babbitt (1937) reported Rana palustris transformed in Connecticut during August. Dunn (1930) found transforming frogs on September 3 at Northampton (MA). Wright and Wright (1949:480) reported transformation in August. My data extend the reported transformation period (Babbitt, 1937; Dunn, 1930; Wright and Wright, 1949) forward several weeks to mid July and may be correlated with my call data, which likewise extended the reported breeding season forward several weeks to early April.

Rana palustris has noxious skin secretions that afford it protection against certain predators. Babbitt (1937) reported frogs (Rana catesbeiana and Rana clamitans) eat pickerel frogs, but snakes such as Nerodia and Thamnophis avoid them. Rana palustris is secure in southwestern New England, occurring in most state parks, sanctuaries, and state forests. They appear less tolerant of urbanization than either Rana catesbeiana or Rana clamitans which thrive in polluted wetlands with little shoreline vegetation. Rana palustris favor sites with thick herbaceous shoreline vegetation which frequently is lacking in urban wetlands.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=13): AMNH 60292, 60490-91, 70364, 107795-97, 108228-31, 116103, 125318

Hartford Co. (n=13): AMNH 107798, 108232-34, 116104, 118007-08, 121598-99, 125319-20, 128847-48

Litchfield Co. (n=20): AMNH 68204-05, 103744-46, 107799-800, 108235-43, 108277, 114258-59, 118009

Middlesex Co. (n=15): AMNH 107801-02, 108244-46, 114260-62, 116105-06, 118010-12, 121600-01

New Haven Co. (n=7): AMNH 107805-06, 114263, 116107-08, 121602, 125321

New London Co. (n=18): AMNH 107803-04, 108247-51, 114264, 116109-10, 118013-15, 121603, 128849, 131749, 131805-06

Tolland Co. (n=14): AMNH 107807-13, 108252, 114265, 118016-17, 128850, 131807-08

Windham Co. (n=12): AMNH 107814-16, 116111, 118018-21, 121605-06; AMNH-FS 9961

Massachusetts

Berkshire Co. (n=47): AMNH 121761-71, 125486-91, 128970-76, 132134-49, 132480-86

Franklin Co. (n=9): AMNH 103741-42, 132487-89, 133239-42

Hampden Co. (n=9): AMNH 121772, 125492-95, 132150-51, 132490-91

Hampshire Co. (n=5) AMNH 7526-27, 51000-02

Rhode Island

Kent Co. (n=6): AMNH 124680-81, 125124, 128665-66, 132572

Providence Co. (n=2): AMNH 124683, 132661

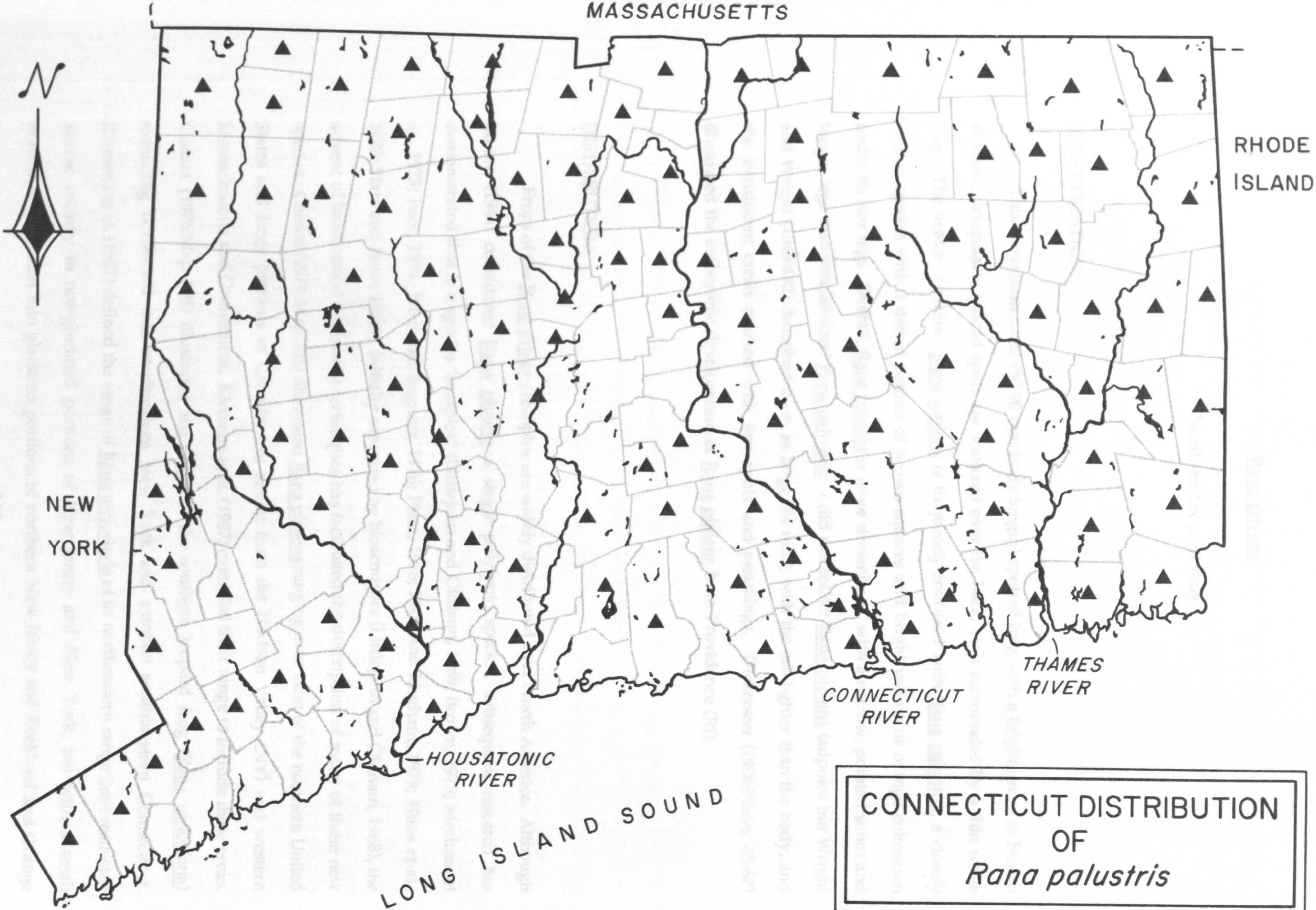
Washington Co. (n=11): AMNH 115957-58, 124684-87, 125126-27, 128669, 128672-73

New York

Columbia Co. (n=1): AMNH 130146

Dutchess Co. (n=11): AMNH 116442, 132910-19

Westchester Co. (n=8): AMNH 108409-10, 125599, 133135-39



CONNECTICUT DISTRIBUTION OF *Rana palustris*

Rana pipiens

Northern Leopard Frog

IDENTIFICATION:

This is medium sized (50-90 mm body length) spotted frog with a bright green or brown dorsum. Irregularly spaced spots are scattered over the back, each surrounded by a thin white ring. The venter is white. Rana pipiens is frequently confused with Rana palustris, a closely related species with a dorsal pattern of brown squares and bright yellow or orange coloration under its rear legs. Overall, Rana pipiens is more streamlined, with a narrow, pointed snout and longer legs than similar-sized Rana palustris. I did not collect Rana pipiens tadpoles but Wright and Wright (1949:482) described them as large (84 mm), with the tail lighter than the body, and the translucent crests marked with fine spots and pencilings. Dickerson (1906:Plates 65-67) illustrated the embryonic development of Rana pipiens from Providence (RI).

DISTRIBUTION:

Frogs of the Rana pipiens complex are widely distributed over North America. Although Moore (1944) considered Rana pipiens a single polytypic species, subsequent research has demonstrated that is a species "complex" (Littlejohn and Oldham, 1968; Brown, 1973; Mecham et al., 1973; Pace, 1974; Frost and Bagnara, 1976; Platz, 1976; Platz and Mecham, 1979; Hillis et al., 1983; Platz and Frost, 1984). Initially separated by bioacoustics (Littlejohn and Oldham, 1968), the advent of biochemical systematic techniques has facilitated the description of many of these new species. Conant (1975:Map 303) illustrated Rana pipiens ranging over most of the northern United States and large portions of Canada, but absent from the Hudson Valley (NY) and western Massachusetts and Connecticut. Klemens et al. (1987) extended their range to include these areas. Conant (1975:Map 305) illustrated the range of the southern leopard frog (Rana utricularia) extending northward into southeastern New York and extreme southwestern Connecticut. Klemens et al. (1987) defined the range of Rana utricularia at its northeastern range limit restricted almost entirely to non-glaciated portions of New Jersey and New York, but with a small northward extension into glaciated portions of northern New Jersey and Rockland and Orange counties (NY). They reported Rana utricularia was the only leopard frog native to both Staten Island and Long Island (NY), and did not consider Rana utricularia part of Connecticut's herpetofauna.

In southwestern New England Rana pipiens is uncommon, restricted to grassy riparian floodplain habitats, which usually lie in river valleys below 700 feet elevation. The highest elevation where I found Rana pipiens was 1150 feet near Pittsfield (MA). Dunn (1930) reported Rana pipiens restricted to elevations below 250 feet near Northampton (MA).

In Connecticut, Rana pipiens is localized in the Housatonic and Connecticut drainage basins, and apparently absent from the Thames drainage. They are widely distributed in the floodplain forests and meadows bordering the Connecticut River and occur at scattered sites within the drainage basins of three of its tributaries, the Scantic, Farmington, and Coginchaug rivers. They occur in the Housatonic River Valley and wetlands surrounding tributary streams and lakes within its drainage basin. In New York, Rana pipiens occurs at widely scattered sites in freshwater tidal marshes of the Hudson River estuary.

In Massachusetts, Rana pipiens were found in the Housatonic drainage (Berkshire Co.) and the Connecticut River Valley (Hampden and Hampshire counties). These are the northward extensions of the previously described Connecticut distribution. Leopard frogs are absent from most of eastern Massachusetts. Lazell (1976) reported a series of specimens (deposited at the American Museum in New York) collected in the early 1900's on Cuttyhunk, one of Cape Cod's Elizabeth Islands (Dukes Co.). However, as he was unable to find leopard frogs on the Elizabeth Islands or Cape Cod, he dismissed these as probable releases of laboratory stock as they closely resembled "Minnesota leopard frogs". It is convenient, but not scientifically sound, to attribute unexplainable occurrences to "releases", without first carefully researching the literature and conducting field investigations. My research has resulted in documentation of Rana pipiens in a narrow band of coastal habitat stretching from Cape Ann in northeastern Massachusetts (Essex Co.) southeastward to Narragansett Bay (RI). Leopard frogs were collected on Aquidneck and Conanicut islands within Narragansett Bay. In addition, a recently discovered field journal (Nichols, 1907) documented that two Rana pipiens were collected on April 20, 1905 by J. T. Nichols on Pasque Island, which is one of the Elizabeth Islands. Based on my field work and Nichols' report, I consider the Rana pipiens specimens collected on Cuttyhunk representative of an extirpated native population.

Preliminary biochemical work conducted in collaboration with James Bogart indicate these frogs are genetically closer to Rana pipiens of the midwestern United States than were frogs collected in western New England. Dissection of males from eastern New England revealed vestigial oviducts (present in midwestern pipiens) whereas those from western New England lacked vestigial oviducts. Moore (1944:363) mapped the distribution of vestigial oviducts in samples of North American male Rana pipiens. Vestigial oviducts were present in his samples from eastern and central (Connecticut River Valley) New England, except a single sample from coastal Maine. Vestigial oviducts were absent in samples from Long Island and New Jersey, now recognized as a distinct species, Rana utricularia. Littlejohn and Oldham (1968) used vestigial oviducts as a diagnostic morphological character in tandem with their bioacoustical data to separate frogs of the Rana pipiens complex. Based on vestigial oviduct data, the leopard frogs of western New England may be more closely allied with Rana utricularia (which lacks vestigial oviducts in males) than previously thought, possibly representing an undescribed taxon. These data suggest New England Rana pipiens comprise two or more genetically divergent groups, their present distributions a result of post-Pleistocene invasions from several refugia. Further research on New England Rana pipiens is needed including an analysis of acoustical data, the collection of additional tissue samples, and an analysis of vocal sac location (internal versus external).

LIFE HISTORY AND ECOLOGY:

I found leopard frogs restricted to open, grassy habitats either along the floodplain of a large stream or river, in wetlands around the margins of large, open lakes, or in meadows adjoining tidal wetlands (both fresh and brackish water). These habitats are periodically inundated by natural events including spring flooding, tides, and severe storms. However, leopard frogs usually shun sites that have been severely disturbed or polluted by human activities, though they flourish in rural areas, utilizing open wet meadows created for and maintained by grazing cattle and hay production. They are extremely difficult to catch, escaping by several long zig-zag evasive hops into thick vegetation. Having confused their pursuer as to their exact whereabouts, they crouch low and remain motionless, blending perfectly into the surrounding grasses.

In Connecticut, I made 30 collections of leopard frogs between 1975-1986 distributed as follows: May (7), June (12), July (1), August (2), and September (8). This is a strong bimodal distribution, which may indicate either reduced summertime activity or summertime movement to inaccessible high grass areas which reduce collecting efficiency.

In Massachusetts, I collected leopard frogs as early as March 24 and 26 at Newbury (Essex Co.) and March 28 at Sheffield (Berkshire Co.) and as late as October 17 at Billerica (Middlesex Co.). Based on these data, the activity season for Rana pipiens in New England begins in late March and extends at least until mid October. In Connecticut, Babbitt (1937) reported they were one of the first frogs emerging from hibernation and collected them "under grass" as late as November 15. Dunn (1930) found them active as early as March 28 near Northampton (MA). My data basically agree with Babbitt and Dunn, as I do not consider collecting frogs "under grass" in November indicative of activity, but more likely the initial stage of winter dormancy.

I did not observe frogs calling or in amplexus. A male collected in a flooded meadow at Sheffield (MA) on March 28 had swollen nuptial pads (enlarged areas on the front toes used to grasp females during amplexus). However, I did not hear the low snore-like call of Rana pipiens at this site, although choruses of Rana sylvatica and Hyla crucifer were audible. Males with swollen nuptial pads and gravid females were collected crossing roads toward breeding ponds on March 24 and 26 at Newbury (MA).

In Connecticut, Babbitt (1937) stated they bred "in the spring". Dunn (1930) reported frogs calling on March 29 and April 19 and found eggs on April 1, April 14, and April 24 near Northampton (MA). Wright and Wright (1949:482) reported breeding from April 1 to May 15. Near Ithaca (NY), these authors found frogs calling and eggs being deposited on April 11 and April 25. My data agree with Dunn's (1930) observations. Frogs may breed slightly earlier in southern New England than at Ithaca, though comparison with Wright and Wright's (1949) data is difficult as they do not give a range of breeding dates for the Ithaca area. I have no data on metamorphosis and none was found in the literature, other than Babbitt's (1937) vague reference to young frogs being "very abundant in late summer".

Babbitt (1937) reported grasshoppers and crickets are preferred food items. Rana pipiens has been a mainstay of the laboratory animal trade, and is commercially collected in many areas, resulting in well publicized population declines in many parts of its range, especially the Midwest.

Releases of laboratory stock have occurred, but I know of no New England population whose establishment can with certainty be attributed to an introduction. Many vertebrates prey on Rana pipiens, as they do not have the noxious taste of their close relative, Rana palustris. Road mortality does not appear significant.

Leopard frogs were considered common throughout Connecticut by Babbitt (1937). However, in a marked departure from his accounts of other amphibians, he did not list towns where he collected these frogs. He published photographs of frogs from Simsbury and Kent and conducted a great deal of his fieldwork in the vicinity of Simsbury, where Rana pipiens is common along the Farmington River. None the less, I cannot explain this inconsistency in the presentation of his data. If he relied on other individuals to supply him with leopard frog information from other sections of Connecticut, certainly some confusion with Rana palustris would have occurred. I have repeatedly been presented with "leopard frogs" by experienced naturalists, which were actually pickerel frogs. The confusion between these species has misled many workers into assuming that Rana pipiens is widespread in southwestern New England. In addition, extirpations have occurred in several areas, notably Race Brook near New Haven.

Leopard frogs are indicators of high quality specialized wetlands. Although they may be the dominant frog in a narrow habitat strip, regionally they are rare. Undoubtedly, flood control measures and impoundments have reduced available leopard frog habitat either by permanently inundating floodplains or altering their dynamic cycles. Although some leopard frog populations occur on protected land, many are unprotected and vulnerable to habitat degradation. Fortunately there is much greater public awareness of the importance of wetlands. Flood control projects, dams, and other massive wetland alterations routinely approved in the post-war decades now come under close public scrutiny and are often denied permits. I suggest the southern New England states (Connecticut, Rhode Island, and Massachusetts) monitor the status of Rana pipiens as a "species of special concern".

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=1): UCS 5319

Hartford Co. (n=37): AMNH 121607-30, 125322-24; UCS 454, 578-581, 1058, 6736, 6805, 7455; USNM 134412

Litchfield Co. (n=48): AMNH 116112-18, 118022-25; TCWC 24781-82, 24787-92, 24794; UCS 577, 3476-78, 3690, 3789-90, 4084-85, 4375-83, 4403, 4476, 4755-57, 5173-74, 8408-10

Middlesex Co. (n=5): AMNH 108253; SCSC 764-65; UCS 8098; USNM 9998

New Haven Co. (n=17): YPM 1022, 1056, 1077, 1130, 1143, 2906-09, 2998-3003, 3068-69

Tolland Co. (n=13): UCS 1043-55

Massachusetts

Berkshire Co. (n=28): AMNH 121773-82, 124961, 125496-98, 128977, 132152-63, 132492

Dukes Co. (n=4): AMNH 3380-81, 3383, 3385

Essex Co. (n=5): AMNH 132164, 132493-96

Hampden Co. (n=10): AMNH 121783-92

Hampshire Co. (n=3): AMNH 7523-25

Middlesex Co. (n=12): AMNH 96575-78, 132165-72

Rhode Island

Bristol Co. (n=1): AMNH 133422

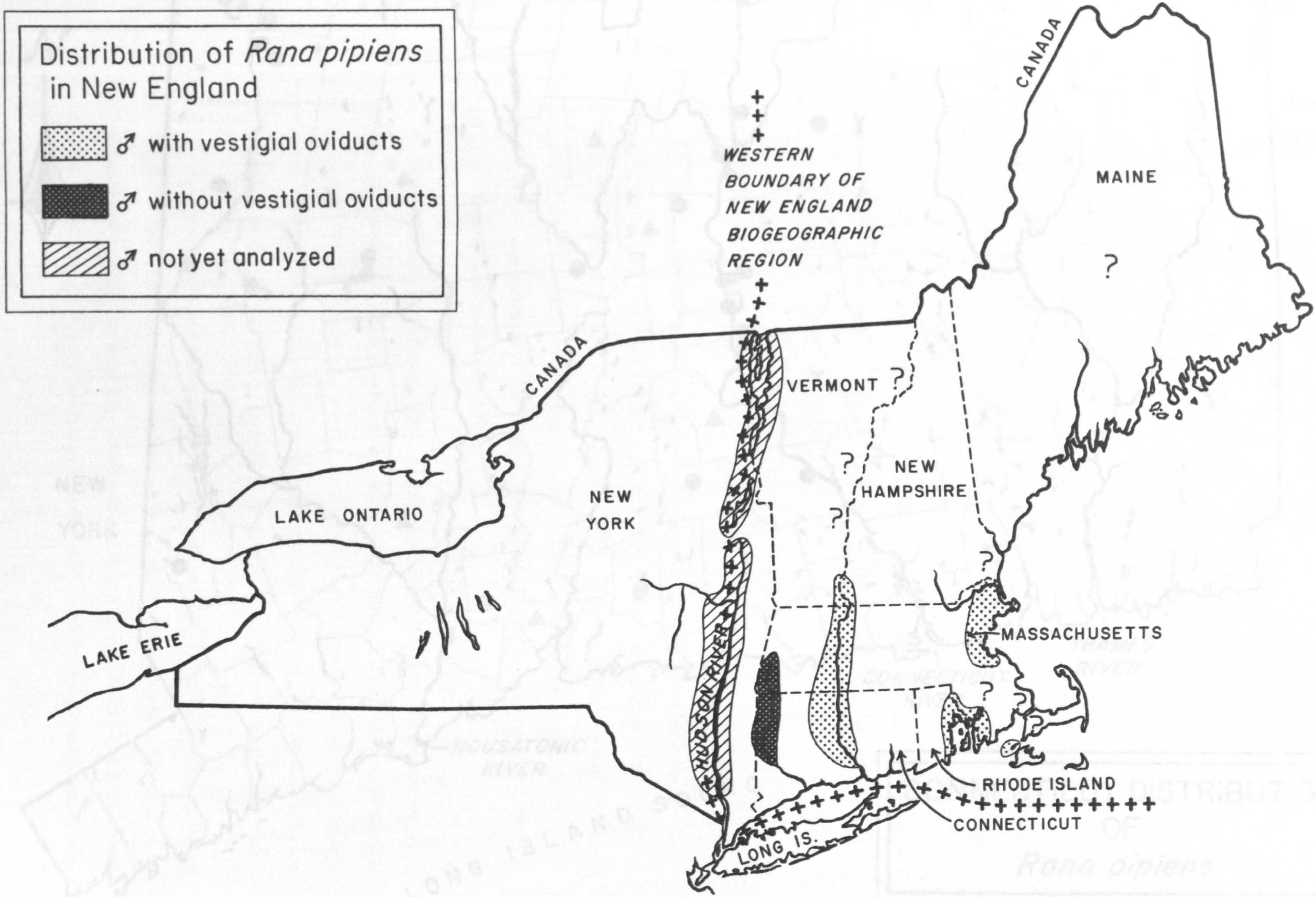
Newport Co. (n=30): AMNH 124688-92, 132577-96, 132662-64, 133423-24

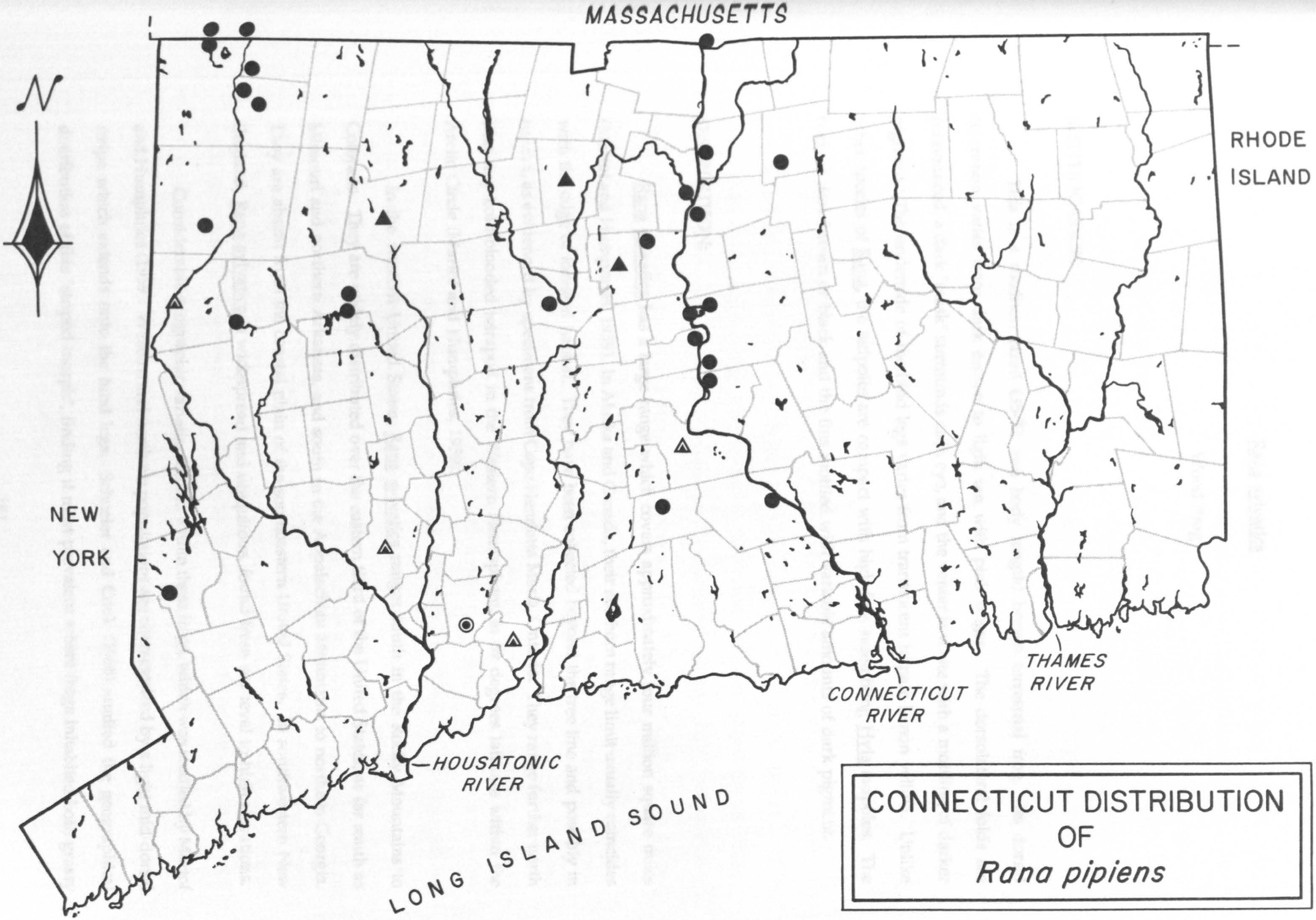
Providence Co. (n=5): AMNH 180, 257-59, 287

New York

Columbia Co. (n=1): AMNH 116412

Dutchess Co. (n=2): AMNH 116411, 118873


Distribution of *Rana pipiens* in New England
♂ with vestigial oviducts
♂ without vestigial oviducts
♂ not yet analyzed
WESTERN BOUNDARY OF NEW ENGLAND BIOGEOGRAPHIC REGION
CANADA
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW YORK
LAKE ONTARIO
LAKE ERIE
HUDSON RIVER
LONG IS.



CONNECTICUT DISTRIBUTION
OF
Rana pipiens

Rana sylvatica

Wood Frog

IDENTIFICATION:

This is a medium sized (35-70 mm body length) brown terrestrial frog. Its dorsal coloration varies from dark brown to light tan with pink tinges. The dorsolateral folds are pronounced, a dark "mask" surrounds each eye, and the venter is white with a mottling of darker pigment. The underside of the hind legs varies from translucent to pale lemon yellow. Unlike other species of Rana, the tadpoles are compact with high fins, resembling Hyla tadpoles. The body is dark brown or black and the fins mottled with variable amounts of dark pigment.

DISTRIBUTION:

Rana sylvatica has a large range which covers approximately four million square miles (Martof and Humphries, 1959). In Alaska and Canada, their northern range limit usually coincides with the edge of forested habitat. They have been collected beyond the tree line and possibly in tundra, as evidenced by specimens from Cape Henrietta Maria, Ontario. They range further north than any cold-blooded tetrapod in the Western Hemisphere, to 69 degrees latitude within the Arctic Circle (Martof and Humphries, 1959).

In the western United States, Rana sylvatica ranges south in the Rocky Mountains to Colorado. They are widely distributed over the eastern third of the United States, as far south as Missouri and northern Arkansas, and south in the Appalachian Mountains to northern Georgia. They are absent from the coastal plain of the southeastern United States. In southwestern New England, Rana sylvatica is widespread and ubiquitous, found from sea level to high elevations.

Considerable geographic variation occurs within these frogs, which was studied by Martof and Humphries (1959). Western and northern populations are characterized by a light mid-dorsal stripe which extends onto the hind legs. Schueler and Cook (1980) studied the geographical distribution of this "striped morph", finding it most prevalent where frogs inhabited both grassy and forested habitats. In the southeastern portion of its range including New England, Rana sylvatica are confined primarily to forested areas, therefore striped frogs are very rare. Schueler and Cook (1980) reported only fifteen geographically isolated occurrences of the "striped morph" after searching museum collections and the literature. These were from southern Canada (3), Indiana (1), Maine (1), Massachusetts (4), New Jersey (1), Pennsylvania (2), Vermont (2), and Wisconsin (1). My field work has added three additional records, each a single specimen, as follows: AMNH 125506 (Alford, Berkshire Co., MA), AMNH 132175 (Sheffield, Berkshire Co., MA), and AMNH 132926 (Hyde Park, Dutchess Co., NY).

LIFE HISTORY AND ECOLOGY:

I found Rana sylvatica in and near forested areas throughout my study area. All types of forest and woodland were utilized, including maritime, deciduous, and coniferous forest. They favored abandoned logging roads, which create small ecotones within deciduous forests that are characterized by luxuriant herbaceous ground cover and dappled sunlight. Frogs utilized grassy areas, often moving into pastures from surrounding forests. A frog was collected in a tidal meadow adjoining a small patch of maritime forest at Quonochontaug (RI). This meadow was located on a narrow spit of land connecting a barrier island to the mainland. Although I found Rana sylvatica in many suburban areas, they were uncommon in urban or severely degraded habitats. Their life history requirements are more complex than Rana catesbeiana or Rana clamitans. Adults prefer heavily forested areas with a thick cover of herbaceous vegetation and duff. Ephemeral wetlands are utilized for breeding, with woodland vernal pools preferred, but grassy pasture ponds, bogs, ditches, fens, wooded swamps, and flooded meadows were also used.

Rana sylvatica is a boreal, cold tolerant species, which is in the southern portion of its range in southwestern New England. They are able to withstand freezing temperatures (Storey and Storey, 1985; Layne and Lee, 1987) and exhibit interpopulation variability in thermal tolerances which are negatively correlated with increasing altitude or latitude (Manis and Claussen, 1986). I found Rana sylvatica active from March 17 through November 11. Between 1975-1986 I made 176 collections in Connecticut distributed as follows: March (26), April (27), May (34), June (28), July (14), August (16), September (21), October (9), November (1). Pierce et al. (1984) reported males migrating on March 7 and females on March 14 to a breeding pond at New

London (CT). The earliest date Babbitt (1937) gave for wood frog activity was March 22. Dunn (1930) reported activity as early as April 6 and hibernation on October 12 near Northampton (MA). Wright and Wright (1949:544) gave October 30 as their latest activity date. My data indicate longer duration of autumn activity than reported by either Dunn or Wright and Wright, but later spring emergence than reported by Pierce et al.

Wood frogs are among the first amphibians to emerge from hibernation and migrate to breeding ponds. Their breeding call resembles a hoarse "quack". Zweifel (1989) reported 49 instances of Rana sylvatica producing calls not related to breeding activity in a population he monitored for 14 years in northern New Jersey. As most of the calls occurred in the autumn, he suggested these may have territorial functions used in the selection or defense of hibernation sites located near a breeding pool. Hibernating near a breeding pool may be advantageous to males, as they would spend more time in the pool (presumably mating with more females) instead of "wasting time" migrating to the breeding site. This may be especially advantageous for male Rana sylvatica, as they breed explosively, completing the annual nuptial cycle in a week or two.

I heard breeding choruses and/or observed frogs in breeding pools on the following dates: March 19 (NY:Amenia), March 21 (CT:Danbury), March 23 (NY:Crofts Corners, Pound Ridge), March 24 (CT:Bozrah, Danbury), March 25 (CT:Andover, Danbury; MA:Wilbraham; NY:Armonk), March 26 (MA:Holyoke), March 27 (CT:Bloomfield; MA:Egremont), March 28 (CT:Bethel; MA:Sheffield; NY:Hillsdale), March 29 (CT:Mansfield), March 30 (CT:Greenwich; MA:Granby, South Hadley, West Springfield), March 31 (MA:Gill), April 1 (CT: Darien; NY:Pawling, Stanford), April 2 (CT:Greenwich; MA:Egremont; NY:Travis Corners), April 3 (CT:North Canaan), April 4 (CT:Danbury, Wallingford), April 5 (CT:Somers), April 6 (CT:Ashford), April 7 (CT:Somers; MA:Great Barrington), April 9 (CT:Colebrook, Pomfret), and April 10 (MA:New Salem).

Egg masses were noted on many of the preceding dates and frogs observed in amplexus on March 23 (NY:Crofts Corners), March 31 (MA:Gill), and April 3 (CT:North Canaan). In Connecticut, Babbitt's (1937) earliest date of breeding activity was March 22. At Northampton (MA), Dunn (1930) found frogs calling from April 6 to April 14 and eggs from April 6 to April 15. Wright and Wright (1949:542) reported the breeding season at Ithaca (NY) ran from March 19 to April 30. My data indicate breeding ends by mid April in southwestern New England.

The dark egg masses are laid in globular clumps attached to submerged twigs and vegetation. Egg masses are often deposited communally, resulting in a "mega-mass", often several feet square. The dark "mega-mass" serves as a "black body", warming more quickly than the surrounding water. This adaptation enables eggs of this early breeding, boreal frog to be deposited in icy water in ponds that are still partially frozen. Waldman (1982) reported communal laying was advantageous for eggs in the center of the clump, as they were insulated from thermal extremes and were warmer than peripheral egg masses. However, even the peripheral egg masses were warmer than single masses scattered around his study the pond. Eggs at the center of the mass had significantly greater hatching success than peripheral masses and contained more eggs, suggesting that larger females obtained central nesting sites. Forester and Lykens (1987) suggested that communal egg laying protected eggs in the center of the mass from desiccation if the egg mass was stranded due to inadequate precipitation.

By late May and early June I found vernal pools teeming with huge schools of wood frog tadpoles, often completely covering the surface of a small pond. In these pools, hundreds of tadpoles could be captured in a single sweep of a dip net. I observed both Nerodia sipedon and Thamnophis sauritus in a small pool (less than a meter in diameter) full of wood frog tadpoles at Thompson (CT). This pool was rapidly drying up, and it appeared as if there were more tadpoles than water in the shallow depression. I assume these snakes were attracted to this tiny pool from a nearby lake by this bountiful supply of easily captured food. I found metamorphosing tadpoles and froglets on June 8 (CT:Granby), June 20 (MA:Agawam), July 4 (CT:Joyceville), July 10 (CT:Thompson), and July 23 (CT:East Hampton). At New London (CT), Pierce et al. (1984) reported recently metamorphosed juveniles began exiting the pond on June 14 with most metamorphosis completed by June 28, though a few metamorphs were captured as late as July 13. Wright and Wright (1949:543) reported that tadpoles transform from June 8 to August 1, but most complete metamorphosis before July 15. My data agree with these authors.

Babbitt (1937) reported they feed on "small flies and insects found in the grass and bushes". They are fed on by a wide variety of vertebrates. I dissected Rana sylvatica from the stomachs of three species of snakes: Coluber constrictor, Thamnophis sauritus, and Thamnophis sirtalis. Road mortality is substantial in many areas. The effects of acid rain upon egg and larval development of amphibians has been a topic of growing concern. Small vernal pools, such as those utilized by Rana sylvatica, are vulnerable to acid precipitation. These pools are subject to rapid fluctuations in pH due to sudden increases in water volume from heavy rains. Pierce et al.

(1984) and Pierce and Sikand (1985) examined the effects of acidity on wood frogs in a pond at New London (CT). Although the average pond pH was about 5, on a single day it ranged between 4.1-6.3. Through laboratory experiments they determined wood frogs from New London were relatively acid tolerant as significant increases in embryonic mortality did not occur until the pH dropped below 4.0. Pierce and Harvey (1987) compared acid tolerance of frogs from four pools in southeastern Connecticut (New London) and four alkaline pools in northwestern Connecticut (Canaan). They found embryos produced by adult frogs from different ponds varied significantly in their ability to hatch in acidic solutions. Hatching success of the embryos was not correlated with the acidity levels in the ponds. Tadpole survival in low pH solutions differed among the ponds, with tadpoles produced by adults from acidic ponds tending to be more acid tolerant.

Although having disappeared from many urban areas, Rana sylvatica remains secure in southwestern New England, occurring in most state parks, forests, and private sanctuaries, as well as in many suburban and rural areas.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=17): AMNH 60484-87, 107817-20, 114266-68, 116119-20, 118026-27, 131750, 133449

Hartford Co. (n=20): AMNH 107821-23, 108254-55, 114269-70, 116121-22, 121631-33, 125325-30, 128851-52

Litchfield Co. (n=18): AMNH 107824, 108256-63, 114271-73, 116123-26, 121634-35

Middlesex Co. (n=8): AMNH 114274-76, 116127, 121636-38, 128853

New Haven Co. (n=5): AMNH 107832, 108264, 114277, 121639, 125331

New London Co. (n=17): AMNH 107825-31, 108265, 116128, 118028, 121640, 128687, 128854-55, 131751, 131809; AMNH-MWK 7972

Tolland Co. (n=12): AMNH 107833-35, 114278, 118029-32, 128856-57, 131810-11

Windham Co. (n=8): AMNH 107836, 116129, 118033, 121641-42, 131812-13; AMNH-FS 9959

Massachusetts

Berkshire Co. (n=37): AMNH 115938, 118085, 121793-800, 125499-506, 125805-06, 128978, 132173-86, 132497-98

Franklin Co. (n=15): AMNH 13940, 125507-10, 132499-507, 133243

Hampden Co. (n=16): AMNH 125511-13, 132187-90, 132508-16

Hampshire Co. (n=1): AMNH 132517

Rhode Island

Kent Co. (n=1): AMNH 132597

Providence Co. (n=3): AMNH 124693, 125129, 132665

Washington Co. (n=6): AMNH 124695-96, 125130, 128678-80

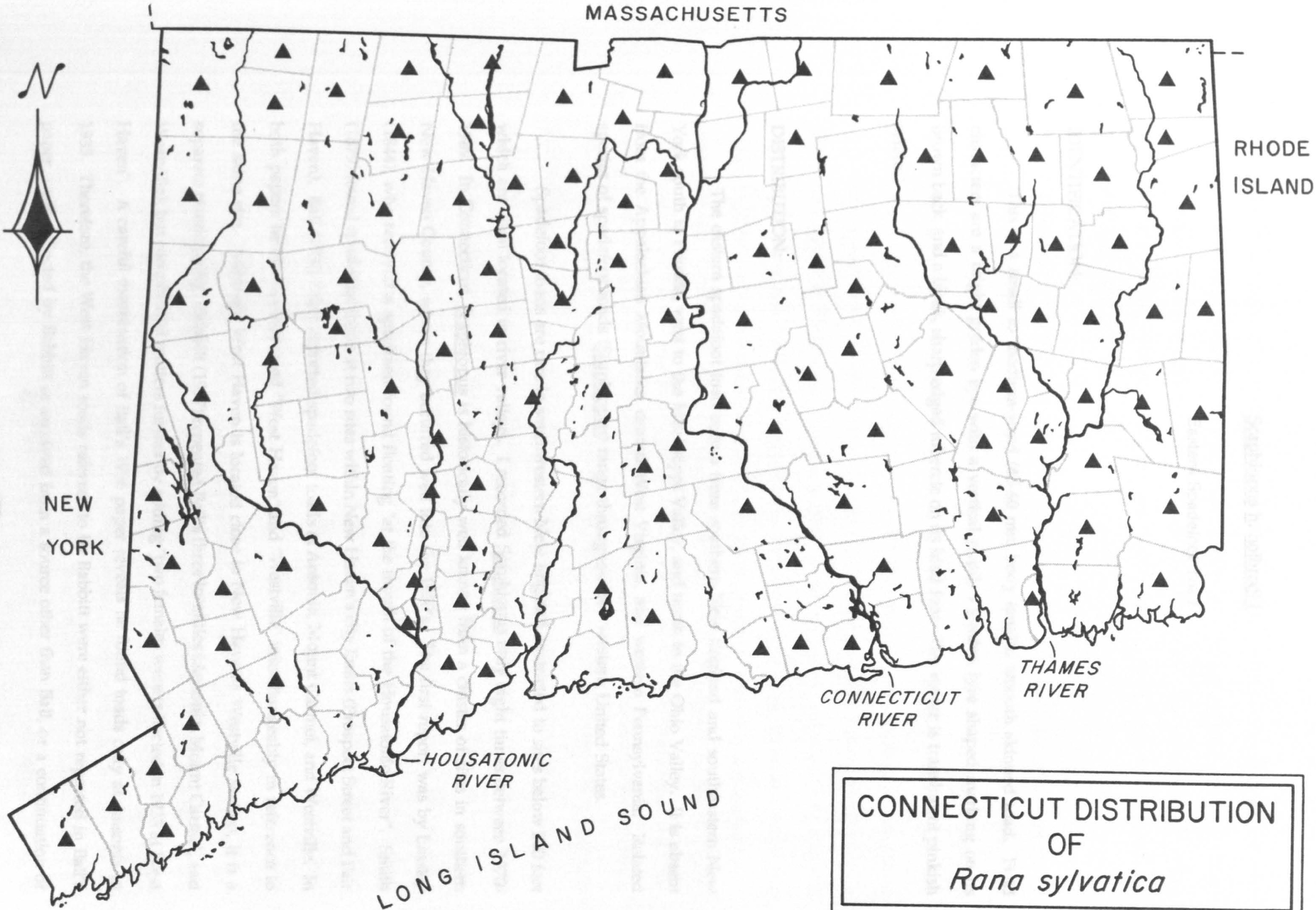
New York

Columbia Co. (n=13): AMNH 114739-49, 132722-23

Dutchess Co. (n=19): AMNH 121849, 129181, 130147, 132920-35

Putnam Co. (n=6): AMNH 121850-54, 125601

Westchester Co. (n=7): AMNH 108411, 115937, 116444, 118071, 125602-03, 129182



CONNECTICUT DISTRIBUTION OF *Rana sylvatica*

Scaphiopus h. holbrooki

Eastern Spadefoot Toad

IDENTIFICATION:

This is a small to medium-sized (45-60 mm body length) smooth skinned toad. Field characters are a bright golden eye with a vertical pupil, a golden lyre shaped marking on its brown back, and a black, sharp edged tubercle on its hind foot. The venter is translucent pinkish white.

DISTRIBUTION:

The eastern spadefoot toad occurs from southern New England and southeastern New York south to Florida, west to the Mississippi Valley, and north to the Ohio Valley. It is absent from the Appalachian Mountains, central West Virginia, and western Pennsylvania. Related species of spadefoot toads (Scaphiopus) range throughout the western United States.

Spadefoot toads are rare in southwestern New England, restricted to sites below 200 feet which are often located in river valleys. I recorded Scaphiopus only eight times between 1970-1989. In Connecticut, Scaphiopus is historically well known from a cluster of sites in southern New Haven County, where they occurred well into the 1930's. The first report was by Linsley (1844), who received a specimen found floating "at the mouth of the Housatonic River". Smith (1879) found spadefoot toads at two sites within New Haven's city limits (Prospect Street and Fair Haven). Ball (1933, 1936) reported spadefoot toads at Ansonia, Mount Carmel, and Westville. In both papers he erroneously used "West Haven" and "Westville" interchangeably in reference to the same site. Although West Haven is located close to New Haven's Westville section, it is a separate municipality. Babbitt (1937) repeated Ball's three localities (Ansonia, Mount Carmel, and Westville), but complicated matters further by adding "two females were collected in 1935 at West Haven". A careful examination of Ball's 1936 paper reveals he found toads only at Ansonia in 1935. Therefore, the West Haven toads referred to by Babbitt were either not reported in Ball's paper, were collected by Babbitt or received from a source other than Ball, or a continuation of

Ball's alternating usage of "West Haven" and "Westville". In summary, Scaphiopus has been reported with certainty from three towns, Ansonia, Hamden (Mount Carmel), and New Haven (Prospect Street, Fair Haven, and possibly Westville) in southwestern New Haven County. Their occurrence at West Haven is uncertain, however quite possible due to its proximity to several known breeding sites.

In Fairfield County (CT) and adjacent Westchester County (NY) their historical distribution is also complicated by the literature. DeKay (1842:66-67) added Scaphiopus to New York's fauna based on specimens collected at Clarkstown (Rockland Co.). He then stated "Dr. Pickering, I learn has recently seen it in the neighborhood of Salem, where they appear in great numbers, at distant periods, after rains of long continuance." DeKay was referring to Salem in Massachusetts (Essex Co.), where spadefoot toads were reported as early as 1825 (Hansen, 1958). Linsley (1844) misread DeKay and stated "Dr. Dekay asserts that it is found in great numbers at Salem, N.Y., which is near our state line, and it is therefore doubtless a denizen of Connecticut in other parts of this county." Allen (1868) in an obscure footnote correctly interpreted DeKay's (1842) attribution to Salem (MA). However, Linsley's erroneous attribution of Scaphiopus to Salem Center (Westchester Co., NY) was widely accepted, adding credence to Babbitt's (1932) report from the nearby town of Ridgefield (CT). Curiously, in his magnum opus on Connecticut's amphibians, Babbitt (1937) omitted several records from his 1932 paper. Along with the Ridgefield Scaphiopus, Simsbury records of the mud puppy, Necturus maculosus, and spring salamander, Gyrinophilus porphyriticus, were not included. The omitted records constitute significant range extensions compared to my data on the distribution of Connecticut's herpetofauna. These records were compiled in the early 1920's, when Babbitt was in his late teens and early twenties. He may have been inexperienced in identifying unusual species or less discriminating in his acceptance of unsubstantiated reports during the early years of his research. I can only assume prior to writing his definitive work on the State's amphibia, he critically reviewed his early data, and concluded that these records should be deleted.

During my survey, Scaphiopus was documented at five sites in eastern Connecticut. I am indebted to Chris Raithel who discovered three of these sites by utilizing techniques he developed to locate spadefoot toads in western Rhode Island. Two sites are near the eastern edge of the Central Connecticut Lowland at Manchester (Hartford Co.) and Somers (Tolland Co.). The Central Connecticut Lowland stretches from New Haven north through Massachusetts and served as the primary dispersal route of Scaphiopus into interior New England from the coastal plain. Smith's

(1879) and Ball's (1933, 1936) sites from New Haven and Hamden also lie within this lowland. Scaphiopus dispersed inland up river valleys including the Housatonic-Naugatuck drainage which encompasses Linsley's (1844) site as well as Ball's (1933, 1936) Ansonia locality. Populations were located in the Quinebaug River valley at Plainfield (Windham Co.) and Preston (New London Co.). Spadefoot toads were also found at North Stonington (New London Co.) in the Pawcatuck River valley. The Quinebaug is one of several large tributaries to the Thames drainage. However, during the postglacial period the Quinebaug and Pawcatuck rivers formed a single drainage, separate from the Thames and its other tributaries. I suggest that Scaphiopus dispersed inland from the coastal plain via the Pawcatuck-Quinebaug drainage, not unlike the swamp darter, Etheostoma fusiforme (Schmidt and Whitworth, 1979). Steep waterfalls located on tributaries near the Thames estuary may have prevented Scaphiopus from dispersing up the Thames drainage. These waterfalls blocked the dispersal of several coastal plain fish species, including Etheostoma fusiforme, into the Thames drainage (Schmidt, 1986). I anticipate additional localities for Scaphiopus will be discovered in eastern Connecticut.

In Massachusetts, Scaphiopus is well documented on the coastal plain from Cape Cod north to Cape Ann (Hoopes, 1937; Hansen, 1958). Lazell (1976) mapped localities on Cape Cod, Nantucket, and Martha's Vineyard. In the Central Connecticut Lowland, Allen (1868) reported them at Springfield and Chicopee (Hampden Co.) and Dunn (1930) and Driver (1936) found spadefoot toads at Northampton (Hampshire Co.).

In Rhode Island, Dickerson (1906:Color Plate 2) illustrated a specimen from Providence. Four spadefoot toads from Providence collected in the early 1900's are deposited in the American Museum's collection (AMNH 314, 3222-24). Drowne (1905) reported a specimen from Barrington (Bristol Co.) and two specimens from Bristol County are deposited in the University of Connecticut's collection (UCS 863-64). Raithel recently documented Scaphiopus at several sites in southwestern Rhode Island (Washington Co.), both on the coastal plain and in the Pawcatuck-Wood drainage further inland.

In New York, Scaphiopus is widespread on the coastal plain and still common on Long Island's eastern end. They have disappeared from most of western Long Island due to urban development. A subadult specimen (SIIAS A-231) was collected at Kingsbridge (Bronx Co.) in 1908. A disjunct population was reported from the Albany Pine Bush by Stewart and Rossi (1981). DeKay's (1842) Rockland County record, the single specimen from Bronx County, and the Albany

Pine Bush reports are the only records known to me from mainland New York. The absence of any historical occurrences of Scaphiopus in the Hudson Valley from Bronx and Rockland counties all the way to Albany is problematic if one assumes dispersal to Albany from the coastal plain via the Hudson Valley corridor. Stewart and Rossi (1981) suggested the Albany Pine Bush population may be a relict from a warmer period, or dispersed into the Pine Bush from the west via the Prairie Peninsula (Schmidt, 1938). Raithel (pers. comm.) suggested an alternative hypothesis of Scaphiopus dispersing northward to Albany via river valleys in eastern Pennsylvania. Comparison of Albany Scaphiopus with samples from Ohio, New England, and eastern Pennsylvania, utilizing genetic and biochemical systematic techniques, may reveal the origins of the Pine Bush population.

LIFE HISTORY AND ECOLOGY:

My limited ecological information on spadefoot toad habitats indicated that sandy, well drained soils are favored. Driver (1936) found them in clay and loam soils along the Connecticut River floodplain at Northampton (MA). Many aspects of the spadefoot toad's life history are geared toward existence in arid environments. These include explosive breeding following heavy rains in contrast to a fixed breeding season, utilization of temporary, rain filled pools for breeding, and rapid larval development. Several species of spadefoot toads are found in arid areas of the western United States. Bragg (1965) gave an excellent account of evolution, distribution, and ecology of the genus Scaphiopus.

In Connecticut, I found spadefoot toads active from June-August. The earliest date was June 1 at Manchester and the latest August 29 at North Stonington. Spadefoot toads were found breeding at Manchester in June (1970), on July 1 (1973), and on June 1-3 (1982). They emitted a harsh "caw caw" breeding call, not unlike a crow, and were observed in amplexus on July 1, 1973. Adults and subadult spadefoot toads were found crossing wet roads at night from June-August. My data indicated breeding occurred later in the year than reported by other authors. Smith (1879) found spadefoot toads breeding on April 29 at New Haven and Ball (1933, 1936) reported breeding between April 15 and June 19 at several sites in southern New Haven County. Dunn (1930) and Driver (1936) also found spadefoot toads breeding in April and early May at Northampton (MA). A review of the literature provided by Hansen (1958) who cited Ball, Dunn, and Driver, indicated spadefoot toads can breed several times in a year at the same site. Based on my observations and data summarized by Hansen (1958), Scaphiopus breeds from mid April to July in southwestern New England.

Spadefoot toads feed on ground dwelling insects, spiders, and other small arthropods, eating insects such as moths if they can catch them (Bragg, 1965:36). Spadefoot toads are expert burrowers as discussed by Ball (1936) who reported toads dug up from depths of two meters at Ansonia. They are rarely observed outside the breeding period, which gives rise to popular myths that they lie entombed for years between breeding episodes. Most Connecticut and Rhode Island specimens found by Raithel were crossing roads on warm, rainy nights during the summer.

Spadefoot toads make sudden appearances at sites where their loud breeding choruses have not been previously noted. Ball (1936) hypothesized that prior to the 1930's, spadefoot toads occurred at low densities at Ansonia, thereby escaping detection. For many years, their breeding success was marginal, with total drying-up of the breeding pool prior to metamorphosis a major mortality factor. However, in the late 1920's the Ansonia spadefoot toads may have had one or more very successful breeding seasons with high juvenile survivorship. This produced the huge breeding aggregations leading to their discovery in the 1930's.

Spadefoot toads are one of southwestern New England's rarest amphibians. Their secretive habits, irregular breeding periods, and population fluctuations makes assessment of their status difficult. In Connecticut, they have largely disappeared from the Central Connecticut Lowland due to urbanization. Ball's sites are presumed extirpated, as no evidence of spadefoot toads has recently been found. The Manchester site is located in a small patch of woods, now enclosed on all sides by urban development. The last breeding aggregation (1982) was much smaller than that observed in 1973. This population is likely doomed to extinction. The Somers site is documented by a single specimen which fell into an in-ground swimming pool. The surrounding habitat consisted of extensive sand deposits interspersed with small wetlands, and appeared ideal for spadefoot toads. Despite efforts of conservation groups and individuals, a large housing development was constructed several years ago destroying most of this habitat.

The best opportunities to conserve spadefoot toads in Connecticut are in the eastern part of the State, specifically the Pawcatuck and Quinebaug river valleys where large tracts of farmland and forest remain. Intensive survey efforts are needed to locate populations and acquire habitats that harbor breeding populations. There is a distinct possibility that spadefoot toads may be discovered in the Pachaug State Forest, which would provide some protection if an appropriate management plan was developed and implemented. At present, spadefoot toads are not known to occur on any protected land within Connecticut.

Spadefoot toads have disappeared from many areas in eastern Rhode Island and southeastern Massachusetts, however still occur in southwestern Rhode Island and on Cape Cod. I have no current information on their status in the Massachusetts portion of the Central Connecticut Lowland, but assume that escalating urban development has been detrimental to this species as in adjacent Connecticut.

SPECIMENS EXAMINED

Connecticut

Hartford Co. (n=5): UCS 6458-59, 6765-67

New Haven Co.* (n=5): AMNH 116401-05

New London Co. (n=5): AMNH-FS 9994-95, AMNH-MWK 7829, 7912-13

Tolland Co. (n=1): AMNH 118034

Windham Co. (n=1): AMNH 130235

* The large series adults and tadpoles in YPM collection, primarily collected by S. C. Ball, were examined but are not individually listed. The five AMNH specimens are representative specimens from these series donated to AMNH in January 1983 by YPM as follows: Ansonia (AMNH 116401-02 = YPM 561, 2663), Mount Carmel (AMNH 116403 = YPM 558), and New Haven (AMNH 116404-05 = YPM 606, 641).

Rhode Island

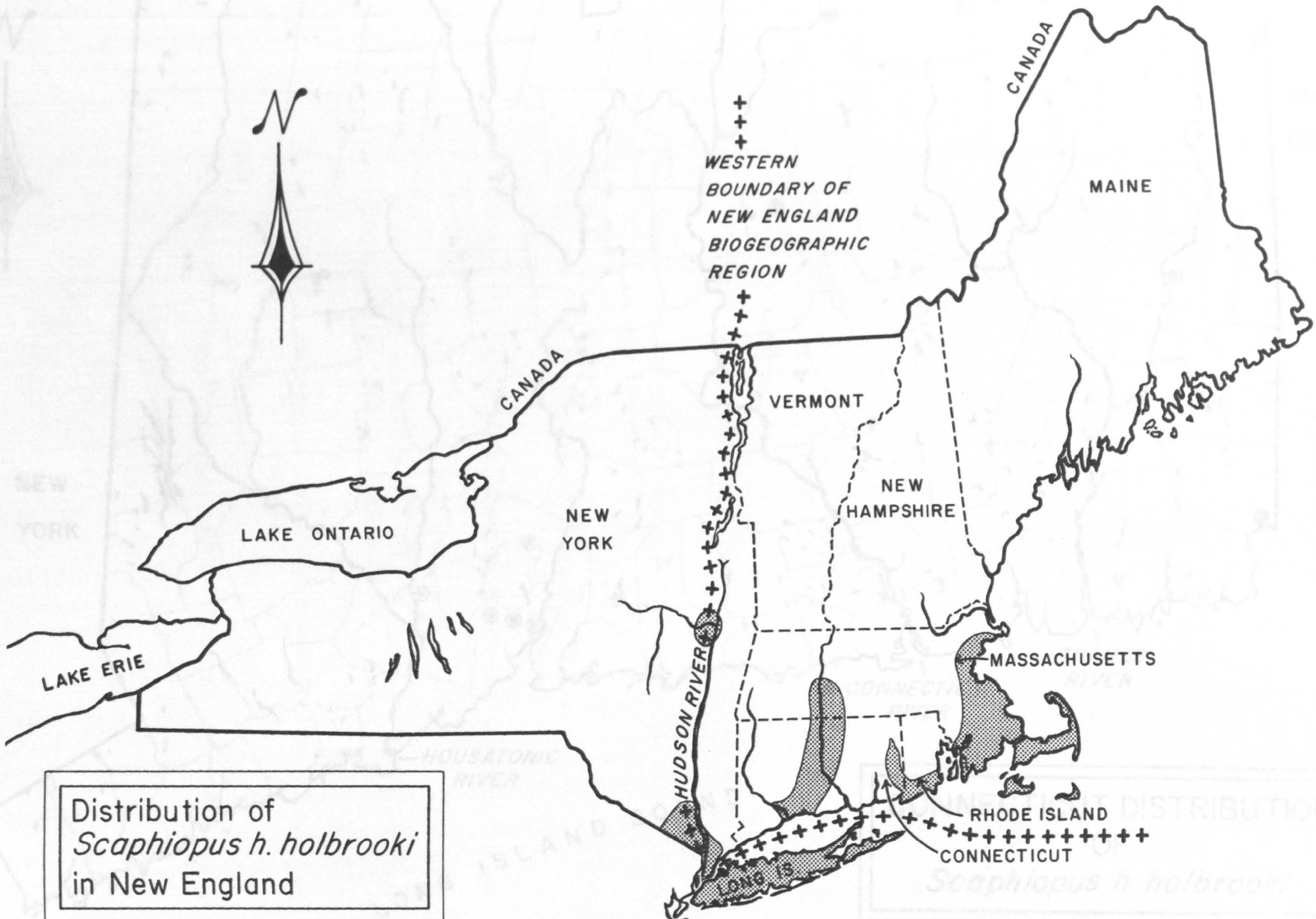
Bristol Co. (n=2): UCS 863-64

Providence Co. (n=4): AMNH 314, 3222-24

Washington Co. (n=3): AMNH 124699, 128688-89

New York

Bronx Co. (n=1): SIIAS A-231


N
WESTERN
BOUNDARY OF
NEW ENGLAND
BIOGEOGRAPHIC
REGION
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VERMONT
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LAKE ONTARIO
LAKE ERIE
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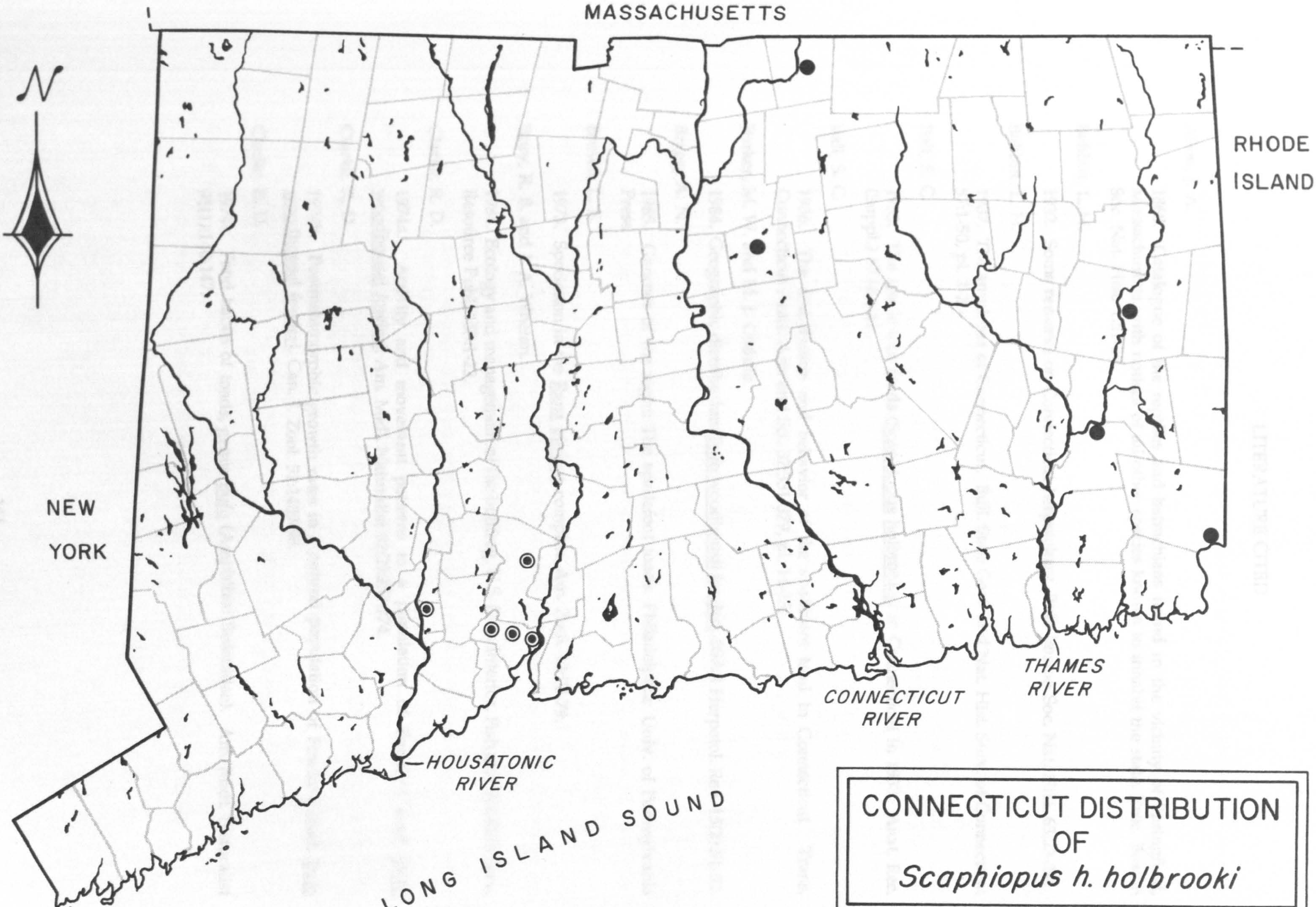
Distribution of
Scaphiopus h. holbrooki
in New England



CONNECTICUT DISTRIBUTION OF *Scaphiopus h. holbrooki*

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CHAPTER FIVE: TESTUDINATA

INTRODUCTION

Turtles are represented in southwestern New England by eight species distributed among three families (Chelydridae, Kinosternidae, and Emydidae). These are individually treated in detail in the following chapter.

In addition, four species of marine turtles have been reported from New England waters, Dermochelys coriacea, Caretta caretta, Chelonia mydas, and Lepidochelys kempi. The leatherback turtle (Dermochelys) is not infrequently observed off of Stonington (CT) in Block Island Sound. A specimen from this locality is preserved in the University of Connecticut's collection (UCS 8676). Cold stunned loggerheads (Caretta), green turtles (Chelonia), and Kemp's ridleys (Lepidochelys) have been salvaged on the north shore of Long Island (Meylan, 1986). However, salvage on the Westchester County (NY) and Connecticut shoreline is a rare event. Whether this reflects differential habitat preferences by the turtles or just the route of the prevailing currents is unclear. The only specimen of Caretta from this area is an adult salvaged at Rye (NY) in 1987 (AMNH 131392), whereas no Chelonia or Lepidochelys have been salvaged to date.

Three freshwater species, Kinosternon subrubrum, Emydoidea blandingii, and Graptemys geographica have been documented from the Hudson Valley, at the western edge of my study area. As these species do not occur in Connecticut, Rhode Island, and western Massachusetts, I did not consider them part of the southwestern New England herpetofauna.

Although Babcock (1920) considered its presence in New England "doubtful", the mud turtle, Kinosternon subrubrum, was erroneously reported from Connecticut by numerous authors including Pope (1939), Carr (1952), Ernst and Barbour (1972), and Conant (1975). Craig, Klemens, and Craig (1980) attributed these reports to misidentified specimens of Sternotherus odoratus as well as secondhand, unsubstantiated reports. As is frequently the case, these errors have been perpetuated by repetition in the literature, with no attempt to verify the validity of the original sources. Craig, Klemens, and Craig (1980) considered mud turtles restricted to non-glaciated portions of the Northeast with their northern range limit on Long Island (NY). They reported a disjunct, probably extirpated population in the Hudson River estuary at Ossining (Westchester Co., NY) based on a verified specimen (RMNH 9479 [formerly USNM 80305]) collected in 1884.

Blanding's turtles, Emydoidea blandingii, have been reported from widely separated sections of Connecticut by Linsley (1844), Babbitt (1932), and Finneran (1948a). I have been unable to locate any populations of Blanding's turtles within Connecticut. Although secretive, this large species is readily trapped and basks conspicuously. A population could not easily escape detection. The range of Blanding's turtle is characterized by disjunct populations, therefore it is conceivable that some Connecticut records represent extirpated populations. If these literature reports were from the same section of the State, a stronger argument could be made for this species' historical occurrence within Connecticut.

Hecht (1943) collected two specimens (AMNH 63767, 64045) at Freedom Plains in Dutchess County (NY). Kiviat (1986) has documented this species in western Dutchess County, in wetlands associated with large tributary streams to the Hudson River. A large disjunct population occurs in eastern New England (northeastern Massachusetts and southeastern New Hampshire).

Kiviat and Buso (1977) reported the map turtle, Graptemys geographica, nesting near Poughkeepsie, Dutchess County (NY). Subsequent work by Klemens (1988) resulted in additional specimen documentation (AMNH 134454-55) from Hyde Park, Dutchess Co. (NY). Map turtles are a midwestern species, widespread in the Great Lakes and Lake Champlain drainages. They probably entered the Hudson drainage in the early nineteenth century through the newly constructed canals connecting the Hudson and Mohawk rivers with the Great Lakes and Lake Champlain drainage basins.

Various exotic species may be found throughout the region, most frequently in small parks and ponds in suburban areas. Usually they do not survive the harsh New England winters. The red eared slider, Chrysemys scripta elegans, is able to hibernate and survive, but does not appear to reproduce in New England. This is in contrast to Long Island (NY) where they have been introduced into ponds and appear to be successfully reproducing.

The distribution of turtles in southwestern New England is strongly influenced by geographical location, elevation, and microclimate. Of the eight native species, five are at or very near their northeastern range limit. Only three species, Chelydra serpentina, Chrysemys picta, and

Clemmys insculpta have ranges extending into northern New England. Altitude and latitude strongly influence the distribution of Clemmys guttata, Clemmys muhlenbergii, Malaclemys terrapin, Sternotherus odoratus, and Terrapene carolina, all species at the edge of their range.

At higher latitudes and altitudes winters are more severe while summers are often cool and short. Turtles may be limited to lower latitudes and elevations because the cool, short summers of upland regions provide insufficient warmth for egg development. Although turtle eggs deposited at higher latitudes and altitudes may successfully develop in warm years, over the long term summer temperatures are too cool for population viability. It is interesting to note that ovoviviparous snakes are the most successful reptiles in northern New England. These species are able to elevate their body temperature through behavioral thermoregulation, thereby accelerating incubation of their eggs.

In southwestern New England, turtles are beset with numerous conservation problems including fragmentation, degradation, and loss of habitat, as well as declining recruitment, and in some instances, excessive collection. As a group, they represent a disproportionate number of species in need of conservation attention.

Chelydra s. serpentina

Snapping Turtle

IDENTIFICATION:

This is the largest freshwater turtle in the northeastern United States. Field characters include a reduced plastron, an oblong or slightly rounded flat carapace with a distinctive saw-toothed rear margin, and a long, plated tail. The dorsum is dark brown or black, the venter lighter, often dirty yellow. A large head, long neck, and sharp hooked beak are additional field characters. Its large size and pugnacious disposition (when encountered on land) set it apart from other turtles.

Hatchlings and juveniles resemble adults, though are distinctly tricarinate with a rough carapace. A row of light spots may be present on the carapace margin.

DISTRIBUTION:

The common snapping turtle (Chelydra s. serpentina) is widely distributed in North America east of the Rocky Mountains. It occurs from southern Canada to Texas. Two additional subspecies occur in Central America and northern South America. In southwestern New England this turtle is ubiquitous, often escaping detection due to its aquatic and primarily nocturnal habits. It occurs from remote mountaintop ponds to Central Park in the heart of New York City (Klemens, 1985).

I have collected this species from sea level up to 1600 feet near Otis (MA), and received reports from higher elevations. The only limiting factor at high elevations may be a paucity of marshes, ponds, and lakes to support this highly aquatic species.

LIFE HISTORY AND ECOLOGY:

Snapping turtles utilize a wide variety of aquatic habitats. Permanent water is favored by adults, though some half grown individuals (150-250 mm) were collected in vernal pools. I caught snapping turtles in rivers, lakes, impoundments, pasture ponds, beaver marshes, creeks, fens, and bogs. Although muddy bottomed wetlands are favored, I occasionally found specimens in swiftly flowing streams with rock or gravel substrate. They readily enter brackish and salt water. In Connecticut I collected or observed individuals in salt marshes and tidal creeks at Essex, Guilford, Groton, and Stratford.

This species is tolerant of pollution and disturbance, occurring in severely polluted rivers and most urban wetlands. Snapping turtles successfully reproduce in New York City's Central Park (Klemens, 1985). They are able to concentrate large quantities of toxic chemicals in their flesh without apparent ill effects. Stone et al. (1980) found high concentrations of PCB's in Hudson River snapping turtles.

Snapping turtles may come out of hibernation in early March. I collected active individuals from vernal pools in mid March and found specimens through mid October. This species is most active at night, frequently basking during the day in shallow water. I observed snapping turtles basking on emergent logs and rocks. These are usually juveniles or subadults, however a few large adults basking out of the water were observed. Turtle traps set overnight frequently yielded snapping turtles, whereas those set in the morning and pulled in the afternoon rarely caught them.

Ernst (1968) estimated home ranges for nine Pennsylvania turtles averaging 4.55 acres. He did not distinguish the sexes of the animals he studied. I have no data on home range of this turtle from southwestern New England. I frequently found subadult snapping turtles moving overland, usually during rainy weather. Most adults found on land were females during the nesting season.

Snapping turtles reach sexually maturity at 200 mm carapace length (Ernst and Barbour, 1972). Petokas and Alexander (1980) measured 28 nesting females in northern New York. The smallest nesting female in their sample measured 220 mm.

Sexual dimorphism is not as marked as in other species of turtles. Mosimann and Bider (1960) found the only reliable indicator of sex is the distance from the rear edge of the plastron to the cloacal opening. In specimens over 200 mm carapace length, the distance is relatively longer in males than females.

I found a mating pair at Bethany (CT) on April 28. Mating occurs from April through November (Ernst and Barbour, 1972). In southwestern New England nesting occurs in late May through June, peaking in the first weeks of June. The earliest dates I observed nesting turtles were May 31 at Haddam (CT) and June 1 at Manchester (CT) and Sheffield (MA). The latest dates were June 20 at New Marlborough (MA) and June 24 at Craryville (NY). These dates fall near the range of May 28 through June 21 given by Petokas and Alexander (1980) for a sample of 52 turtles observed in northern New York in 1977. Snapping turtles nest between June 4 and June 30 at Tivoli Marsh, Dutchess County, New York (Kiviat, 1980).

Nesting occurs in the morning, late afternoon, or evening. During the nesting season females can be found moving on land at all times of day. Rainy weather appears to increase terrestrial activity. Females seek well-drained, sunny areas to deposit their eggs. Railroad beds traversing wetlands are favored nesting spots for several species of turtles, including snappers.

Nest predation is extensive. Petokas and Alexander (1980) reported a nest predation rate of 94% during one season. Raccoons were implicated in 80% of these predatory events. Finneran (1948a) observed crows eating snapping turtle eggs at Branford (CT). Heavy rains following nesting appear to wash away many scent cues that would lead predators to the eggs.

The eggs are spherical, often likened to small ping pong balls. The shell is pliable and water permeable. A maximum clutch size of 83 eggs was reported from southern Canada (Bleakney, 1957). Finneran (1947) reported a female depositing 52 eggs at Branford (CT). Petokas and Alexander (1980) examined 16 complete clutches from northern New York ranging between 16-59 eggs, with an average of 30.9 eggs. They found clutch sizes of 20-40 eggs in 75% of their sample.

Incubation time varies with the amount of sunlight, environmental temperature, and nest location. Hatching occurs in September and October. My records include September 1 (Sheffield, MA), September 3 (Manchester, CT), September 7 (Mansfield, CT), September 18 (Hillsdale, NY), September 25 (Greenwich, CT), September 29 (Harwinton, CT), and October 21 (East Granby, CT).

I found three newly hatched snappers near the Farmington River at Windsor (CT) on September 18. Turtles may overwinter in the nest (Toner 1933, 1940), though I have no confirmation of this in southwestern New England. Hatchlings are preyed upon by a wide variety of mammals and birds, as well as other turtles, snakes, frogs, and fish. I received a hatchling taken from the stomach of a largemouth bass from the Peconic River on Long Island (NY).

Snapping turtles exceeding 12 inches straight line carapace length (=SLC) are common and specimens 14 or 15 inches SLC are not unusual. However, this species maximum size is frequently exaggerated, often resulting from poor measuring techniques. Conant (1975) stated a maximum recorded length of 18.5 inches (470 mm) SLC. A male collected in 1979 at Rockland Lake, Rockland County, New York (AMNH 120620) is slightly larger, measuring 483 mm and weighing 45 pounds. My largest Connecticut specimen (AMNH 119014) was from Sharon measuring 17.5 inches SLC and weighing 43.5 pounds. A specimen reported by Gerholdt (1986) from Minnesota measured 19.5 inches SLC and weighed 67 pounds. The popular press frequently reports turtles with greater lengths and weights.

Bowler (1977) reported a snapping turtle surviving over 38 years in captivity. Adult wild specimens have few enemies except man and may approach this figure, though confirmation is lacking.

Snapping turtles are frequently killed because of their purported depredations of game fish and waterfowl. Although snapping turtles may be locally important waterfowl predators in selected areas (Coulter, 1957), the bulk of their food consists of plants and non-game fish species. Alexander (1943) examined 470 stomachs of snapping turtles collected in Connecticut lakes, ponds, streams, and swamps. He found some variation in the percentages of various types of food in the diet of snappers from different habitats. Aquatic plants and fish were important food items. Crayfish were a major dietary item in stream habitats. Fish species taken were mainly suckers, bullheads, sunfish, and perch. Faster game fish were not taken in appreciable amounts. Waterfowl accounted for one half of a percent of the total food volume in this study. Two males I collected on Block Island (RI) had their stomachs packed with pond weed (Potamogeton pulcher), fragrant water lily (Nymphaea odorata), and green wild grapes (Vitis labrusca). Babcock (1916) reported a specimen from Cape Cod (MA) with its stomach filled with recently eaten marsh grass (Distichlis spicata). A specimen from West Hartford (CT) contained mammal hair, while a specimen from Sharon (CT) contained fish.

Snapping turtles are abundant and widespread in southwestern New England. Large numbers of migrating subadults and nesting females are killed on roads each year. They are able to thrive in close proximity to humans, often in severely polluted waters. In many areas snapping turtles are eaten possibly presenting a public health problem due to the potential concentration of environmental contaminants in their flesh. Snapping turtles are one of the few species of amphibians and reptiles in southwestern New England that are considered economically important. They are collected for sale in many areas and individuals found crossing roads are collected for consumption.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=12): AMNH 111429, 119012, 119240-44, 119570-71, 123094-95, 127956

Hartford Co. (n=10): AMNH 118691, 119572, 123096, 124955, 127263, 130003-04, 130560-61; AMNH-MWK 8005

Litchfield Co.(n=6): AMNH 119014, 119573, 123097, 124956-57; UMMZ 153009

Middlesex Co. (n=6): AMNH 119574, 123098, 124958-60, 127957

New Haven Co. (n=6): AMNH 111427-28, 119575, 127958, 130005-06

New London Co. (n=7): AMNH 119245, 119576-77, 123099, 127264, 127959, 133440

Tolland Co. (n=5): AMNH 119013, 119246-47, 123100; UMMZ 152983

Windham Co. (n=2): AMNH 119248, 134250

Massachusetts

Berkshire Co. (n=10): AMNH 128126-28, 130118, 130689, 133534-36, 134337-38

Franklin Co. (n=2): AMNH 134339-40

Hampden Co. (n=2): AMNH 124935, 133537

Rhode Island

Kent Co. (n=1): AMNH 134703

Providence Co. (n=1): AMNH 134704

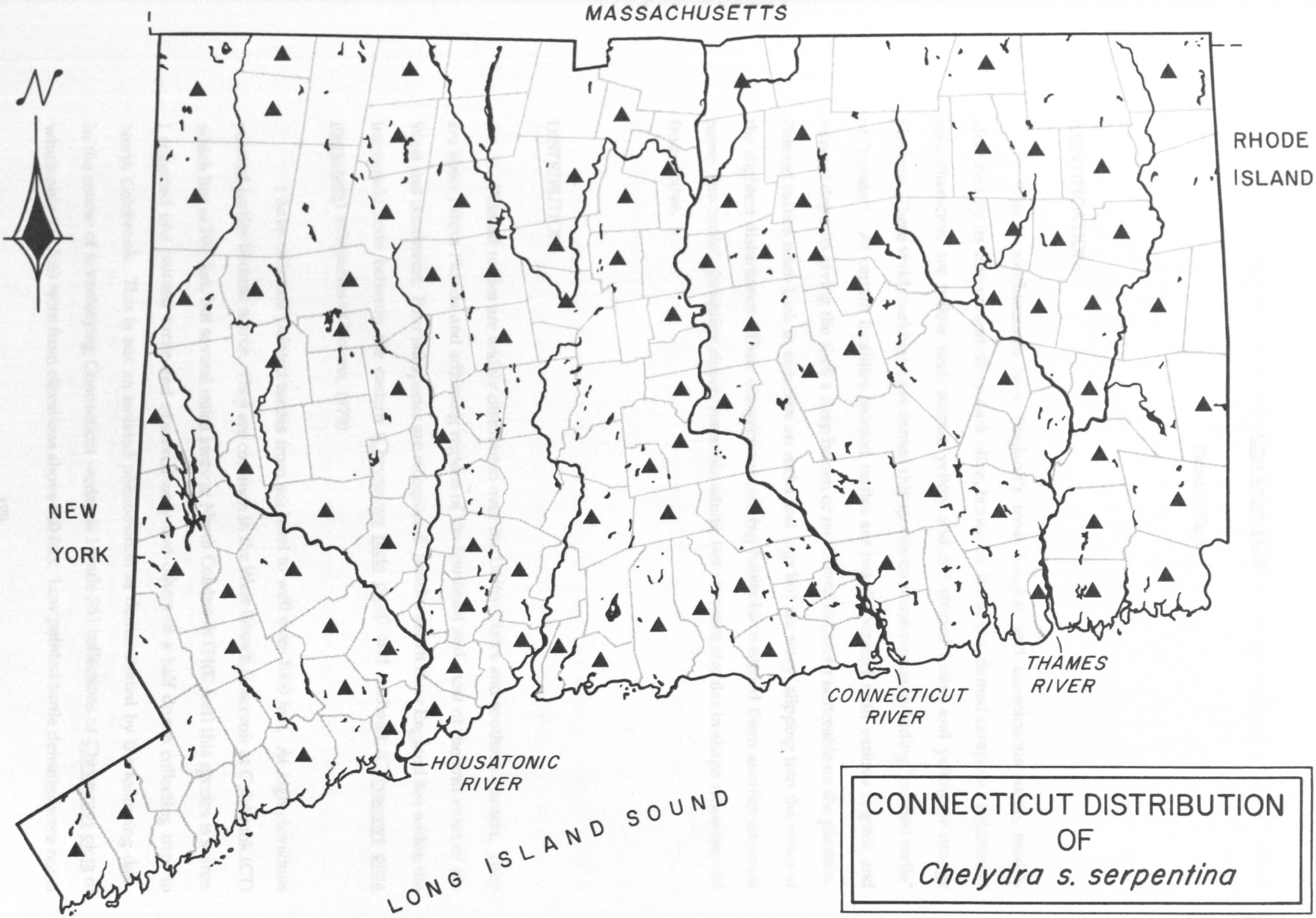
Washington Co. (n=2): AMNH 129881-82

New York

Columbia Co. (n=5): AMNH 7172-74, 7176, 134391

Dutchess Co. (n=13): AMNH 88673, 90619, 125451, 128158, 128220, 130764-65, 124392-97

Westchester Co. (n=27): AMNH 65468, 66558, 67015, 67092, 73221, 84554, 102284, 118649, 127749-61, 128215-19, 134398


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
THAMES RIVER
CONNECTICUT RIVER
HOUSATONIC RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION
OF
Chelydra s. serpentina

Chrysemys picta

Painted Turtle

IDENTIFICATION:

This is southwestern New England's most familiar and conspicuous turtle, readily identified by its smooth and shiny dark olive, brown, or black low domed carapace. Additional field characters are yellow neck stripes, yellow and red striped limbs, and yellow or orange plastron. These vivid markings have earned this species common names including "painted turtle" or "painter". At certain localities painted turtles are heavily stained with various organic and mineral deposits giving the shell a deep brown or red coloration, most noticeable on the plastron. Painted turtles often bask in numbers on rocks and logs but are wary, slipping into the water at the slightest disturbance. Their conspicuous basking habits have earned them another common name "sun turtle". Juveniles closely resemble adults, but are more circular in shape when viewed from above.

DISTRIBUTION:

Painted turtles are widely distributed over the United States and southern Canada. They are absent from Florida and adjoining regions of the Southeast and most of the arid areas of the West and Southwest. Four subspecies are recognized. Southwestern New England lies within the intergrade zone between the eastern (Chrysemys picta picta) and midland (Chrysemys picta marginata) subspecies (Klemens, 1978).

I have collected painted turtles from sea level to well over 1000 feet. At high elevations painted turtles become scarce. They are common in the West Branch Reservoir at Colebrook (CT) which lies at 700 feet, but several miles away at North Colebrook (1100 feet) this species is scarce. I collected one painted turtle and observed only two others in a half dozen collecting trips to North Colebrook. This is not an isolated phenomenon as demonstrated by the following data. In the course of inventorying Connecticut wetlands I made 362 collections of Chrysemys picta of which only 9 (2.5%) were from elevations above 900 feet. Low painted turtle densities were noted in many upland regions of New England including the Berkshire Mountains (MA) and White Mountains (NH).

LIFE HISTORY AND ECOLOGY:

I collected painted turtles in muddy bottomed rivers, lakes, reservoirs, wooded swamps, vernal pools, pasture ponds, and fens. They avoid swift flowing, rocky bottomed streams and I have not found them in brackish water. They are able to survive in severely disturbed and polluted habitats. Ponds surrounded by manicured lawns such as those found at golf courses and corporate parks frequently contain dense populations of painted turtles. These ponds are enriched with fertilizer runoff from the surrounding lawns, resulting in dense blooms of pond weed and algae which the turtles feed on.

Painted turtles begin to bask on warm, sunny days in late March. By mid April they are strongly in evidence, basking for most of the day. Basking continues well into October. I collected an actively swimming female in a pond which was almost totally frozen over on March 20 at Sharon (CT).

On sunny days, painted turtles begin to bask in the early morning. I observed turtles leaving comparatively warm water to bask during cool weather. Windy and cloudy weather curtails basking. As the season progresses and water temperature rises, turtles bask early in the morning, spending most of the day feeding and swimming. In late May and June they begin to bask on mats of aquatic vegetation, with only their carapace tops exposed.

By late April and early May, painted turtles are attracted to baited traps and can be presumed to be actively feeding. Trapping success drops off sharply by the end of September, probably correlated with cessation of feeding activity. This species does not appear to be nocturnal, the few I observed at night appeared inactive or asleep.

Although aquatic, painted turtles are often found on land. Males frequently wander overland during spring and early summer. Terrestrial movements by females are largely confined to the nesting season. Klemens (1978) reported a mass overland migration from a drying farm pond to a nearby wetland. Painted turtles rapidly colonize newly formed bodies of water.

Individuals may be found in the same pond year after year, while others may be marked and never seen again.

Turtles with a straight line carapace length in excess of 90 mm are usually sexed without difficulty. Males are distinguished by long front toe nails and a long, thick tail with the anal opening located posterior to the rear margin of the shell. Females have short front toe nails, and a comparatively short and thin tail with the anal opening situated under the rear margin of the carapace. Females are more highly domed than males of the same size and achieve noticeably larger maximum sizes than males. Most painted turtles from southwestern New England exceeding 130 mm straight line carapace length are females.

Females tend to be more wary than males. Most adult painted turtles that I hand collected in water were males. Trapping yields a more equitable sex ratio than hand collection, though still biased in favor of males. Various types of turtle traps and collection methods may produce artificially skewed sex ratios (Ream and Ream, 1966).

Courtship begins shortly after emergence from hibernation and continues through April and May. I have observed courting pairs on April 12 at Albany (NY) and April 22 at Hyde Park (NY). Finneran (1948a) found a mating pair on May 2 near Branford (CT). During courtship the male swims in front of the female rapidly vibrating his long toenails along her head. Mating usually follows, the male swimming atop the rear portion of the larger female's carapace.

I have found nesting females from May 30 through June 22. Finneran (1948a) observed nesting between June 3 and 28 at Branford (CT). Nesting occurs throughout the day and evening with rainy weather increasing nesting activity.

Congdon and Tinkle (1982) found clutch sizes of southern Michigan turtles ranging between 2-11 eggs with an average clutch size of 7.6 eggs. Finneran (1948a) examined seven nests laid at Branford and found clutch sizes of 5-7 eggs. The following table gives the clutch sizes of 16 Connecticut painted turtles which ranged between 5-9 eggs, with an average clutch size of 7.25 eggs which does not appreciably differ from Congdon and Tinkle's (1982) average clutch size.

TABLE 1

Clutch Sizes of Connecticut _Chrysemys picta_

AMNH NO.	LOCALITY	SLC (mm.)	CLUTCH SIZE
119259	New Fairfield	130	5
123134	Southington	136	6
127976	Essex	143	6
127965	Barkhamsted	148	6
123133	Southington	144	7
123135	Southington	147	7
127968	Barkhamsted	149	7
127966	Barkhamsted	151	7
123125	Greenwich	156	7
123129	Southington	146	8
119588	North Stonington	151	8
124996	Portland	158	8
119584	Groton	163	8
dead on road	Kent	???	8
123119	Greenwich	147.5	9
127280	Canaan	149	9

Finneran (1948a) recorded hatching dates from August 18 through September 2 at Branford and reported finding newly hatched turtles on April 26 and May 23. He attributed the April and May dates to overwintering in the nest. All hatchling painted turtles I collected were found in springtime, including a hatchling crossing a road a considerable distance from water at Kent (CT) on April 20. This individual had a well healed yolk sac scar and no caruncle, which is typical of hatchling painted turtles I find in late April and May. The absence of both caruncle and fresh yolk sac scar is evidence that painted turtles hatch in the autumn and overwinter in the nest, as newly hatched turtles possess a caruncle and fresh yolk sac scar. In southwestern New England hatchling Chrysemys appear to overwinter in the nest, the notable exception being Finneran (1948a). Zweifel (1989) reported overwintering in the nest to be the usual occurrence on Long Island (NY). Breitenbach et al. (1984) found confirmed reports of overwintering in the nest more common than those of autumn emergence. Storey et al. (1988) reported hatchling Chrysemys picta have the ability to survive freezing of extracellular body fluids enabling hatchlings to overwinter in shallow, exposed nest sites.

Growth is rapid during the first years of life. There is an ontogenetic change in carapace shape from round to oval as the turtles mature. Unlike other southwestern New England turtles, painted turtles shed their carapace and plastron scutes. This usually takes place in mid to late summer. The top layer of the scute peels off, revealing a fresh, often brightly colored, undersurface. This process may take several weeks to reach completion, and is most striking in heavily stained or algae encrusted turtles.

Two subspecies of painted turtles intergrade in southwestern New England resulting in a tremendous diversity of plastral patterns. Although the entire region is an intergrade zone between Chrysemys picta picta and Chrysemys picta marginata, Klemens (1978) found significant differences between western Connecticut turtles when compared to those from the Central Connecticut Lowland, coast, and eastern Connecticut. Turtles from western Connecticut had a higher incidence of plastral patterning indicative of Chrysemys p. marginata. Turtles from the coast, Central Connecticut Lowland, and eastern regions of the State had a lower incidence of plastral patterning indicative of Chrysemys p. picta. There were no significant differences in other taxonomic characters examined between these regions.

These data support hypotheses of Schmidt (1938) and Bleakney (1958) of postglacial invasion of Chrysemys picta into New England. During the Wisconsin glacial episode these turtles, as did all the region's flora and fauna, moved southward to non-glaciated refugia. As the ice receded and a temperate climate was restored, amphibians and reptiles began to migrate into southwestern New England. Chrysemys picta marginata moved through the Mississippi Valley, across the Midwest via the Great Lakes, entering New England from the north and west. Chrysemys picta picta moved northward via the much enlarged Atlantic Coastal Plain, entering New England from the southwest and spreading along the coast into the Central Connecticut Lowland and eastern New England. Several thousand years later these migration routes can be traced by examining the percentages of each gene pool represented in various extant Chrysemys picta populations.

Painted turtles are frequently parasitized by leeches and are susceptible to fungi and bacterial infections. These infections often begin at sites of shell scrapes and injuries. Their shell is relatively thin and delicate, these turtles sacrificing protection for speed and agility. Their streamlined light shell enables them to swim rapidly, swiftly shifting their direction if pursued in water. On land they are comparatively vulnerable and easily crushed by large carnivores. Raccoons, skunks, foxes and other vertebrates prey on eggs, young, and adults. Automobiles kill many every year.

Painted turtles are among the region's most successful turtles, surpassed only by snappers (Chelydra serpentina) in their ability to flourish in disturbed and polluted habitats. Although large numbers are killed each year, their high population densities adequately compensate for these losses. Painted turtles and their eggs may be locally important food sources for other vertebrates. They present no threat to game fish, although many get hooked and are subsequently killed by irate fishermen.

The creation of impoundments, reservoirs, and artificial ponds has benefited painted turtles by making more habitat available to them. Painted turtles utilize manmade open spaces to nest including railroad beds, lawns, and cultivated fields.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=30): AMNH 2115-17, 65439-40, 119249, 119257-59, 119579, 119598-99, 123117-27, 124982, 127273-75, 130562-63, 135231

Hartford Co. (n=27): AMNH 119252, 119580, 123128-35, 124983-88, 127276-79, 127960, 130007, 130564-67, 134251

Litchfield Co. (n=38): AMNH 119581-82, 119994-95, 119600-05, 124989-94, 127280-86, 127961-74, 133441

Middlesex Co. (n=10): AMNH 119583, 123136-38, 124995-96, 127975-77, 130568

New Haven Co. (n=51): AMNH 9144, 111431-33, 119253, 123139-68, 124997-125004, 127287, 127978-82, 130008-09

New London Co. (n=35): AMNH 119187, 119254, 119578, 119584-97, 119606-07, 123169-72, 125005-07, 127288-90, 127983-85, 130569, 133442-43

Tolland Co. (n=23): AMNH 119250, 119255-56, 123173, 127291-96, 127986-95, 130570-72

Windham Co. (n=54): AMNH 119251, 127297-344, 127996-99, 133444

Massachusetts

Berkshire Co. (n=42): AMNH 128129-32, 130119-26, 130690-95, 133538-59, 134341-42

Franklin Co. (n=9): AMNH 134343-51

Hampden Co. (n=4): AMNH 128133, 130696, 133560, 134352

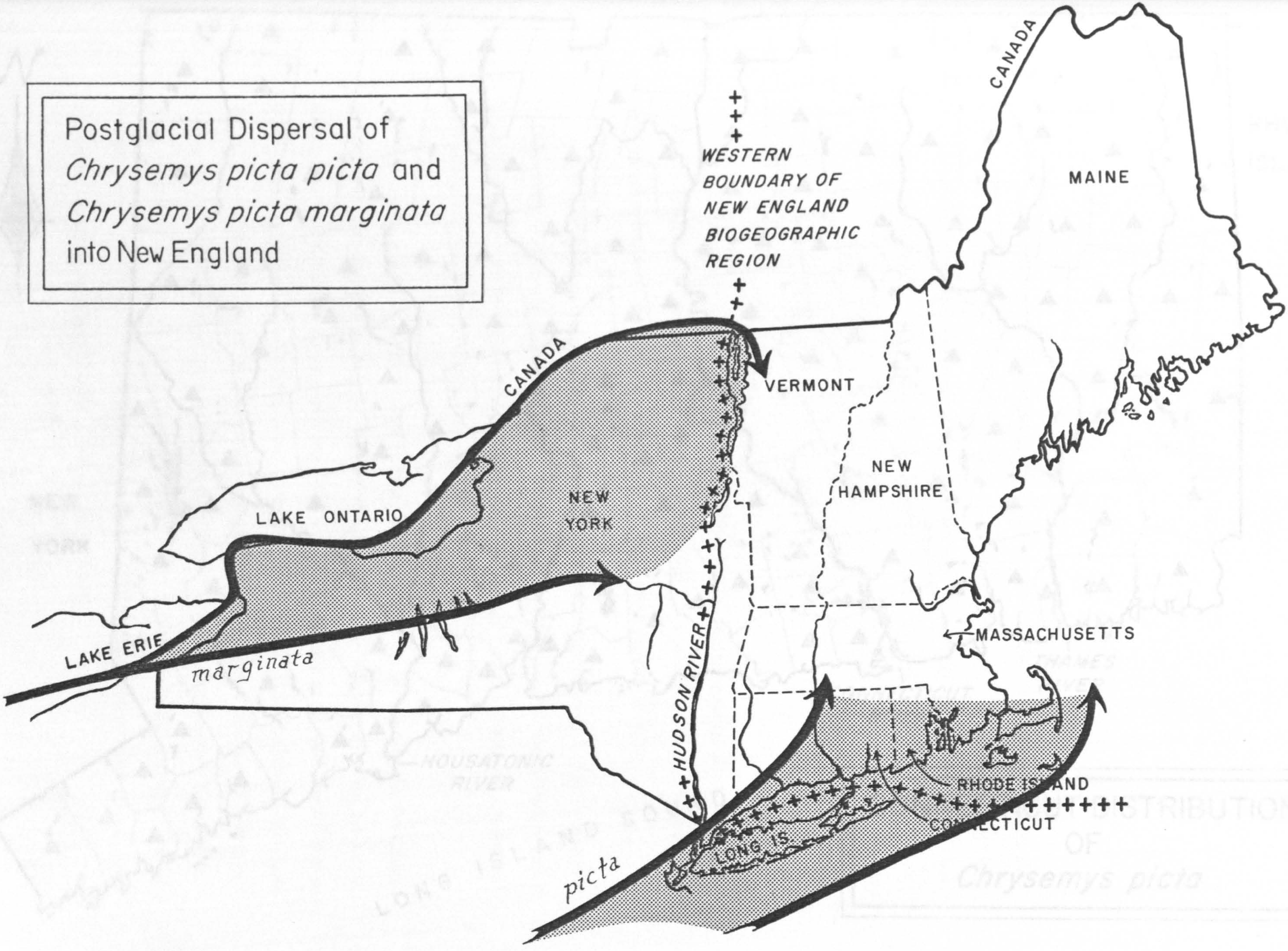
New York

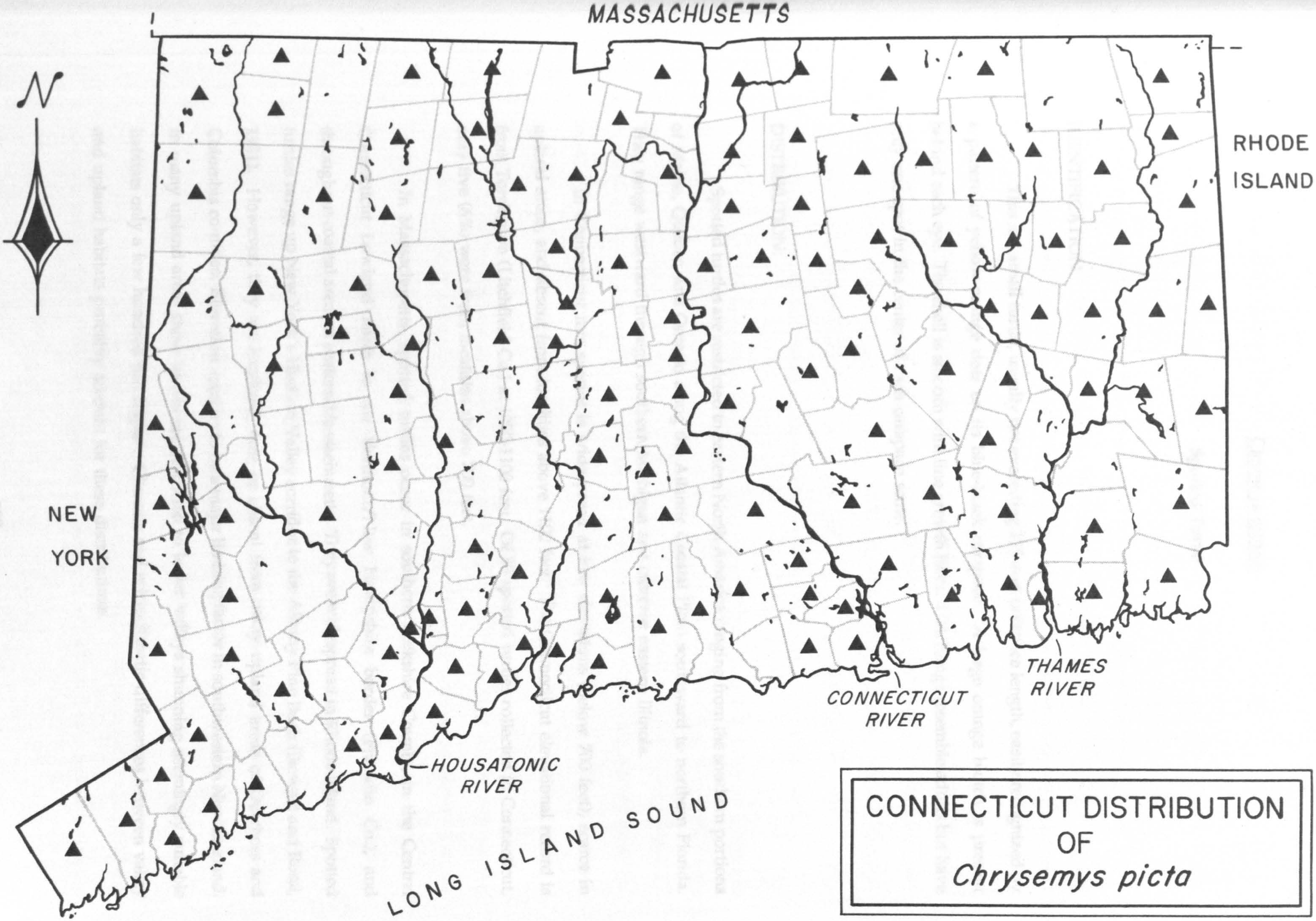
Columbia Co. (n=8): AMNH 130425-30, 134399; AMNH-MWK 7832

Dutchess Co. (n=50): AMNH 88672, 90620, 120136, 125455-56, 130162, 130769, 131456, 133615-16, 134400-39

Putnam Co. (n=6): AMNH 22724, 127464-65, 128163, 130165-66

Westchester Co. (n=10): AMNH 27711, 111943-45, 120042, 130167-68, 134542-44


Postglacial Dispersal of
Chrysemys picta picta and
Chrysemys picta marginata
into New England
CANADA
MAINE
WESTERN
BOUNDARY OF
NEW ENGLAND
BIOGEOGRAPHIC
REGION
CANADA
VERMONT
NEW
HAMPSHIRE
NEW
YORK
LAKE ONTARIO
MASSACHUSETTS
LAKE ERIE
marginata
HUDSON RIVER
RHODE ISLAND
CONNECTICUT
LONG IS.
picta



CONNECTICUT DISTRIBUTION OF *Chrysemys picta*

Clemmys guttata

Spotted Turtle

IDENTIFICATION:

This is a small turtle, usually not exceeding 125 mm carapace length, easily recognized by a pattern of yellow-orange dots on its blue-black carapace. A large orange blotch is present behind each eye. The shell is smooth with fine growth lines. Hatchlings resemble adults but have only one spot in the center of each carapace scute.

DISTRIBUTION:

Spotted turtles are restricted to eastern North America ranging from the southern portions of Maine, Quebec, and Ontario along the Atlantic Coastal Plain southward to northern Florida. They range westward through southern Michigan and extreme eastern Illinois.

In Connecticut this species is widespread at low elevations (below 700 feet), scarce in upland areas, and absent from localities above 1100 feet. The Connecticut elevational record is from Torrington (Litchfield Co.) at 1050-1100 feet. Of 85 spotted turtles collected in Connecticut, only five (6%) were from localities above 700 feet.

In Massachusetts, spotted turtles occur in southern Berkshire County, in the Central Connecticut Lowland north to the Vermont/New Hampshire border (Franklin Co.), and throughout coastal areas of eastern Massachusetts. They are widespread in Rhode Island. Spotted turtles range up New York's Hudson Valley corridor to the Albany Pine Bush (Stewart and Rossi, 1981). However, they are localized, rare, or absent from many upland areas of Dutchess and Columbia counties. Elevation appears to be a major limiting factor in southwestern New England. In many upland areas these turtles are restricted to lower valleys shunning seemingly suitable habitats only a few hundred feet higher. Climatic and microclimatic differences between valley and upland habitats probably account for these distributions.

LIFE HISTORY AND ECOLOGY:

Spotted turtles utilize a wide variety of shallow water habitats, both temporary and permanent. In southwestern New England spotted turtles occur in muddy bottomed, slow moving streams, marshy areas of large lakes, river floodplains, fens, drainage ditches, red maple swamps, vernal pools, quarry pools, bogs, small ponds, and tidal creeks. The ability of spotted turtles to utilize a wide variety of aquatic habitats may account for their widespread distribution in lowland areas.

Spotted turtles emerge from hibernation in early spring and may be found active in vernal pools contemporaneously with early breeding amphibians such as Ambystomid salamanders. My earliest seasonal observations of this turtle from Connecticut are February 19 (Hebron), March 30 (Greenwich), April 5 (Wallingford), and April 8 (Suffield). Spotted turtles are active at relatively low temperatures, often basking or moving about before the emergence of other turtles.

I found this turtle most frequently from April through June, but collected specimens throughout the summer into the autumn. The collection months of 74 Connecticut turtles were distributed as follows: February (1), March (1), April (7), May (29), June (24), July (6), August (3), September (2), and November (1). The progressive growth of wetland vegetation during the summer effectively camouflages turtles. They may be more active during summer and autumn months than my collection data indicate.

Terrestrial activity in males was common during April and May followed by nesting females in late May and early June. Terrestrial activity diminished during the summer, almost all turtles were captured in wetlands. The proclivity of this turtle to utilize temporary aquatic habitats may account for some terrestrial movements due to drying of ephemeral wetlands in late spring and early summer. I have no evidence of estivation in southwestern New England finding turtles active in wetlands during protracted hot, dry summer weather. The reduction in numbers collected from July onward may be interpreted as indicating estivation. However, this reduction may only indicate reduced collecting success due to the turtle's diminished terrestrial activity and the camouflage afforded by the luxuriant growth of herbaceous wetland vegetation.

Ernst (1970) found spotted turtles in Pennsylvania became mature at approximately 80 mm plastron length. The smallest nesting female he found was 80.9 mm and the smallest courting or mating male was 83.4 mm.

Mature males are characterized by a dorsally compressed carapace, a slightly concave plastron, tan chin, brown eyes, and a long, thick tail, with the anal opening further away from the rear edge of the plastron than females. Mature females have a comparatively highly domed carapace, slightly convex plastron, yellow chin, orange eyes, and a proportionately thinner tail with the anal opening nearer the rear edge of the plastron than in males.

I observed courting and mating turtles in Connecticut on May 7 (Thompson) and May 16 (Bethel). Finneran (1948a) reported mating pairs at Branford (CT) on March 21 and May 2.

I collected gravid or nesting females on June 1 (Hartland, CT), June 4 (Bedford, NY), June 6 (Egremont, MA), June 8 (Sheffield, MA), June 9 (Granby, CT), June 11 (Hyde Park, NY), June 14 (Greenwich, CT), June 15 (Andover, CT), June 16 (Sheffield, MA) and June 17 (Hyde Park, NY).

Spotted turtles utilize well drained embankments and pastures, as well as the tops of tussocks in fens and bogs for nesting. Clutch sizes of twelve specimens are given in the following table.

TABLE 2

Clutch Sizes of Clemmys guttata

AMNH NO.	LOCALITY	SLC(mm)	CLUTCH SIZE
127467	Bedford (NY)	103	3
134444	Hyde Park (NY)	103	3
134442	Hyde Park (NY)	103.5	3
123176	Greenwich (CT)	107	3
128134	Sheffield (MA)	108	3
134253	Andover (CT)	99.5	4
128000	Hartland (CT)	110	4
134443	Hyde Park (NY)	110	4
134441	Hyde Park (NY)	111.5	4
130011	Granby (CT)	113	4
130702	Sheffield (MA)	107	5
134445	Hyde Park (NY)	115	5

A specimen from Danbury (CT) laid four eggs in captivity. Ernst and Barbour (1972) gave a range of 3-5 eggs for 12 Pennsylvania specimens.

Finneran (1948a) stated that the eggs of this species hatch around September 20 at Branford (CT). I found hatchlings in spring and early autumn. An egg containing a live, fully developed turtle (AMNH 130575) was dug up in a vegetable garden at Chester (CT) on November 30. This specimen is the only evidence I have that this species overwinters in the egg.

Two males collected in the course of my study were exceptionally large, one equal to the record size of 127 mm given by Conant (1975). UMMZ 152980 from Eastford (CT) measured 127 mm SLC and AMNH 133564 from Great Barrington (MA) measured 124 mm SLC. In a population at Hyde Park (NY) marked in 1988, ten males ranged between 100-116.5 mm SLC and ten females between 93-115 mm SLC. The males weighed between 145-200 gm, the females between 115-225 gm.

Moski (1957) reported two genera of algae growing on the carapaces of spotted turtles he collected in North Haven (CT) and Wallingford (CT), Dermatophyton radicans and Cladophora Kuetzingiana.

Spotted turtles frequently have well healed predation injuries including gnaw marks along periphery of the shell, missing digits and limbs, and stub tails. For example, in a sample of twenty adults (ten of each sex) marked at Hyde Park (NY), fourteen had well-healed predation injuries. Warny (pers. comm.) found a smashed spotted turtle shell in a herring gull colony on Plum Island (NY). Road mortality, especially on the secondary roads, is high in late spring and early summer. I found spotted turtles with head and limbs chewed off by predators (most likely raccoons) and one turtle killed by vandals with an air rifle (BB gun).

The small and shallow wetlands inhabited by spotted turtles are easily drained and have been fragmented by development. Spotted turtles remain locally common in many areas of southwestern New England, though have become rare in many areas of Westchester County (NY) and lower Fairfield County (CT) due to suburbanization. The species' ability to exploit a wide variety of shallow water habitats may account for its widespread distribution. Overcollection of this attractive turtle poses a minor threat to certain populations. Habitat loss and fragmentation are the prime long term conservation problems facing this species. Spotted turtles are well protected in parks and forests managed by federal, state, and local jurisdictions, as well as in privately owned sanctuaries.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=14): AMNH 7799, 75799, 119260, 119608, 123174-76, 125008-10, 127345, 130010; CMNH 60128; UMMZ 155063

Hartford Co. (n=20): AMNH 119609, 123177-79, 127346, 128000, 130011, 133445, 134252; AMNH-MWK 7850; UCS 1860, 4693, 6462, 6469, 6501, 6675, 7054, 8104-05, 8093

Litchfield Co. (n=11): AMNH 119261, 123180, 127347, 133446; AMNH-MWK 7874, 7901; CMNH 19182; UCS 1861, 3438, 3445, 8434

Middlesex Co. (n=19): AMNH 119610, 123181-82, 125011-13, 127348, 128001-03, 130573-75, 134671; MVZ 147504; UCS 1858-59, 6772, 8433

New Haven Co. (n=12): AMNH 111434-35, 123183, 127349-50, 130012; SCSC 580; UCS 2164, 2998, 4811, 5787; YPM 7322

New London Co. (n=12): AMNH 119188, 119611-12, 127351-52, 130013, 130576, 133447-48; UCS 7192, 7506, 8432

Tolland Co. (n=19): AMNH 119262, 125014, 127353, 134253; AMNH-MWK 7863; BMNH 1973.2315; UMMZ 153004, UCS 1851-57, 7153, 7582, 7725, 8091; YPM 7321

Windham Co. (n=13): AMNH 127354, 128004, 133449; AMNH-MWK 7857; UMMZ 152980; UCS 961, 971, 979, 2488, 7172, 7393, 7777, 8431

Massachusetts

Berkshire Co. (n=8): AMNH 128134, 130127, 130702-03, 133561-64

Franklin Co. (n=1): AMNH 134353

Hampden Co. (n=3): AMNH 133565-67

Rhode Island

Kent Co. (n=7): AMNH 129918-20, 134715-16, 134800-01

Providence Co. (n=3): AMNH 129922, 130874, 134802

Washington Co. (n=10): AMNH 129629, 129923-25, 130875, 134717, 134807, 134810-11, 134813

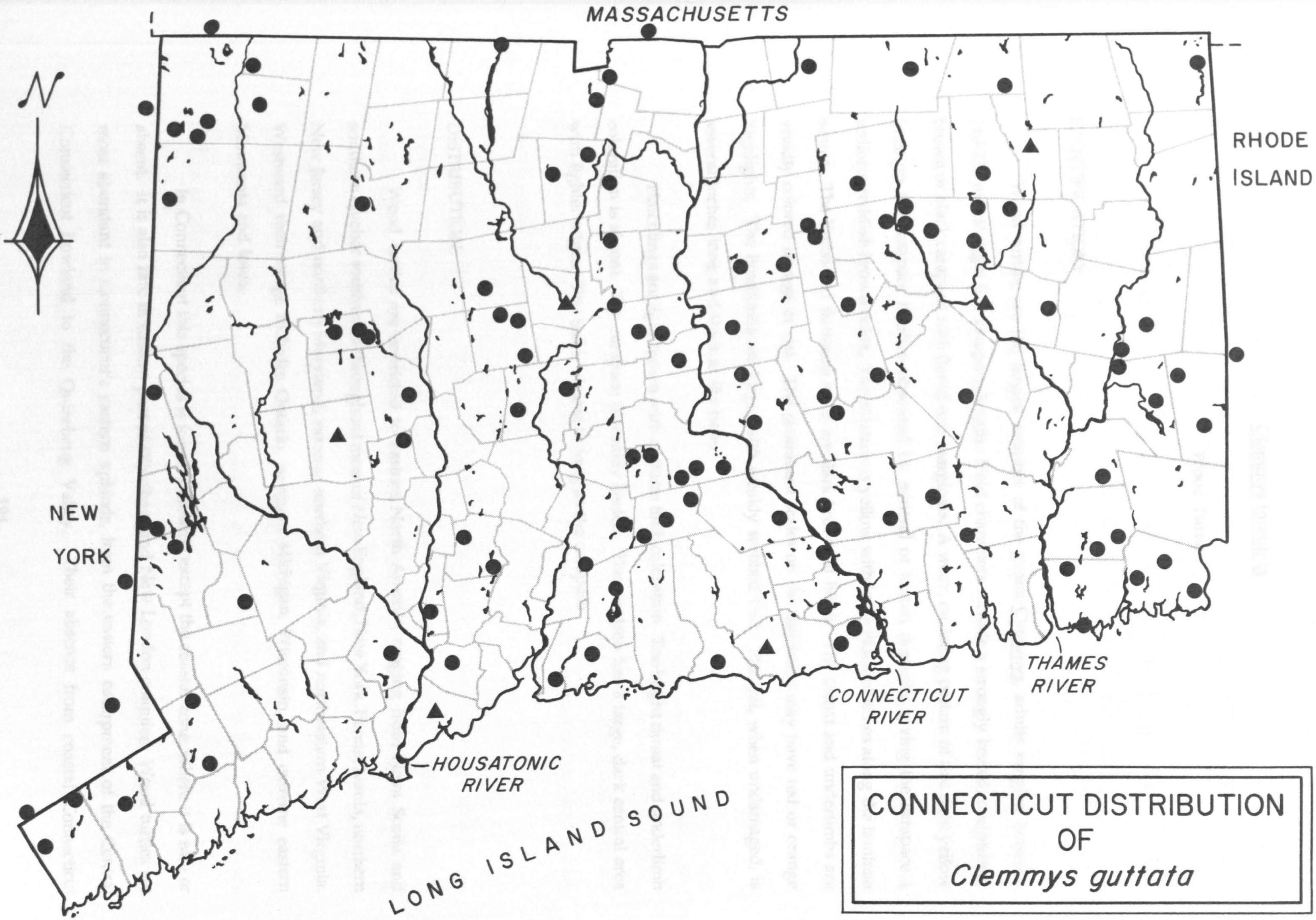
New York

Columbia Co. (n=1): AMNH 133617

Dutchess Co. (n=13): AMNH 130169, 133001-02, 133618, 134440-47; AMNH-MWK 7825

Putnam Co. (n=1): AMNH 130770

Westchester Co. (n=7): AMNH 4579, 65443-44, 127467, 130170-71; AMNH-MWK 7875


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
THAMES RIVER
CONNECTICUT RIVER
HOUSATONIC RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION OF *Clemmys guttata*

Clemmys insculpta

Wood Turtle

IDENTIFICATION:

Wood turtles are the largest member of the genus Clemmys, adults ranging between 140-230 mm straight line carapace length. Field characters include a strongly keeled, sculptured, brown or black carapace with flared rear marginals. A weak, radiating pattern of fine light yellow lines on the carapace is often obscured by mineral or tannin deposits, giving the carapace a uniform reddish brown color. The plastron is yellow with large black blotches along the laminae seams. The limbs and flattened head are dark brown or black. The throat and underlimbs are vividly colored orange or red. The prominent scales on the forelimbs may have red or orange highlights. The hindlimbs are large, with weakly webbed feet. The tail, when undamaged, is several inches long and thick at the base.

Hatchlings are light brown with uniform limb coloration. The bright throat and underlimb coloration is absent. The carapace is weakly keeled. The plastron has a large, dark central area with lighter edges. The tail is almost as long as the carapace.

DISTRIBUTION:

Wood turtles are restricted to eastern North America ranging from Nova Scotia and southern Quebec southward throughout most of New England, New York, Pennsylvania, northern New Jersey and northern Maryland, extreme northern Virginia, and northeastern West Virginia. Westward their range includes Ontario, northern Michigan, Wisconsin, and extreme eastern Minnesota and Iowa.

In Connecticut this species is found statewide except the coastal zone, where it is rare or absent. It is also rare in eastern part of Windham and New London counties. Wood turtles are most abundant in Connecticut's eastern uplands, from the eastern escarpment of the Central Connecticut Lowland to the Quinebaug Valley. Their absence from coastal Connecticut complements a regional pattern in the Northeast. Wood turtles are absent or very localized in coastal and pine barren habitats which encompass most of Rhode Island, Cape Cod, Long Island, southern New Jersey, and the Delmarva Peninsula. Wood turtles are locally common in the western half of Massachusetts and are widely distributed in New York's Putnam, Dutchess, and Columbia counties. They have become rare in Westchester County (NY) and adjacent areas of Fairfield County (CT) due to suburbanization.

Wood turtles occur from near sea level to highland regions. Of 61 wood turtles collected in Connecticut, only two (3%) were collected above 1000 feet. The scarcity of deep, low gradient streams may be a limiting factor at high elevations, as opposed to actual altitude. The highest elevations recorded in my survey are 1450 feet at Norfolk (Litchfield Co., CT), 1630 feet at Becket (Berkshire Co., MA), and 1700 feet at Plainfield (Hampshire Co., MA).

LIFE HISTORY AND ECOLOGY:

Wood turtles require riparian habitats bordered by floodplain, woodland, or meadows. I collected this species in swift, clear, pebble bottomed streams, as well as meandering, turbid, muddy waters, beaver meadows, fens, and wooded swamps. Terrestrial habitats utilized during the summer include pastures, old fields, woodlands, power line cuts, and railroad beds, bordering on or adjacent to streams and rivers.

Spring emergence occurs in late March and early April. Early seasonal records from Connecticut include March 10 (East Hampton), March 29 (Mansfield), April 8 (Vernon), April 13 (Mansfield), and April 17 (Manchester). At this time of year they bask on stream banks, having spent the winter hibernating nearby in deep pools or lodged below undercut banks. During late spring and throughout the summer, wood turtles may become quite terrestrial, moving into nearby fields and woodland. However, I have collected adult wood turtles in streams throughout the summer. As autumn approaches they return to streams, often congregating in small groups at favorite hibernating sites.

This species exhibits fidelity to specific streams and basking locations. I found the same male on a small section of railroad track at Vernon (CT) on July 11 and 24, 1975 and on May 27, 1976. Carroll and Ehrenfeld (1978) displaced 189 subadult and adult turtles between 0.35-50 km from their collection sites in the Catskill Mountains (NY). These turtles exhibited a strong homing ability though their success rate declined markedly in displacements exceeding two kilometers.

Wood turtles usually do not reproduce until they are at least ten years old. Sexual dimorphism is marked, males are larger and have a distinctly long and thick tail. Their heads are much larger when compared to females. The male's plastron is concave and his carapace dorsally compressed when compared to a female. Females tend to be smaller in overall body proportions. Their small and comparatively delicate heads lack the powerful jaw musculature of the males, their tails are thinner, and the plastron is flat or slightly convex. The tend to be more highly domed for their size than males.

Mating occurs in water and has been reported both in the spring and autumn. Fisher (1945) reported an early spring mating during a warm spell on March 26 near Wilton (CT). A mating pair was found by R. Schmidt (pers. comm.) on August 23 in the Shawangunk Kill (Orange Co., NY).

Gravid females can be found from mid May through July. I have found gravid or nesting females on the following dates: May 17 (Manchester, CT), May 19 (West Hartford, CT), May 27 (Falls Village, CT), May 28 (Bedford, NY), June 11 (Hyde Park, NY), June 12 (Amenia, NY), June 14 (Coventry, CT and Claverack, NY), June 17 (Hyde Park, NY), July 2 (North Canaan, CT). Clutch sizes of five specimens are given in the following table.

TABLE 3

Clutch Sizes of Clemmys insculpta

AMNH NO.	LOCALITY	SLC(mm.)	CLUTCH SIZE
134256	Coventry (CT)	166	4
127355	North Canaan (CT)	177	5
128009	Somers (CT)	168	7
MWK 7826	Claverack (NY)	174	7
133619	Amenia (NY)	178	12

Ernst and Barbour (1972) gave a range of 4-12 eggs for this species. Hatchling wood turtles were found on April 17 (Mansfield, CT), May 5 (Brookfield, CT), and June 10 (Sheffield, MA). As none of these turtles had a caruncle or fresh yolk sac scar, I assume that they hatched the previous autumn. Finneran (1948a) found a newly hatched, earth encrusted turtle at Branford (CT) on September 3.

A sample of ten wood turtles from a population marked in 1988 at Hyde Park (NY) had the following dimensions. Three males ranged from 182-200 mm SLC and seven females from 159-189.5 mm. The males weighed between 775-1000 gm, the females from 650-1000 gm.

Oliver (1955) reported a longevity of 58 years in captivity. I commonly find individuals between 15-20 years old. After twenty years annuli counts become increasingly unreliable. Some old individuals are worn smooth, obscuring all growth annuli.

Young wood turtles are eaten by a wide a variety of vertebrate predators. I often find adult wood turtles with various predation injuries including stub tails, missing digits and limbs, and gnawed or bitten shells. Road mortality is high, especially in developed areas. Despite their agility, climbing abilities, and intelligence, wood turtles occasionally become trapped between railroad tracks and die from exposure. I received a report of an individual trapped within a coil spring of a discarded mattress on a river bank at Shelton (CT). Latham (1971) reported dead wood turtles washing up on eastern Long Island (where they do not naturally occur) following Connecticut floods. I have found wood turtles infested with leeches of various sizes.

Wood turtles have been collected for food, by biological supply companies for laboratory use, and for the pet trade. A steady decline in numbers has been noted in many areas. Wood turtles are nominally protected from collection in CT, MA, NY, and RI. The greatest threat is the continued loss and fragmentation of habitat. This species has suffered severely from the effects of habitat fragmentation in many parts of southwestern New England. Heavy road mortality, overcollection, and loss of habitat has removed many adult turtles in these areas. This has resulted in localized extinctions as well as functionally extinct populations comprised of old adults with negligible recruitment of young turtles (Klemens, 1989). The loss of adult turtles is particularly deleterious to wood turtle populations as this species may take ten years to reach sexual maturity and has a low reproductive output. Wood turtles occur on lands protected by federal, state, and local jurisdictions as well as private sanctuaries. Due to the wood turtle's large home range only extensive tracts of protected land will provide sufficient habitat to effectively ensure its long term survival.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=13): AMNH 119189-90, 119263, 123184-85, 126586, 134254; UCS 942, 5072, 5202, 5764, 6379, 8102

Hartford Co. (n=13): AMNH 119264, 119613-14, 123188; UCS 1840, 6466-67, 6500, 6561, 6788, 7150, 7726, 8678

Litchfield Co. (n=12): AMNH 99552, 123186-87, 125015, 127355, 128005; UCS 1850, 3439, 3446, 4791, 7381, 7488

Middlesex Co. (n=3): AMNH 134255; UCS 1848-49

New Haven Co. (n=12): AMNH 79065-66, 119615-16, 128006-07, 134216-17; CMNH 40525;

UMMZ 99704, YPM 4955, 7732

New London Co. (n=3): AMNH 127356-57; UCS 6454

Tolland Co. (n=32): AMNH 119191, 119265, 119617, 125016-17, 128008-09, 130577, 133450, 134256; AMNH-MWK 7868; BMNH 1973.2316; UCS 1838-39, 1841-47, 2913, 5426, 5784, 7202, 7322, 7460, 7487, 7546, 8094, 8287, 8431

Windham Co. (n=8): AMNH 119266, 125018, 127358; UMMZ 154002; UCS 2615, 4692, 5766, 7484

Massachusetts

Berkshire Co. (n=8): AMNH 128135, 130128, 130704-05, 133568, 134354-55, 134516

Hampden Co. (n=2): AMNH 130129, 133628

Hampshire Co. (n=1): AMNH 134356

Rhode Island

Kent Co. (n=1): AMNH 134814

Washington Co. (n=2): AMNH 129926, 130876

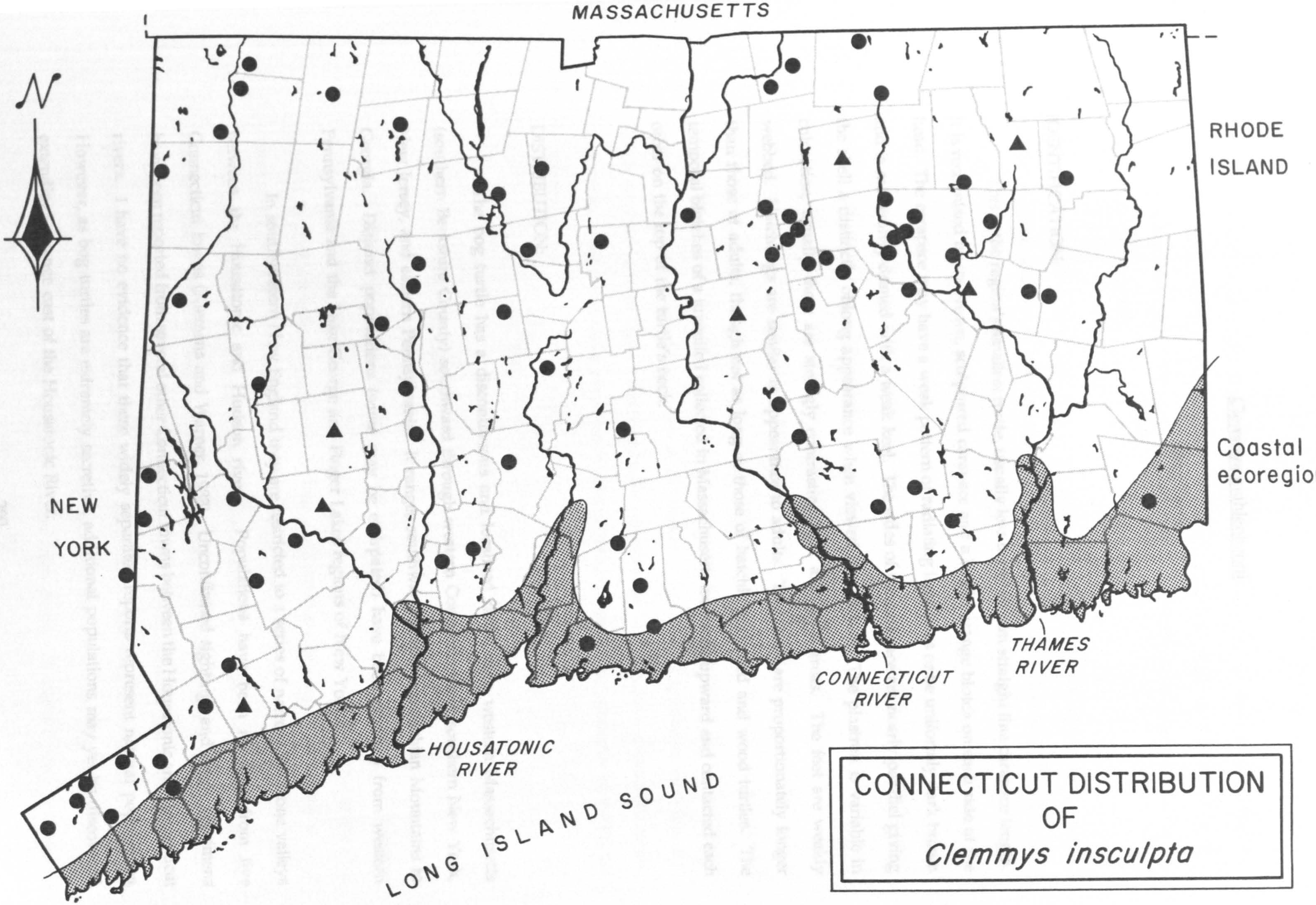
New York

Columbia Co. (n=2): AMNH 130771, AMNH-MWK 7826

Dutchess Co. (n=11): AMNH 89359, 130172, 130772-73, 133619, 134448-52; UMMZ 154408

Putnam Co. (n=4): AMNH 22725-26, 127468, 130175

Westchester Co. (n=3): AMNH 97277, 130774, 134453


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
Coastal ecoregion
THAMES RIVER
CONNECTICUT RIVER
HOUSATONIC RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION OF *Clemmys insculpta*

Clemmys muhlenbergii

Bog Turtle

IDENTIFICATION:

This is the region's smallest turtle, usually less than 100 mm straight line carapace length. It is recognized by its brown, sculptured carapace and a bright orange blotch on each side of the head. The carapace may have a weak pattern of radiating light lines or be uniformly dark brown and is moderately domed with a weak keel. The sides of the carapace are nearly parallel giving the shell a distinctly oblong appearance when viewed from above. The plastron is variable in coloration, usually there are strongly contrasting light and dark areas. The feet are weakly webbed. Hatchlings are similar in appearance to adults. Their tails are proportionately longer than those of adults, though not as long as those of hatchling spotted and wood turtles. The temporal blotches of a juvenile I collected in Massachusetts extended upward and contacted each other on the top of the turtle's neck.

DISTRIBUTION:

The bog turtle has a discontinuous and localized range from western Massachusetts (southern Berkshire County) southward through western Connecticut and southern New York, New Jersey, and eastern Pennsylvania. It ranges southward in the Appalachian Mountains to Georgia. Disjunct populations (some may be extirpated) have been reported from western Pennsylvania and the Lake George and Finger Lakes regions of New York.

In southwestern New England they are restricted to a series of narrow limestone valleys between the Housatonic and Hudson rivers. Populations have been reported from five Connecticut towns (Klemens and Warner, 1983). Unconfirmed sightings and single specimens have been reported from several other Connecticut towns between the Housatonic and Connecticut rivers. I have no evidence that these widely separated reports represent natural populations. However, as bog turtles are extremely secretive, additional populations may yet be discovered, extending its range east of the Housatonic River.

In Massachusetts populations have been recently discovered at three sites in southern Berkshire County (Klemens and Mirick, 1985; Klemens, in press). A single specimen from central Berkshire County (Blanchard, 1970) is not considered representative of an extant population by Klemens and Mirick (1985).

In southeastern New York, bog turtles occur at several sites in southeastern Columbia, eastern Dutchess, and eastern Putnam counties as well as west of the Hudson River (Rockland and Orange counties). Historically they appeared to be more widespread within this region. Bog turtles are probably extirpated in Fairfield County (CT) and Westchester County (NY).

Bog turtle populations in southwestern Connecticut and adjacent New York occur between 400-500 feet elevation. Populations in northwestern Connecticut and adjacent areas of Massachusetts and New York attain maximum elevations of 800 feet, though two individuals have been found at higher elevations (between 1,000-1300 feet). Of 35 bog turtles captured in northwestern Connecticut and adjacent Massachusetts (Berkshire Co.) 33 (94%) were captured between 500-700 feet. This narrow elevational range coincides with the distribution of calcareous wetlands, favored habitat of bog turtles in this region. Two isolated specimens were found at widely separated sites at higher elevations, under circumstances that may have involved relocation by humans. However, these may also represent transient turtles or remnants of extirpated populations.

LIFE HISTORY AND ECOLOGY:

In Connecticut and extreme southwestern Massachusetts this species is found in or near calcareous wetlands. Favored habitats are wet meadows and fens with a continuous gentle flow of water seeping through the surface soil. These areas are also characterized by a diverse floral community with few trees or tall shrubs. Usually bog turtles inhabit small pockets of optimum habitat located within a diverse and dynamic wetland ecosystem. Kiviat (1978) found bog turtles able to disperse between habitat patches of changing vegetation within a long term, stable, wetland complex. He found that beaver, deer, and cattle may be instrumental in maintaining the open canopy wetlands essential for this species' survival. Succession of many wetlands from open canopy fens to closed canopy red maple swamps may account for the bog turtle's irregular distribution. The "trapping out" of beaver in these areas during colonial and early post-colonial times undoubtedly accelerated changes in wetland vegetation by allowing the unimpeded growth of wooded swamps with subsequent decline of bog turtles.

New England bog turtle habitats support a unique assemblage of regionally rare plants including tamarack (Larix laricina), dwarf birch (Betula pumila), shrubby cinquefoil (Potentilla fruticosa), grass of Parnassus (Parnassia glauca), fringed gentian (Gentiana crinita), and various sedges (Carex sp.). These specialized habitats are extremely fragile and susceptible to a host of destructive factors. Nutrient enriched water from septic and fertilizer runoff can enrich calcareous fens, causing rapid growth of vegetation with subsequent canopy closure. Although light grazing of cattle may be beneficial, heavy bovine use destroys the unique plant community through overgrazing and nutrient enrichment from feces. Disturbance of surface soil can result in the establishment of alien wetland plants such as purple loosestrife (Lythrum salicaria) and reed grass (Phragmites australis). These two invasive species are usually found where drainage ditches or ponds have been dug in calcareous wetlands. Favored colonization sites are the berms of excavated soil placed alongside ponds and ditches. After establishing themselves on these disturbed microhabitats, they rapidly spread into the adjacent wetlands, replacing a diverse botanical community with an alien monoculture.

Field studies have been conducted on bog turtles in Pennsylvania (Barton and Price, 1955; Ernst, 1977), New Jersey (Zappalorti, 1976), and Delaware (Arndt, 1977). These sites are usually not calcareous (except northwestern New Jersey) and varied in types of vegetation and land usage. They include pastures, wet meadows, and the borders of red maple swamps with a diversity of underlying soils and vegetational communities. In short, bog turtles appear more widespread, inhabiting a greater diversity of wetland types in the central portion of their range than at their range limit in southwestern New England. I have begun detailed ecological studies at several sites in Massachusetts (Klemens, in press). Published reports concerning this species in southwestern New England are range extensions accompanied by brief habitat descriptions (Stewart, 1947; Robinson, 1956; Klemens and Warner, 1983; and Klemens and Mirick, 1985).

In northwestern Connecticut and southwestern Massachusetts, I found bog turtles active from April 26 through September 26, with 85% of my collections occurring in May and June. In eastern Pennsylvania Ernst (1977) found them active from late March through late September.

Daily activity in Massachusetts populations varies considerably with the prevailing weather conditions and the previous night's temperature. On very warm days (80-90 F) in late May and June turtles emerge between 8:00-9:00 h. Basking often ends by mid morning. During spring and autumn, or during cool weather, turtles emerge in mid morning and may bask all day. On windy days they bask under a cover of dry vegetation on the top of a tussock.

One male from Sharon (CT) and one female from Sheffield (MA) moved several hundred feet between capture and recapture points within an elongate habitat strip. A female from Egremont (MA) moved 1100 feet between capture and recapture points within a month. Ernst (1977) calculated a mean home range of 1.28 ha for 19 bog turtles in eastern Pennsylvania. Males averaged 1.33 ha and females 1.26 ha respectively.

Single individuals have been found considerable distances from suitable habitat at several sites in Connecticut and New York. These apparent long distance movements may result from emigration out of habitats declining in quality through disturbances or succession.

Population densities vary from site to site. The number of turtles found at Connecticut sites is low when compared to many literature reports and my Massachusetts study areas. This may well be due to the lack of intensive, daily work at the Connecticut sites. However, several Connecticut sites have been damaged by purple loosestrife, which by diminishing habitat quality may lower the population density of bog turtles. Additional field work is urgently needed to assess the status of Connecticut bog turtle populations in the towns of Sharon and Salisbury (Litchfield Co.) where viable habitat remains.

Turtles marked at three Massachusetts sites were distributed as follows:

TABLE 4

Composition of Three Massachusetts Bog Turtle Sites

SITE NAME	MALE	FEMALE	JUVENILE	HATCHLING	TOTAL
Sheffield:1	8	21	2	5	36
Sheffield:2	7	5	1	0	13
Egremont	9	15	1	5	30

Sexual dimorphism is marked in adult animals. Males are characterized by a proportionately flatter carapace, concave plastron, and long, thick tail with the vent beyond the posterior carapace margin. Females are more highly domed for their size, have flat or slightly convex plastrons, relatively short and thinner tails, with the vent located beneath the posterior margin of the carapace.

The smallest sexually mature individuals found at my Massachusetts sites were a male with a fully developed tail and plastral concavity in his ninth year measuring 73 mm plastron length and two gravid females measuring 76 mm and 79 mm plastron length in their fifteenth and tenth years respectively. In eastern Pennsylvania, Ernst (1977) found both sexes attained sexual maturity at 70 mm plastron length, with some individuals maturing in their sixth year.

In Massachusetts, I observed mating turtles on May 14, 18, 21, and 24 and found gravid bog turtles from May 24 through June 16. Gravid turtles were distributed as follows: May 24 (1), May 29 (1), May 30 (4), May 31 (1), June 4 (2), June 6 (2), June 8 (1), June 9 (2), June 15 (1), June 16 (1).

A Sheffield (MA) female examined by radiography contained three eggs. Two clutches deposited in the tops of tussocks at Egremont (MA) contained four eggs each. Warner (pers. comm.) reported four eggs laid in captivity by a Ridgefield (CT) specimen several weeks after capture. Clutch size varies from one to five eggs, with three to five the normal number (Bury, 1979). Eggs are frequently reported as being deposited in the tops of tussocks which characterize bog turtle habitats. This appears to be the preferred nest site of bog turtles in Massachusetts. I observed a hatchling emerging under natural conditions from an egg on September 2 at Egremont (MA). This hatchling remained in the tussock top nest until September 13. Barton and Price (1955) reported a nest hatching under natural conditions on September 7 in eastern Pennsylvania. Ten Massachusetts hatchlings measured between 18.5-21.6 mm (average 20.4 mm) plastron length. Ernst (1977) gave size ranges of 17.2-28.5 mm plastron length for Pennsylvania hatchlings. In Massachusetts I found hatchlings in May, June, and September. Those found in September had fresh yolk sac scars and caruncles, whereas hatchlings found in May and June had well healed yolk sac scars and no caruncles. I marked a hatchling on May 23 and recaptured it on July 19. During that period it grew from 25 mm to 30.5 mm SLC. These data indicate that bog turtles hatch in the autumn but do not commence growth until the following summer.

Of 65 adult Massachusetts turtles measured in my three study areas the largest male was 97 mm SLC and the largest female 96 mm. The size range was 79.5-97 mm which falls within the lower end of a range of 80-115 mm given by Ernst and Barbour (1972). The SLC measurements of these adult turtles are given in the following table.

TABLE 5

Adult Bog Turtle Measurements at Three Massachusetts Sites

SITE	MALES	FEMALES
Sheffield:1	79.5-97 mm (n=8)	80.5-94.5 mm (n=21)
	(average 89.7 mm)	(average 88.7 mm)
Sheffield:2	87-92.5 mm (n=7)	84-89.5 mm (n=5)
	(average 89.6 mm)	(average 87.2 mm)
Egremont	88.5-95 mm (n=9)	83-96 mm (n=15)
	(average 91.3 mm)	(average 90.2 mm)

Many individuals aged by annuli counts were in their mid teens. At about fifteen years, annuli counts became unreliable due to wear as well as the narrowness of the new growth lines. Bowler (1977) gave an age of 14 years for an individual maintained in captivity.

The small size of adult bog turtles may make them more vulnerable to predators than larger species such as wood turtles. In my sample of 65 adult Massachusetts bog turtles (41 females, 24 males) 21 females and 8 males had well healed predation injuries varying from tooth marks to missing marginals and limbs. These data indicate that over 50% of females versus 33% of males had predation injuries. I found several bog turtles with the head and limbs chewed off, received several killed on roads, and one which fell into a below ground swimming pool and drowned. The greatest threat to their survival is loss or alteration of its highly specialized habitat and collection for the wild animal trade.

The bog turtle has little economic importance save to those unscrupulous individuals who collect and sell them in an often flourishing wild animal trade. Apart from its small size and attractive shell and coloration, its rarity makes it eagerly sought after by collectors. Occasionally individuals conducting work on behalf of various state and conservation agencies are unable to resist the temptation to keep one or two turtles in captivity as "educational exhibits" or engage in some "captive breeding", "head starting", or "relocation" without considering the basic principles of conservation biology or sound wildlife management. These abuses are among the most difficult to stop as they are perpetrated by individuals who feel that these activities benefit bog turtles. Bog turtles are strictly protected against collection throughout their New England range, though enforcement is difficult. Often too much emphasis has been placed on protecting the species and not the habitat.

Habitat loss, fragmentation, and alteration are the main causes of their continued decline. Several wetlands containing bog turtle populations have been recently acquired with a combination of state and private funding. These purchased areas are relatively small, and although encompassing the turtle population, leave the drainage basin largely unprotected. Therefore, although the core habitat may be protected, the amount and quality of water entering these areas, which ultimately determines their suitability for bog turtles, is not controlled. The loss and alteration of these habitats may result in this species extirpation from Connecticut in the "foreseeable future" (Klemens and Warner, 1983).

Among the ecological problems associated with bog turtle habitats are succession to wooded swamps, drainage and flooding of habitats through diversion or damming of feeder streams, chemical and heavy metal pollution, nutrient enrichment from fertilizer and septic runoff, and the establishment of alien plants.

The only hope for this species' survival will be the protection of bog turtle habitats with some control over large portions of surrounding areas to serve as buffer zones. Management of certain sites may be warranted to offset accelerated succession resulting from disturbance. Drainage basin protection plans for small streams draining bog turtle habitats have been proposed for several New England sites with a composite of habitat protection mechanisms including outright ownership by state or private conservation agencies, acquisition of certain rights to a parcel of land such as development and water without actual land ownership (easement), and codified but not legally binding management agreements with private landowners (registry).

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=3): AMNH 119267-69

Litchfield Co. (n=7): AMNH 120255, 127359; UCS 5795, 7138, 7156-57, 7382

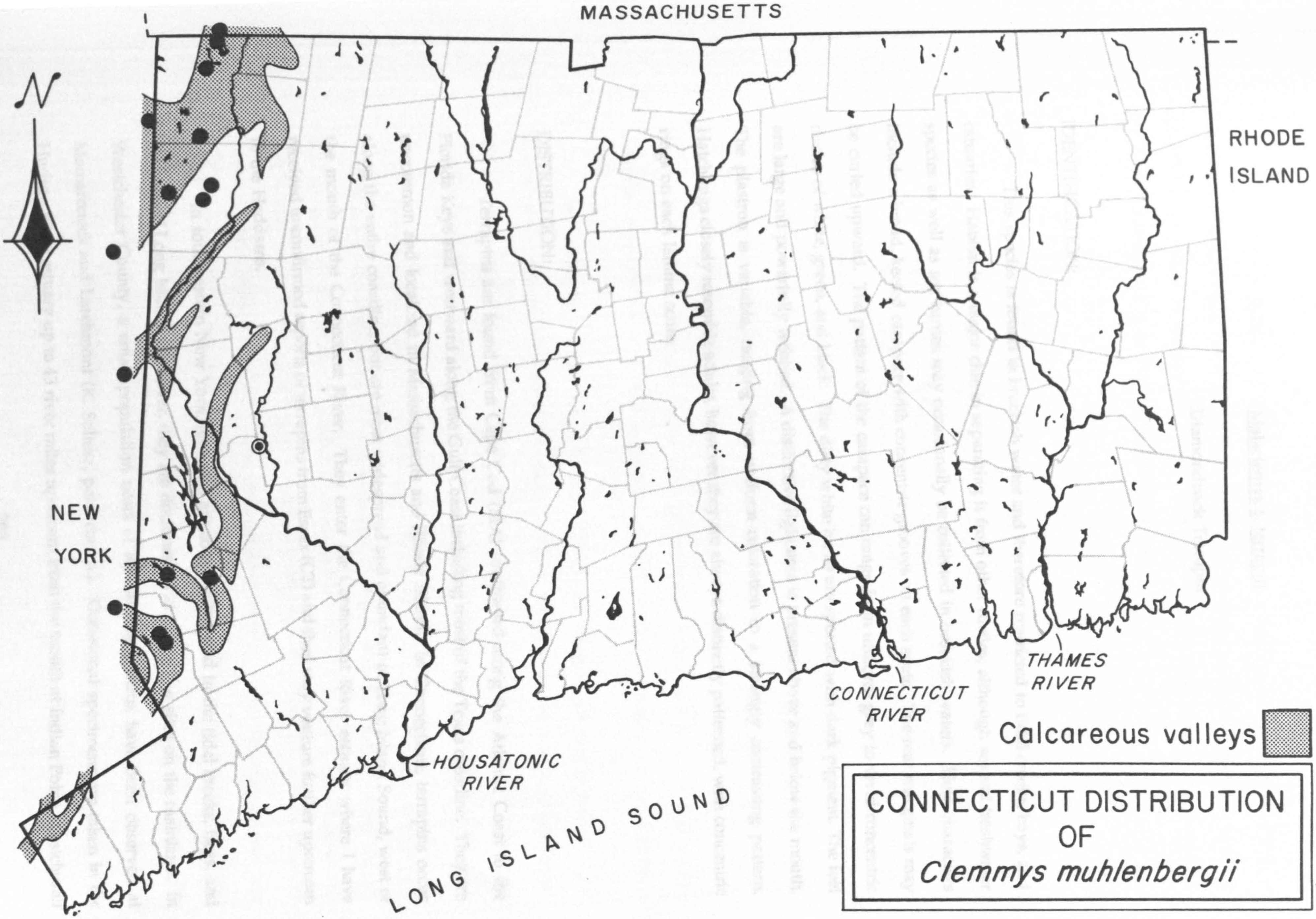
Massachusetts

Berkshire Co. (n=10): AMNH 130706-10, 133569-72; AMNH-MWK 8012

New York

Dutchess Co. (n=1): AMNH 67854

Westchester Co. (n=15): AMNH 97655, 98470-71+7, 100387-91


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
THAMES RIVER
CONNECTICUT RIVER
HOUSATONIC RIVER
LONG ISLAND SOUND
Calcareous valleys
CONNECTICUT DISTRIBUTION OF *Clemmys muhlenbergii*

Malaclemys t. terrapin

Diamondback Terrapin

IDENTIFICATION:

This species is found in brackish water and therefore restricted to tidal creeks, bays, and estuaries. Habitat is a major clue in separating it from other turtles, although several freshwater species as well as sea turtles may occasionally be collected in brackish waters. Field characters include a broad, keeled carapace with concentric grooves on each scute. The rear marginals may be curled upward. The pattern of the carapace can range from uniform grey to vivid concentric circles of white, green, and black. The dirty white limbs are spotted with dark pigment. The feet are large and powerfully webbed. A distinctive light area is present above and below the mouth. The plastron is variable, ranging from uniform coloration to a strongly contrasting pattern. Hatchlings closely resemble adults, however they are always distinctly patterned, with concentric rings on each lamina scute.

DISTRIBUTION:

Terrapins are found from Cape Cod (MA) southward along the Atlantic Coast to the Florida Keys and westward along the Gulf Coast including most of the Texas coastline. They are uncommon and localized in Massachusetts and Rhode Island. In Connecticut, terrapins occur along the entire coastline, but are most widespread and abundant in Long Island Sound, west of the mouth of the Connecticut River. They enter the Connecticut River estuary where I have received unconfirmed reports of terrapins from Essex (CT) and they may venture further upstream to the Haddams.

In southeastern New York, terrapins are commonly found in the tidal creeks, bays, and marshes of Long Island. However, they are documented at only a few sites on the mainland. In Westchester County, a small population nests at Rye and specimens have been observed at Mamaroneck and Larchmont (K. Soltesz, pers. comm.). Occasional specimens are taken in the Hudson River estuary up to 43 river miles upstream from the mouth at Indian Point, Westchester

Co. (Platt, 1978). A female was collected by seine in the Hudson River at Bear Mountain (Rockland Co.) on October 20, 1978. A terrapin was observed in the Hudson River at Piermont Marsh (Rockland Co.) by Boyle (1969). Two specimens were collected in the Bronx River in 1955 on May 23 and July 27 (J. A. Oliver, unpublished data).

LIFE HISTORY AND ECOLOGY:

Terrapins are restricted to brackish water habitats, specifically bays, salt marshes, tidal creeks, and estuaries. They tolerate pollution, thriving in waters surrounding New York City, Bridgeport, and New Haven. Terrapins favor many of the smaller coastal rivers which have areas of healthy salt marsh.

Little is known about the activity cycles of terrapins in southwestern New England. They become active later in the season than freshwater turtles due to the slower warming of ocean water. I canoed through a Norwalk salt marsh where terrapins are abundant on a warm day in late April. I did not see any terrapins although freshwater turtles had been active in nearby wetlands for several weeks. Several weeks later I received a report of terrapin activity at this site.

At Jamaica Bay Wildlife Refuge in New York City, adults were observed as early as April 29 and were commonly seen after mid May (R. Cook, pers. comm.). In southern New Jersey, terrapins were found hibernating in depressions at the bottom of tidal creeks, dug into creek banks near the upper tide limit, and beneath undercut banks in the intertidal zone (Yearicks et al., 1981).

Female terrapins are considerably larger than males. Conant (1975) gave a size range of 150-229 mm for females and 100-140 mm for males. A female from Fairfield measured 190 mm SLC. Finneran (1948b) measured an adult female from Milford Point that weighed 690 grams and was 160 mm long. Babcock (1919) gave detailed measurements of an adult female from Cos Cob (CT) with a SLC of 7.5 inches (=190 mm). Females have broader, blunter heads than males, and wider, more highly domed shells. Males have long, thick tails with the anal opening well beyond the posterior margin of the carapace. Females have shorter tails with the anal opening in front of the posterior margin of the carapace. Mating aggregations were observed at Jamaica Bay Wildlife Refuge on May 14 and May 24 (R. Cook, pers. comm.).

Nesting takes place in June and continues through July. Maximum nesting activity often coincides with high tides which decrease the time period the female is exposed to predators. Nesting at high tide reduces the risk of desiccation or thermal stress, and decreases the distance a turtle must walk to a nesting area above the high tide line (Burger and Montevecchi, 1975). Nesting during high tide also ensures the turtles' nests are placed above areas of maximal tidal inundation. At Jamaica Bay Wildlife Refuge, maximum nesting activity occurred during high tides from June 8 through July 22. Peak activity occurred in late June and early July (R. Cook, pers. comm.). At Rye (NY) terrapins have been observed nesting on June 23 and July 10 (K. Soltesz, pers. comm.). Finneran (1948b) reported terrapin eggshells on the marsh side of Milford Point (CT) beach in late June. Bob Craig (pers. comm.) found two predated nests at Hammonasset State Park (CT) on June 25. Ernst and Barbour (1972) gave a clutch size of 4-12 eggs. Clutch sizes in southwestern New England are often larger. A terrapin collected July 13 at Fairfield (CT) measured 190 mm SLC and contained 12 eggs. She was in her thirteenth growing season. A nest exhumed at Westport (CT) contained 13 eggs. Eleven terrapin nests examined at Jamaica Bay Wildlife Refuge contained 11-18 eggs with an average clutch size of 14.9 eggs (R. Cook, pers. comm.). Three clutches from Rye (NY) contained 8, 11, and 15 eggs. Double clutching with a seventeen day interval has been documented at Rye. A marked female deposited 15 eggs on June 23 and was recaptured on July 10 after laying 11 eggs (K. Soltesz, pers. comm.).

Hatchlings were found at Norwalk (CT) in June and late September. At Jamaica Bay Wildlife Refuge there are two peaks of hatchling occurrence, in late April through May and again in September. The earliest hatchling found was on April 21 and the latest on November 8. Hatchlings found in spring frequently lacked caruncles while those found in the autumn often had fresh yolk sac scars and caruncles (R. Cook, pers. comm.). These data indicate hatching usually takes place in late summer and early autumn.

In 1984 five undisturbed terrapin nests were monitored from date of laying to hatching at Jamaica Bay Wildlife Refuge. Incubation periods for these nests were 72, 75, 76, 93, and 100 days. Three of these clutches were deposited on July 2 with incubation periods of 72, 76, and 93 days (R. Cook, pers. comm.)

Terrapins are extremely variable in shell coloration and patterning. I have examined brightly marked individuals as well as all grey specimens. Limb coloration can vary from white with numerous black dots to uniform grey. Commercial restocking of terrapins into several areas, with subsequent mixing of gene pools, may account for some diversity of color patterning. Terrapins from different parts of the eastern United States were experimentally crossed at the U.S. Fisheries Biological Station at Beaufort, North Carolina, to develop large and tasteful turtles for human consumption (Hildebrand, 1933). Possibly some of these crosses were released into the wild.

Hildebrand (1929) estimated that terrapins can survive at least 25-40 years. Bowler (1977) reports a survivorship of nine years in captivity. Terrapins feed on a variety of marine and tidal mollusks, snails, invertebrates, fish, and carrion. The flattened and wide alveolar jaw surfaces enables them to break open the shells of their prey.

Eggs and immature terrapins are eaten by variety of vertebrate and some invertebrate predators. I found a decapitated juvenile in a salt marsh heavily used as a feeding ground by herons and egrets near Norwalk (CT). Humans and their activities are the prime cause of adult mortality. Terrapins are collected for consumption in unprotected parts of Jamaica Bay as well as other areas. Large numbers of nesting females and hatchlings are killed on coastal roads. Motorboats have been implicated in terrapin deaths in several areas including Rye. Terrapins drown when entering submerged crab and lobster traps. I examined drowned terrapins from Gardiners's Island (Long Island) and Jamaica Bay, the latter had several barnacles attached to her carapace.

Terrapins were commercially harvested in large numbers during the early decades of the twentieth century. The United States government ran a terrapin hatchery at Beaufort (North Carolina) which is a testament to this species' economic importance. Dwindling numbers of terrapins, the economic depression of the 1930's, and a change in culinary preferences resulted in reduced terrapin fishery in the subsequent decades. Terrapin populations have recovered remarkably. In many areas where terrapins were considered a rarity twenty years ago, large viable populations presently exist. Terrapins provide an excellent example of a species brought to the brink of local extinction by decades of non-sustainable harvesting. Despite their subsequent recovery they remain vulnerable should intensive, unregulated exploitation resume.

Terrapins are able to survive in waters polluted by sewage, chemicals, heavy metals, and elevated temperatures. They congregate at warm water discharge sites of electrical generating stations along the Connecticut shoreline. The tolerance of terrapins to chemical and heavy metal pollution may render them unsafe for human consumption in various areas.

Continued destruction of salt marsh and adjacent beach areas reduces terrapin habitat. In southwestern Connecticut and adjacent New York (Westchester Co.) terrapins are restricted to fragments of salt marsh. Heavy motor boat traffic may have an adverse impact upon terrapins especially in late spring, when large numbers congregate and mate at the water's surface.

Terrapin habitats, including nesting areas, are protected within several Connecticut State Parks, two Westchester County Parks, and at the Jamaica Bay Wildlife Refuge in New York City (Queens and Kings counties). A restored salt marsh at Fairfield (CT) has been colonized by a small but growing population of terrapins.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=11): AMNH 119618, 128010-11, 134257, 135232; CU 4136; UCS 1901-02, 7707-08, 8653

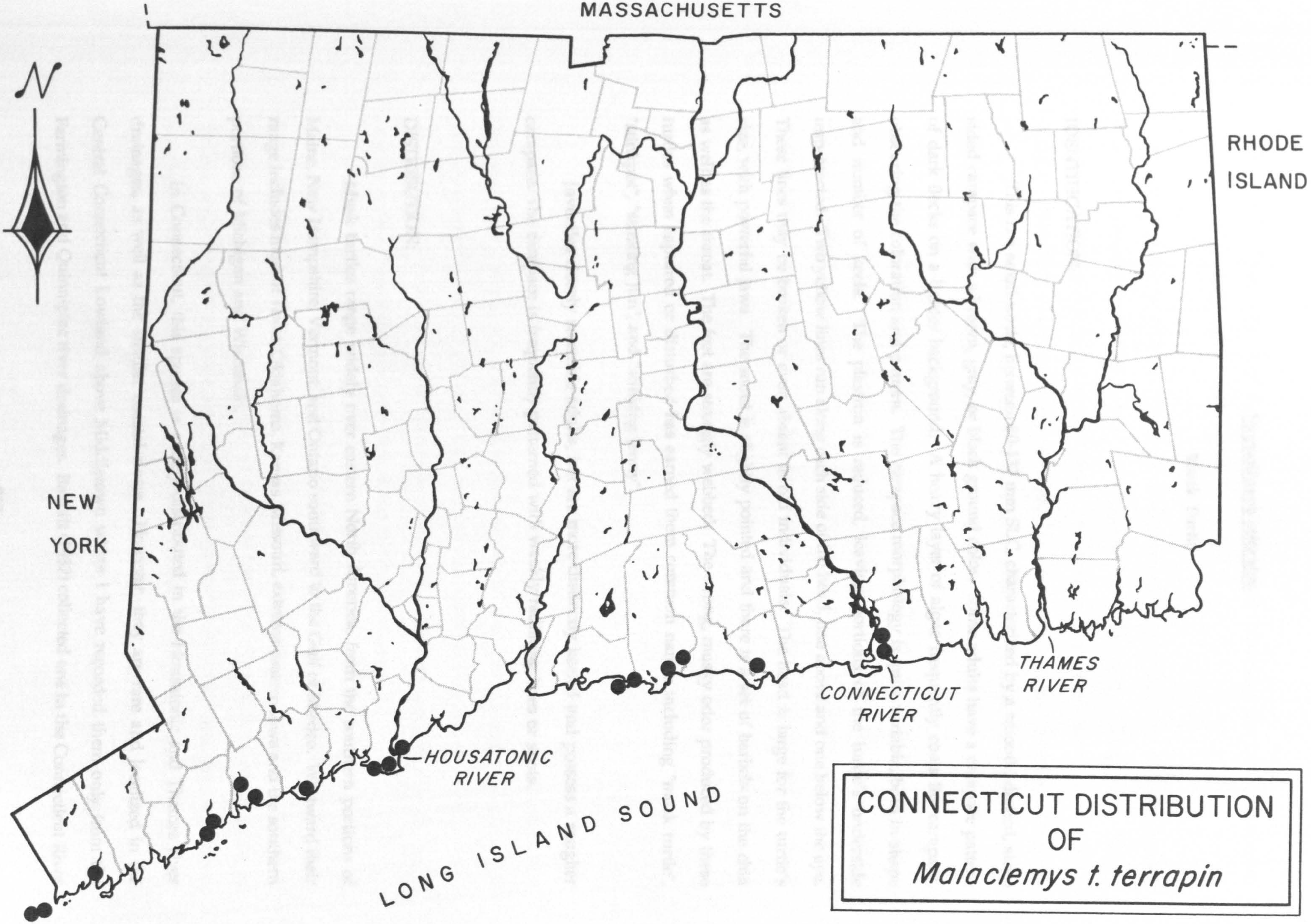
Middlesex Co. (n=1): UCS 7116

New Haven Co. (n=9): AMNH 123189-90, 134258; UCS 7196; YPM 2902, 2914, 8058-60

New London Co. (n=1): USNM 134406

New York

Westchester Co. (n=5): AMNH 134517, AMNH-MWK 7882-85



CONNECTICUT DISTRIBUTION
OF
Malaclemys t. terrapin

Sternotherus odoratus

Musk Turtle

IDENTIFICATION:

This is a small turtle, between 80-137 mm SLC, characterized by a smooth, domed, steep sided carapace with a brown, gray, or black ground color. Some adults have a carapace pattern of dark flecks on a lighter background. A heavy layer of algae frequently coats the carapace, obscuring the coloration and pattern. The carapace morphology is quite variable, both in shape and number of keels. The plastron is reduced, leaving portions of the turtle's underside unprotected. Two yellow lines run along each side of the head, one above and one below the eye. These lines may be broken or even absent in old individuals. The head is large for the turtle's size, with powerful jaws. The snout is slightly pointed and there is a set of barbels on the chin as well as the throat. The feet are strongly webbed. The strong, musky odor produced by these turtles when captured or disturbed has earned them common names including "musk turtle", "stinkpot", "stinking Jim", and "stinking Jenny".

Juveniles closely resemble adults, but are more distinctly keeled and possess a rougher carapace. The carapace is frequently patterned with weakly radiating lines or spots.

DISTRIBUTION:

Musk turtles range widely over eastern North America, from the southern portions of Maine, New Hampshire, Vermont, and Ontario southward to the Gulf of Mexico. Westward their range includes most of Texas, Oklahoma, Kansas, Missouri, extreme eastern Iowa and the southern portions of Michigan and Wisconsin.

In Connecticut, this species is widely distributed in the Housatonic and Thames river drainages, as well as the smaller coastal rivers. However, they are rare and localized in the Central Connecticut Lowland above Middletown where I have recorded them only from the Farmington and Quinnipiac river drainages. Babbitt (1932) collected one in the Connecticut River at Rocky Hill. They occur in a few northwest Connecticut lakes, but are absent from many seemingly suitable habitats.

Musk turtles occur throughout most of Massachusetts, becoming increasingly rare in the upland western portions of the state and absent from highland regions. They have not been documented from Berkshire County (MA) but I suspect they are present. Musk turtles occur in many tributaries to the Hudson River in Columbia, Dutchess, Putnam, and Westchester counties (NY), as well as in small coastal rivers in Westchester County. They are widespread in Rhode Island, occurring in the major drainage basins.

I collected musk turtles from near sea level up to 900 feet. Of 70 collections made in Connecticut, 58 (83%) were at elevations of 500 feet or lower. The regional elevational record is 900 feet at Bantam Lake (Litchfield Co., CT). High elevations in northwestern Connecticut and adjacent Massachusetts and New York may contribute to the species' irregular distribution in that region.

LIFE HISTORY AND ECOLOGY:

In southwestern New England, musk turtles are restricted to riparian systems, favoring slow moving muddy bottomed streams and rivers. They flourish in the numerous impoundments that were created on rivers and streams, and are especially abundant in weed choked, shallow portions of small reservoirs. Although they may colonize small bodies of water near rivers and reservoirs, musk turtles are absent from ponds and lakes not directly connected to or near a riparian system. I have not collected musk turtles in brackish water.

In southern Michigan, Risley's (1932) earliest dates of musk turtle activity were March 23 and 25 compared to my earliest collections made on April 20 at Cross River (NY) and April 25 at Killingworth (CT). I frequently found musk turtles in late April and early May congregating in shallow, sunny coves of lakes and reservoirs. Musk turtles remain active through early autumn into October. I collected two in baited hoop nets at Ledyard (CT) on September 28. I received musk turtles from two Connecticut lakes collected at night by fisheries biologists using an electroshocker. These specimens were collected in Twin Lakes on October 25 and Moodus

Reservoir on October 31. However, these late dates may not be reliable indicators of turtle activity, as the electrical current may have jolted them out of early hibernation.

Musk turtles can be found basking throughout the day, resting on mats of vegetation in shallow water with the top of their carapaces barely under water. I found them basking on emergent stumps, logs, and rocks as well as in bushes and small trees several feet above the water's surface. This species appears active at twilight and at night. My best trapping success was using baited hoop nets set late in the afternoon and checked the following morning.

Musk turtles are highly aquatic and may be more susceptible to desiccation than other native turtles. Overland movements are limited to females during the nesting season. The single exception was a male killed on a road bordering an extensive wetland at Sharon (CT) on July 24. Twenty-three Pennsylvania musk turtles averaged 152 meters between recaptures (Ernst and Barbour, 1972). Williams (1952) found adult musk turtles had some homing ability within 36.5 acre lake in southern Michigan. He did not find homing ability in juvenile turtles. I have no data on home range of this species.

Tinkle (1961) documented sexual maturity in northern musk turtles with male mature at a minimum of 63 mm SLC (average 73 mm) and females mature at a minimum of 80 mm (average 96 mm). He found the majority of northern males were mature at three years compared to between four and seven years for females.

Males possess a longer and thicker tail and two patches of rough skin on the inside of each hind leg used to stabilize the females's carapace during mating. There is more skin between the plastral seams in males than females. Female's shells tend to be wider and more globular than males, though the extremely variable shell morphology of this species makes this character unreliable when used alone. A detailed review of sexual dimorphism can be found in Risley (1929).

I observed courtship activity and mating on April 20 (Cross River, NY), April 25 (Killingworth, CT), April 29 (Armonk, NY), and May 6 (Stafford, CT). Finneran (1948a) reported a pair copulating plastron to plastron on April 26 (Branford, CT). The usual copulatory position for this species is the male astride the female, his plastron in contact with her carapace. My observations fall into the range of April 1 through May 15 for matings in southern Michigan reported by Risley (1932). Lagler (1941) reported autumn matings of musk turtles in Michigan.

I collected gravid females on May 27, June 10, and June 11 (Hyde Park (NY), June 12 (Sharon, CT), June 17 (New Fairfield, CT), June 18, 19, and 20 (Hyde Park, NY), and June 30 (Weston, CT). Risley (1932) reported nesting between June 10 and July 5 in southern Michigan. Clutch sizes of seven turtles are given in the following table.

TABLE 6

Clutch Sizes of Musk Turtles

AMNH	LOCALITY	SLC (mm)	CLUTCH SIZE
119270	New Fairfield (CT)	93	5
124965	Sharon (CT)	92	6
134473	Hyde Park (NY)	99.5	6
134475	Hyde Park (NY)	106.5	6
134476	Hyde Park (NY)	108	6
130027	Lake Saltonstall (CT)	111	7
134474	Hyde Park (NY)	104.5	8

Tinkle (1961) reported an average clutch size of 4.6 with a range of 2-7 for females in the northern portions of the species' range. He found a positive correlation between latitude and clutch size, with northern turtles producing larger clutches than southern individuals. Gibbons et al. (1982) reported clutch sizes of 2-8 eggs for South Carolina musk turtles. Graham and Forsberg (1986) gave a range of 3-9 (mean 6.3) eggs for six specimens collected at Little Watchic Pond in Cumberland County, Maine.

Hatching occurs in the early autumn. I found a newly hatched turtle on October 8 in the East Branch of the Croton River (Putnam Co., NY), a few miles west of the Connecticut state line. Another hatchling was collected on October 17 near the West River in Guilford (CT).

Musk turtle carapace morphology is extremely variable. I commonly find tricarinate, single keeled, dorsally indented, and dumb-bell shaped carapaces in most Connecticut musk turtle populations. Seidel et al. (1981) examined protein structure and morphological variation in musk turtles throughout eastern North America, including a sample from Mansfield Hollow (CT). They found this species highly variable within populations, but with low interpopulation variability.

One large male (AMNH 119620) from Bantam Lake in Litchfield (CT) measured 130.5 mm SLC which is close to Conant's (1975) record size of 137 mm. In 1988, I marked 22 musk turtles from a single population at Hyde Park (NY). Fourteen males ranged from 80-102 mm SLC and eight females from 98-112 mm SLC. The corresponding weights of these samples are of interest. The males weighed between 75-155 gm compared to the females which weighed between 155-240 gm. The females in this population appeared to attain larger sizes than males. Bowler (1977) gave a longevity of 54 years for this species in captivity. I have no data on survivorship in the wild.

Musk turtles are primarily carnivorous, feeding on a wide variety of invertebrates and small vertebrates. They are not swift enough to capture game fish. Specimens I collected defecated fragments of bivalve and gastropod shells and pieces of crayfish exoskeleton. These are all prey items listed by Ernst and Barbour (1972). The flat alveolar surfaces of the musk turtle's jaws are powerful crushing devices enabling these turtles to feed on hard shelled invertebrates.

Musk turtles are attracted to a variety of baits used by fishermen. Once hooked, the turtle is often killed, because of the mistaken notion they compete with or eat large quantities of game fish. I frequently am alerted to musk turtles' presence at various sites by finding their crushed remains at fishing spots.

Musk turtles are preyed upon by a wide variety of vertebrates. Eggs and young are eaten and I found adults with the head and limbs chewed off. Road mortality is low, due to their highly aquatic lifestyle. Many specimens collected in the Fall Kill drainage (Dutchess Co., NY) were afflicted with a condition causing pock-marking with subsequent loss of shell bone. This was especially severe along the periphery of the carapace and plastron.

Musk turtles are unreported in many areas because of their secretive, nocturnal, and aquatic habits. Even experienced naturalists are unaware of them in areas where dense populations are present. Although irregularly distributed, they are often locally abundant, therefore they may be significant predators on aquatic invertebrates is certain ecosystems. They have little economic importance and are rarely collected for pets due to their drab coloration, odor, and proclivity to bite. The creation of impoundments on many and streams and rivers has increased available habitat utilized by this species.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=24): AMNH 65437-38, 119270-71, 123101-08, 127265-66; UCS 941, 5024, 5115, 7775, 7968, 7858-62

Hartford Co. (n=5): AMNH 119619, 124961-64

Litchfield Co. (n=22): AMNH 119620-23, 124965-66, 128021-24, 134262; CMNH 19177-79; TCWC 21428-30; UMMZ 155165; UCS 7713, 7776, 8659-60

Middlesex Co. (n=18): AMNH 123109-11, 124967-74, 128025-30; UCS 6485

New Haven Co. (n=14): AMNH 130024-30, 130588; UMMZ 99710; UCS 7181; YPM 8000-03

New London Co. (n=23): AMNH 119624-25, 123112-16, 124975-81, 127267-68; SCSC 469; UCS 914, 1870, 2561, 6455, 7128, 8422

Tolland Co. (n=27): AMNH 119272-81, 119626-32, 128031-32; UMMZ 152984; UCS 1865-69, 1871, 7486

Windham Co. (n=10): AMNH 127269-72, 128033; UMMZ 152976; UCS 4695, 7122, 8310, 8421

Massachusetts

Franklin Co. (n=1): AMNH 134357

Rhode Island

Kent Co. (n=1): AMNH 134718

Washington Co. (n=3): AMNH 129636-38

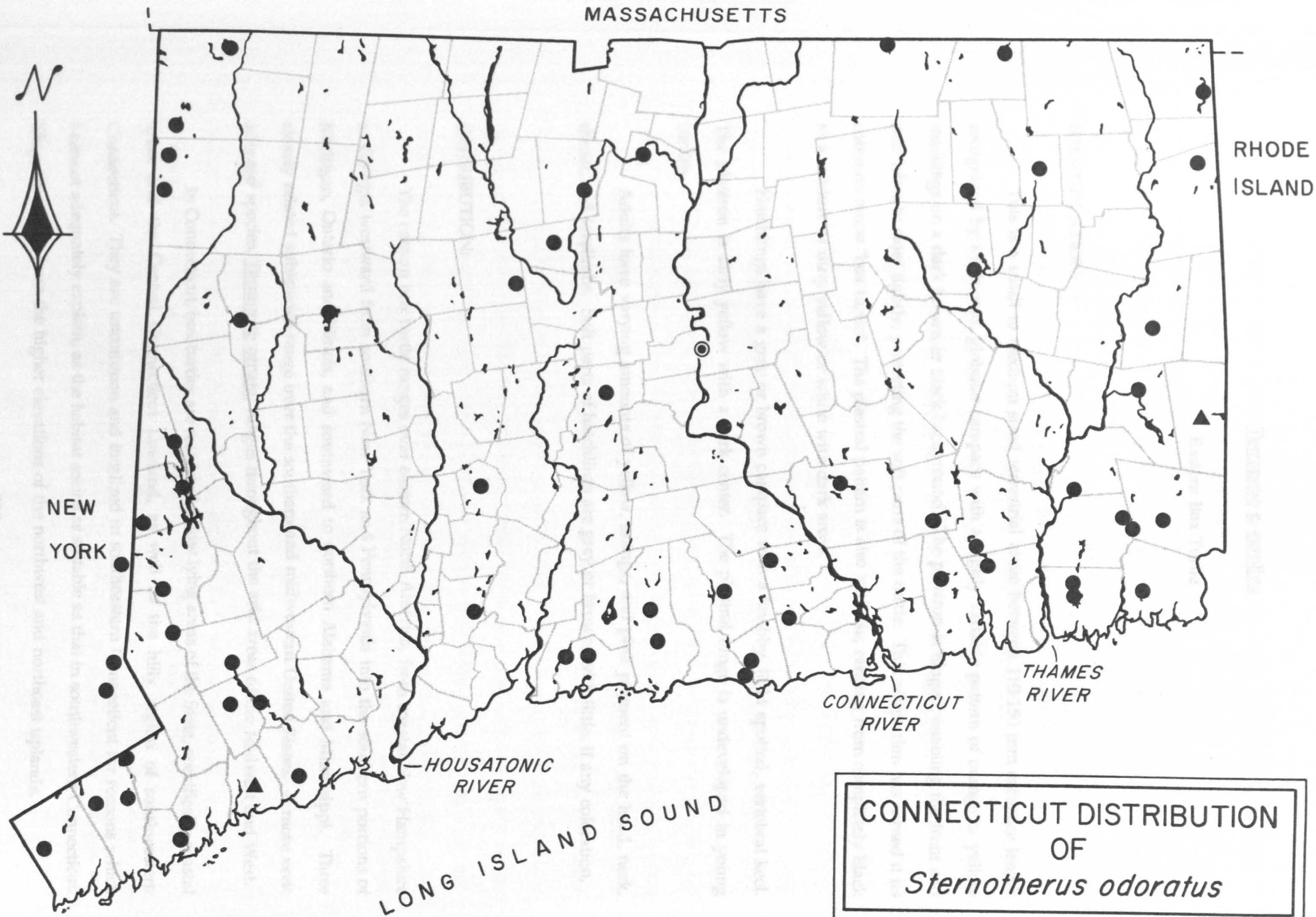
New York

Columbia Co. (n=1): AMNH 130776

Dutchess Co. (n=14): AMNH 91651, 125454, 134466-77

Putnam Co. (n=2): AMNH 71655, 127463

Westchester Co. (n=13): AMNH 120048-54, 130179-82, 130777-78



CONNECTICUT DISTRIBUTION
OF
Sternotherus odoratus

Terrapene c. carolina

Eastern Box Turtle

IDENTIFICATION:

This is a small to medium sized terrestrial turtle between 110-150 mm carapace length recognized by its domed, globular carapace with a highly variable pattern of orange or yellow markings on a dark brown or black background. The plastron is hinged, enabling the front and rear lobes to close tightly, protecting the soft parts of the turtle. This adaptation has earned it its common name "box turtle". The plastral pattern is also variable, ranging from completely black to a mixture of dirty yellow or white with dark areas.

Hatchlings have a grey or brown carapace with a knobby, light spotted, vertebral keel. The plastron is dirty yellow with a dark center. The plastral hinge is undeveloped in young turtles.

Adults have varying amounts of yellow, orange, and pink pigment on the head, neck, throat, and forelimbs. Soft parts of hatchlings are grey or brown, with little, if any coloration.

DISTRIBUTION:

The eastern box turtle ranges over eastern North America, from coastal New Hampshire to Georgia westward from southern New York and Pennsylvania into the southern portions of Michigan, Ontario and Illinois, and southward to northern Alabama and Mississippi. Three closely related subspecies range over the southern and midwestern United States. A more xeric adapted species, Terrapene ornata, ranges throughout the arid areas of the Midwest and West.

In Connecticut, box turtles are restricted to low lying areas of the State, specifically coastal areas and the Central Connecticut Lowland, as well as the hilly region of southwestern Connecticut. They are uncommon and localized in southeastern Connecticut for reasons which I cannot adequately explain, as the habitat seems as suitable as that in southwestern Connecticut. They are absent from the higher elevations of the northwest and northeast uplands.

Box turtles are widely distributed from sea level up to 500 feet. They become increasingly scarce and localized up to a maximum elevational limit of just above 700 feet. In Connecticut, I collected box turtles at 87 sites of which 74 (85%) were 500 feet or lower. Box turtles extend their range into upland areas along low lying river valleys including the Farmington and Nepaug river valleys in north-central Connecticut.

Box turtles may be excluded from higher elevations by both a lack of soft, well drained soil to burrow into for hibernation and a deeper frost line. Additionally, summer temperatures in many upland areas may not be warm enough to allow box turtle eggs to fully develop before the onset of freezing weather. Severe late spring and early autumn frosts may be another limiting factor in upland areas.

In Massachusetts, this species is common in the eastern coastal regions, especially Cape Cod. They also occur in the Central Connecticut Lowland, but the northern extent of their range is poorly known. Dunn (1930) considered box turtles rare in the Holyoke and Northampton areas.

In Rhode Island, box turtles occur throughout most of the State but are more common in the lower, coastal regions. They are widely distributed in southwestern Washington County, but I have been unable to locate populations westward in adjacent areas of Connecticut. The Connecticut-Rhode Island border coincides with an abrupt habitat change caused by the Harbor Hill Recessional Moraine which emerges from under Long Island Sound at Westerly, just east of the Connecticut state line. The moraine creates a very sandy, coastal habitat, ecologically similar to Long Island and Cape Cod. This habitat type appears well suited to box turtles with high population densities on eastern Long Island and Cape Cod. This abrupt habitat change at the Connecticut-Rhode Island border may explain box turtle rarity in nearby southeastern Connecticut, which is less sandy, has more rock outcroppings, and a different vegetational community.

Box turtle distribution in southeastern New York presents an interesting zoogeographical pattern. Three valleys characterize the region. The most western is the Hudson Valley, a narrow corridor following the river. In some areas, such as the Hudson Highlands, the valley is nonexistent, the river being bordered by steep cliffs. Approximately halfway between the Hudson River and the Connecticut border is a poorly defined central valley in which the Taconic Parkway is situated. The most eastern Harlem Valley, in which Route 22 is situated, parallels the

Connecticut state line. The elevation of the Harlem Valley floor rises in northern Dutchess County to over 700 feet at Millerton.

Box turtles are widespread in Westchester County where sufficient habitat remains to support them. They are more localized in Putnam County and absent from most of the Harlem Valley north of Brewster. In Dutchess County, box turtles are locally common in the Hudson Valley up to the Columbia County line. Stewart and Rossi (1981) cite a single record from northeastern Columbia County as well as records from the Albany Pine Bush. In Dutchess County's central valley they have been recorded at least as far north as Baird State Park. They are absent from portions of the Harlem Valley that lie within Dutchess County.

Box turtles are frequently kept as pets, therefore it is not uncommon to encounter single specimens (released or escaped) outside the species' natural range. Caution is advised in accepting range extensions based on single specimens without additional field work to determine the presence of a population. Most of the localities plotted on my range maps are representative of verified populations, not occurrences of single individuals. Records of single individuals were used only when they were found within the core of the box turtle's New England range, i.e. a single specimen was not sufficient to document an outlying or peripheral box turtle population.

LIFE HISTORY AND ECOLOGY:

Box turtles favor "old field" habitat and deciduous forest ecotones, including power line cuts and logged over woodland. Although strictly terrestrial, this species is seldom found far from water, usually a small stream or pond. I observed three box turtles at the edge of a salt marsh at Duxbury (MA). Box turtle habitats are generally characterized by sandy, well drained soils, although I have collected them in wet meadows and lowland swamps. Box turtles occur on basalt ridges in the Central Connecticut Lowland where I observed turtles crawling among talus at the edge of steep precipices on West Rock at New Haven (CT). Several specimens from West Rock had severe carapace injuries, including large pieces of laminae (outer shell layer) chipped off. This may have resulted from tumbling down small sections of the sharp-edged talus slope.

Box turtles overwinter on land. They enter into hibernation earlier and emerge from hibernation later than their aquatic counterparts. Terrestrial hibernation may favor early entry and late emergence as, unlike aquatic turtles, box turtles are unprotected from sudden temperature drops by a large buffer of slowly cooling water. Early entry into hibernation may also allow box turtles sufficient time to dig down before the advent of freezing weather. I have not found box turtles active before late April nor after mid October. My earliest box turtle records are April 25 (Manchester, CT), April 27 (Oxford, CT), and May 8 (Windsor, CT). One exception was a hatchling found during an early spring thaw on March 8 at Marlborough (CT). My latest records are October 11 (Greenwich, CT), October 18 (Bolton, CT), and October 20 (Durham, CT).

Box turtles are strictly diurnal. During hot weather they are active early in the morning or during thunderstorms. They spend the hot portions of the day buried under leaves or in soil, often in moist areas. In the spring and early summer and autumn they may be found active throughout the day, often sitting for long periods in dappled sunlight along the edges of wooded areas and fields. Their blotched shell pattern affords excellent camouflage in these situations, breaking up the dark shell outline, enabling the turtle to blend into the surrounding habitat.

Overton (1916), Engelhardt (1916), and Ditmars (1934) reported congregations of estivating box turtles on Long Island. I have not encountered estivating box turtles in southwestern New England, but have noted they are not commonly found during protracted hot weather. However, my lack of box turtle sightings during the summer months is also influenced by the growth of thick, dense herbaceous vegetation. By mid June most box turtle habitats are thickly covered with several feet of lush vegetation, affording the turtles much better cover than early in the season.

Box turtles are an extremely sedentary species with a small home range (Nichols, 1939; Stickel, 1950). It is not unusual to encounter the same box turtle within the same area year after year. Unfortunately box turtles are frequently removed from their home range by humans for a variety of reasons with subsequent release elsewhere. More than likely the turtle will attempt to return to its home, using a variety of navigational cues. If a box turtle is found attempting to cross a road, the best assistance one can provide is to move it across the road in the direction it was headed, rather than pick it up and release it elsewhere.

Kiester et al. (1982) in a telemetry study of home ranges of a closely related subspecies, Terrapene carolina triunguis, discovered three males in their sample were true transients without apparent home ranges. These males moved through the study area, mating with females, and continued onward. The presence of a low number of transient individuals in this sedentary species is important in maintaining gene flow and colonizing new habitats.

Sexual dimorphism is marked. Males usually have a bright red iris, a concavity in the center of the rear plastral lobe, a distinctly flared carapace, and brightly colored head and forelimbs. Females have a yellow, carmine, or brown iris, a convex rear plastral lobe, a comparatively weakly flared carapace, and less extensive markings on head and forelimbs. Females possess a more globular carapace compared to males which tend toward more dorsally compressed carapaces. Males have larger and thicker claws and a more distinctly hooked beak. New England males on average exceed females by 8-9 mm SLC.

This species mates on land. I have observed courtship displays which include male combat, pursuit of females, as well as the male butting the female's shell and nipping at her limbs and head. Following courtship displays, the male mounts the female, his concave plastron accommodating the rear of the female's highly domed carapace. His large powerfully clawed hind feet hook onto the rear edge of the female's carapace while he cranes his neck over the top of the female's carapace. Although most mating occurs in the spring after emergence from hibernation, I found a mating pair on September 1 on Prudence Island (RI).

In southwestern New England box turtles nest in June, with a concentration of activity in the middle of the month. I have collected or received gravid box turtles or reports of nesting females on May 31 (Northcastle, NY), June 8 (Farmington, CT), June 9 (East Granby and Granby, CT), June 10 (Marlborough, CT), June 11 (Vernon, CT), June 14 (Hyde Park, NY), June 16 (Bristol, CT), June 17 (Avon, Bolton, Newtown, and Waterford, CT), June 18 (Bolton, CT), June 19 (Goldens Bridge, NY), June 23 (Briarcliff Manor, NY), and June 26 (Weston, CT). Clutch sizes of eleven females are given in the following table.

TABLE 7

Clutch Sizes of Box Turtles

AMNH	LOCALITY	SLC(mm)	CLUTCH SIZE
MWK 7853	Andover (CT)	150	3
134260	Farmington (CT)	137	5
MWK 7965	Avon (CT)	???	5
134461	Hyde Park (NY)	136	6
released	Bolton (CT)	140	6
130583	Bristol (CT)	150	6
130015	East Granby (CT)	148	8
119283	Newtown (CT)	151	8
130016	Granby (CT)	152	8
released	Bolton (CT)	???	9
released	Briarcliff Manor (NY)	???	9

Finneran (1948a) reported a clutch of five eggs laid on June 5 at Branford (CT). Warner (1982) reported a clutch of eleven eggs deposited on June 15 at Wilton (CT) by a 159 mm SLC female which is a record number for this species.

Incubation periods vary, dependent on temperature, amount of sunlight, and the location of the nest. A clutch laid on June 18, 1975 at Bolton (CT) hatched under natural conditions on September 26. A clutch laid the previous year at the same locality on June 17 hatched under natural conditions on October 18 during a snow flurry!

Female box turtles have the ability to retain viable sperm for some time after mating. Box turtles have deposited fertile eggs in captivity a year or more after their last contact with a male turtle (Finneran, 1948a).

New England box turtles are extremely variable, any number of shell shapes and patterns occurring within a single population. They attain larger maximum sizes than turtles I have examined from Virginia and West Virginia. The largest recorded eastern box turtle was collected at Glendale, Westchester County, New York. This turtle measured 198 mm SLC (Cook et al., 1972). These authors mention an unconfirmed length of 178 mm for a turtle collected in a maple, oak, and tulip forest at Weston (CT). Regretfully, this record size Connecticut box turtle was released at Woodstock (W. Frair, pers. comm.) in northeastern Connecticut where box turtles do not naturally occur.

Measurements of 111 sexually mature New England box turtles are given in the following three tables.

TABLE 8

SLC Measurements of Adult Male New England Box Turtles

STATE	N=	MIN(mm)	MAX(mm)	AV(mm)	>140 mm (=%)
CT	30	129	170	153.3	27 (90%)
NY	13	132	174	152.2	10 (77%)
RI	12	139	164	147.7	11 (92%)
MA	3	143	148	146.3	3 (100%)
ALL	58	129	174	151.5	51 (88%)

TABLE 9

SLC Measurements of Adult Female New England Box Turtles

STATE	N=	MIN(mm)	MAX(mm)	AV(mm)	>140 mm (=%)
CT	28	125	164	144.7	20 (71%)
NY	7	130	154	143.7	4 (57%)
RI	6	128	150	139.7	4 (67%)
MA	5	123	145	138.4	4 (80%)
ALL	46	123	164	143.2	32 (70%)

TABLE 10

SLC Measurements of Adult New England Box Turtles

Including Males, Females, and Indeterminates

STATE	N=	MIN(mm)	MAX(mm)	AV(mm)	>140 mm (=%)
CT	60	125	170	149.2	49 (82%)
NY	25	130	174	150	19 (76%)
RI	18	128	164	145	15 (83%)
MA	8	123	148	141.4	7 (88%)
ALL	111	123	174	148.1	90 (81%)

In his exhaustive review of Terrapene, Milstead (1969) examined ten turtles from the "ecotone between the Canadian and Carolinian biotic provinces", which included New England (CT, MA, and RI). He found turtles from the northeastern (New England) and northwestern (Michigan) extremes of the range were the largest Terrapene c. carolina, averaging 140 and 139 mm SLC respectively. Although Milstead's Michigan sample of 39 turtles may have adequately documented the size range at the subspecies' northwestern range limit, his New England sample yielded a deceptively small average size. Although this may be partially a function of small sample size (there were only a handful of New England specimens in museum collections prior to my survey), the preponderance of coastal animals in his sample skewed the data. Turtles from coastal New England tend to be smaller than those from the Hudson Valley, western Connecticut, and the Central Connecticut Lowland. My Massachusetts (n=8) and Rhode Island (n=18) samples are mostly coastal animals averaging 141 and 145 mm SLC respectively. This contrasts with my Connecticut (n=60) and New York (n=25) samples primarily comprised of inland animals, averaging 149 and 150 mm SLC respectively.

The data I have collected from 111 turtles indicate the average New England box turtle is considerably larger than Milstead's average SLC of 140 mm. Therefore, turtles from this region appear to be the largest representatives of the subspecies Terrapene c. carolina.

Larger turtles are at a distinct disadvantage in northern parts of their range, requiring more food and taking longer to heat up. The advantages of being large must outweigh the disadvantages in order for larger body mass to be selected for. Larger body mass would confer a greater degree of protection against sudden frosts, a large turtle would cool more slowly, and may escape freezing. Late spring and early autumn frosts are important limiting factors to box turtle distribution.

Larger females may be able to produce larger eggs, which in turn could produce larger, healthier young due to additional nutrients available in larger eggs. A tempting proposition for investigation is whether larger eggs are able to develop faster than smaller ones, due to additional nutrition available in the egg. If this were the case, large eggs would have a decided advantage in areas with short summers. Conversely, larger females could produce more eggs per clutch, which would be advantageous if successful hatching occurred only every second or third season due to cool summer weather. Frequently New England species deposit clutches approaching the upper limit of the clutch size range. Further south, species may produce smaller clutches but successfully nest several times in a season. There is little data on double clutching in New England, but with summers often short and cool, successful reproduction may best be served by females laying one large clutch during the optimal nesting period.

The longevity of turtles is often overstated. However, occasional centenarian box turtles have been documented. Babcock (1928) illustrated one from Enfield (CT), and Oliver (1953, 1954) documented one from Hope Valley (RI). Graham and Hutchison (1969) reported additional longevity records from Rhode Island.

At the William Floyd Estate on Long Island 18 turtles marked between 1924-1956 by John T. Nichols were recovered between 1980-1989 by Richard Stavdal, who is continuing Nichols's mark and recapture work. By September 1989, Stavdal had marked an additional 491 turtles not marked by Nichols. Therefore these aged turtles represented 3.5% of a total marked population of 509 animals. Nichols marked hundreds of turtles in the thirty odd years he spent on the Floyd Estate and although more of his turtles may be recovered, the majority are no longer extant.

These data are noteworthy providing the first documentation that aged turtles make up a small percentage of a Terrapene population. To date, all longevity records of Terrapene have been single individuals from widely scattered sites. The following table gives the minimum ages of the 18 Nichols turtles recovered by Stavdal. As these turtles were all marked as adults, I added 20 years to these minimum ages, which is approximately the time it takes for a box turtle to reach adult size on Long Island and New England.

TABLE 11

Known Age Box Turtles Marked at Floyd Estate
Long Island, New York (R. Stavdal, pers. comm.)

YEAR MARKED	YEAR RECAPTURED	MINIMUM AGE (+ 20 YEARS)
1924	1989	86
1919	1982	84
1927	1989	83
1925	1984	80
1926	1985	80
1925	1982	78
1925	1980	76
1934	1989	76
1935	1989	75
1931	1984	74
1934	1985	72
1938	1988	71
1942	1982	61
1946	1986	61
1949	1989	61
1947	1984	58
1953	1983	51
1956	1983	48

Based on annuli counts, the adults which I collected were usually over twenty years old. Many individuals were considerably older, worn completely smooth and devoid of annuli. New England box turtle populations do not approach the densities recorded on Long Island or further south in Virginia.

A wide variety of plant and animal material is eaten, including carrion and poisonous mushrooms. A specimen I collected at Orange (CT) defecated some snake skin. Whether the snake was captured alive or found dead is a matter for speculation. Hutchison and Vinegar (1963) report a captive box turtle killing and eating a garter snake Thamnophis sirtalis.

Adult box turtles are frequently scarred with well healed injuries including chipped, burnt, and gnawed shells, and as well as missing limbs. Peters (1948) cited specimens from Windsor (CT) infested by bot fly larvae. Large carnivores occasionally kill and eat adult box turtles. Warny (pers. comm.) found a smashed shell of a small individual in a herring gull colony on Plum Island, New York lying in an area where gulls had smashed open many mussels and two other species of turtles.

Many box turtles are killed on roads and by motorized farm and lawn cutting equipment. I have found remains of box turtles that had been shot at close range. Eggs and young turtles are eaten by a wide variety of vertebrate predators. Murphy (1964) found a hatchling box turtle in the stomach of a copperhead (Agkistrodon).

The box turtle's economic importance is limited to consuming a few species of injurious insect larvae and occasional nibbling at garden produce. Rust and Roth (1981) found Delaware box turtles important agents in the dispersal of mayapple seeds. Seeds ingested by turtles had a greater probability of successful germination. Braun and Brooks (1987) found box turtles potentially important seed dispersers of a variety of forest plants.

This species figured prominently in the rituals of the Iroquois Indian cultures of western New York and adjoining areas. Ceremonial objects were constructed utilizing large numbers of box turtle shells. Adler (1968, 1970) hypothesized the absence of box turtles from western New York and southern Ontario resulted from collection of turtles for ceremonial purposes coupled with large scale cultivation of maize in the limited low lying areas inhabited by the turtles.

Large portions of its southwestern New England range have been lost to intensive urban development. The regions's low lying areas favored by box turtles have seen tremendous suburban development in the last decades. Unlike the wood turtle, (Clemmys insculpta), this species has survived in small pockets of suitable habitat, in close proximity to humans. This is due to its extremely limited movements and small home range. The steep trap rock ridges of the Central Connecticut Lowland serve as refuges for this species in many urbanized areas including New Haven, Meriden, and Middletown (CT) and Springfield (MA).

Land management practices have a decided effect on box turtle populations. Selective logging, which "opens up" woodland, has beneficial effects by creating edge areas, a favored habitat of this species. The reversion of agricultural land to old fields and second growth woodland creates additional box turtle habitat.

Stickel (1951) reported DDT spraying did not alter the number of adult box turtles in her study area, nor affect growth rates of young turtles. Her study, encompassing only five years, was too short to evaluate the effects of DDT on reproductive success in her population.

Overcollection of box turtles has been a minor factor in accelerating the decline of populations in several areas. Like the wood turtle, this species takes a relatively long time to reach sexual maturity, often in excess of ten years, and produces a small number of eggs with low juvenile survivorship. In some populations the loss of adult turtles exceeds the number of young reaching sexual maturity. Once mature, box turtles reproduce for decades. I have collected gravid turtles with the shell worn smooth of annuli and therefore quite old.

Box turtles and their habitat are protected in many federal, state, and county parks, as well as private sanctuaries. Due to its sedentary habits and correspondingly small home range, I anticipate they will remain secure in the region despite increased habitat fragmentation. Maintaining gene flow between small, increasingly isolated pockets of box turtle habitat is a potential conservation problem.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=20): AMNH 119282-83, 119633-36, 123191, 128012, 130578, 135233; UCS 1879, 1886, 5146, 5163, 5425, 6378, 6789, 7733, 8101; UMMZ 155062

Hartford Co. (n=46): AMNH 119284-86, 119637-40, 125019-22, 128013, 130014-17, 130579-85, 133451, 134259-61; AMNH-MWK 7958, 7965; UCS 3020, 6348, 7057, 7133-34, 7179, 7201, 7313, 7367, 7395, 7489, 7686, 8053-54, 8061, 8642; UMMZ 150086

Litchfield Co. (n=3): AMNH 119641, 125023, 130018

Middlesex Co. (n=12): AMNH 123192, 125024, 127360, 128014-16, 130586-87, UCS 6559, 8270, 8280, 8436

New Haven Co. (n=20): AMNH 119287-89, 119642-43, 123193-94, 127361-62, 128017, 130019-23; UCS 5788, 7405, 8435, 8661; UMMZ 152988

New London Co.(n=5): AMNH 119290, 128018, 133452-53; UCS 6453

Tolland Co.(n=8): AMNH 119291, 128019-20, AMNH-MWK 7853, 7908; UCS 7191, 7696, 8652

Massachusetts

Barnstable Co. (n=2): AMNH 6406, 134520

Hampden Co. (n=2): AMNH 133573-74

Plymouth Co. (n=4): AMNH 130711-13, 133575

Rhode Island

Kent Co.(n=3): AMNH 130877-78, 134693

Newport Co. (n=8): AMNH 130665-70, 134694-95

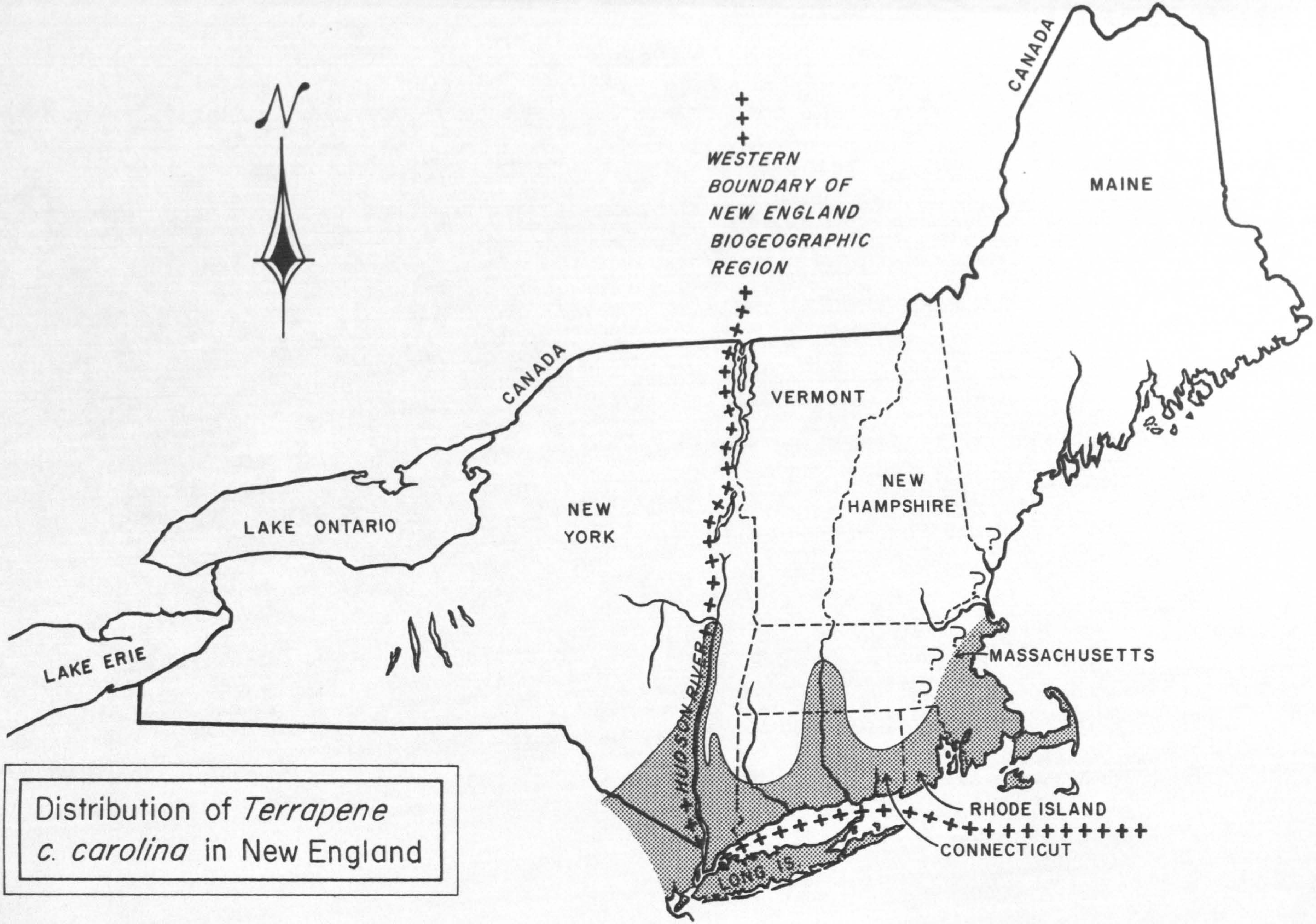
Washington Co. (n=10): AMNH 74468, 129927-28, 130671, 134697-702

Providence Co. (n=1): AMNH 134696

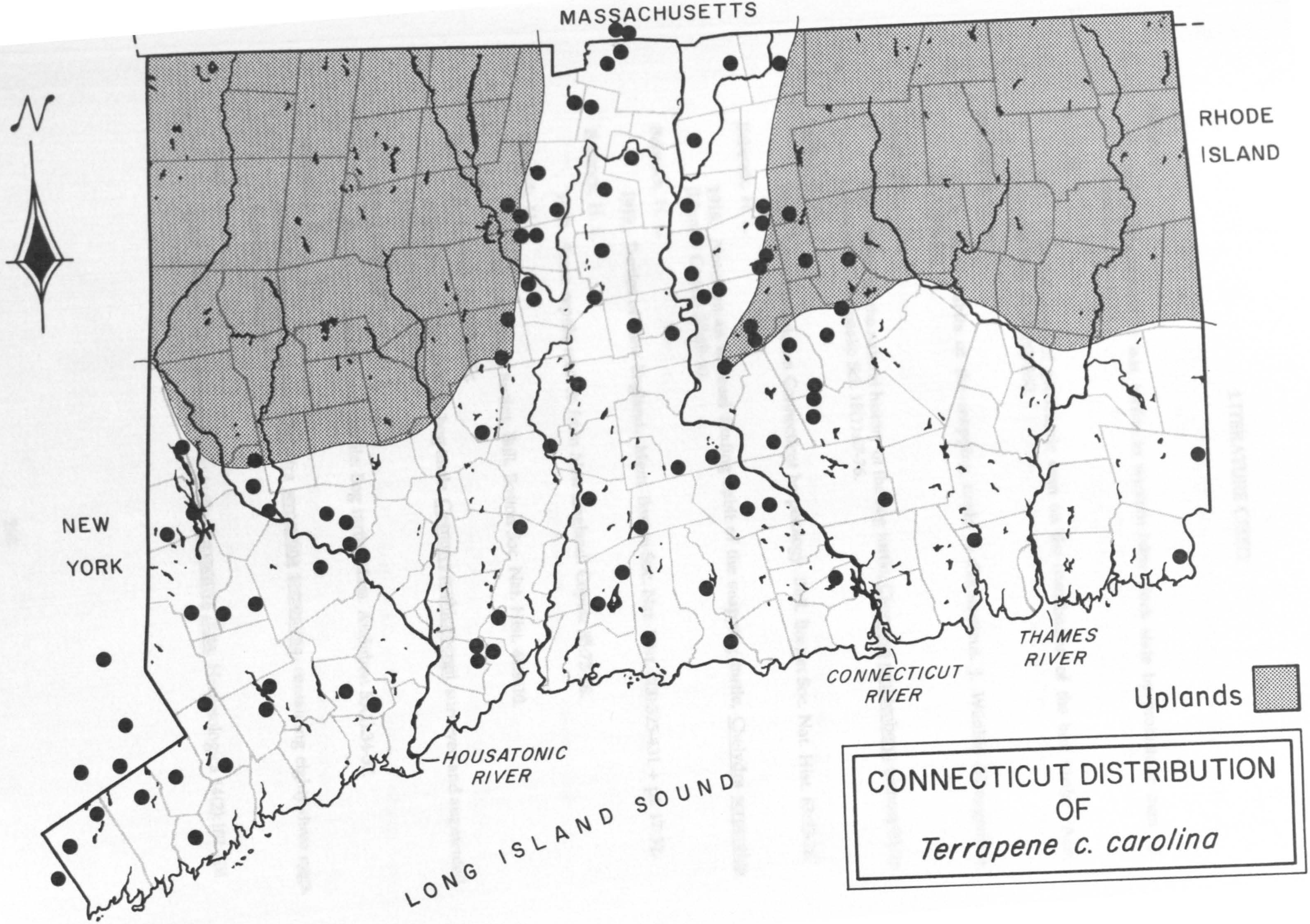
New York

Dutchess Co. (n=14): AMNH 131457-59, 131476, 130932-33, 133630, 134457-63

Westchester Co. (n=14): AMNH 8791, 102579, 118659, 120055-56, 120716, 127469, 127740, 130176-77, 130775, 131477, 133623, 134574



Distribution of *Terrapene c. carolina* in New England



CONNECTICUT DISTRIBUTION OF *Terrapene c. carolina*

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CHAPTER SIX: SQUAMATA

INTRODUCTION

The Squamata (lizards and snakes) are represented in southwestern New England by fifteen species distributed among three families, Scincidae, Colubridae, and Crotalidae.

Two additional species have been reported from New England. The fence lizard, Sceloporus undulatus hyacinthinus, just enters my study area in New York's Hudson Valley, which coincides with the western boundary of the New England biogeographical region. It is not found in any of the New England states. Fence lizards have an extensive range over non-glaciated portions of eastern North America. Disjunct populations occur on several ridges bordering the Hudson River's east bank. In Westchester County, a cluster of ridges and outcroppings near Peekskill are inhabited by fence lizards including Dickerson Hill (AMNH 36600-1), Keg Mountain (AMNH 43275-79), and Anthony's Nose (AMNH 109237-38, 130436-44, 133005). Fence lizards occur on Breakneck Ridge, at the Putnam-Dutchess County line (AMNH 31916-19, 31928-30, 43281).

The keeled green snake, Opheodrys aestivus, has been reported from several sites in Connecticut. Ditmars (1896) first reported them from "Plymouth County, Connecticut", where he found them quite common. He erroneously used the term county instead of town. Subsequently, Ditmars (1907) corrected this locality to "near Waterbury", a city located just south of Plymouth. However, he stated "the common habitat of this snake is southern New Jersey southward through Florida". Both Lamson (1935) and Dowhan and Craig (1976) considered this species native to Connecticut based on Ditmars' report.

However, two additional Connecticut reports have gone largely unnoticed. Babbitt (1932) reported that a friend "secured a young specimen at Simsbury in 1928" and a specimen (University of Massachusetts, Museum of Vertebrate Zoology, Catalogue Number 26-17-32-4) was reportedly collected at West Haven in 1943. Babcock (1920) cited Ditmars' Plymouth record and noted the existence of a specimen labelled "Springfield" (Springfield Massachusetts Museum No. 22) and a specimen from "Massachusetts" (ANSP 5695).

Mislabelled museum specimens are quite common, especially in older collections which date from an era when "gentlemen naturalists" often received specimens second or third hand.

At that time, species' distributions were poorly known and scientists had little reason to question locality data that is now viewed as suspect. Their emphasis was on securing representative samples of various taxa for comparative purposes. Locality data was rarely treated properly, in fact it was sometimes truncated or omitted. The two Massachusetts specimens are probably mislabelled. The West Haven specimen was part of a collection made by W. F. Prince in 1943 and subsequently housed at University of Massachusetts Wildlife Department, until it was donated to the Museum of Zoology and finally cataloged in 1983. Presumably this specimen was part of a teaching collection. Under such circumstances labels, jars, and specimens can easily be transposed, resulting in new combinations of specimens and locality data. Babbitt's (1932) report of a young Simsbury specimen was received second hand. Juvenile Opheodrys are small, therefore vernalis and aestivus may be readily confused unless carefully examined. Babbitt's friend probably observed a juvenile Opheodrys vernalis.

Ditmars' original report is the hardest to discount. He certainly should have been able to distinguish between the two species of Opheodrys. Babcock (1920) commented on several snakes which he considered dubious or at best "casually" occurring in New England, including Opheodrys aestivus. He stated that "It is unfortunate that records based on insufficient or inaccurate observations find their way from time to time into faunal lists, even though reported by observing gentlemen with quite a taste for natural history, as it is much easier to get them in than to get them out."

I consider reports erroneously attributing Opheodrys aestivus to the southwestern New England herpetofauna originating from either mislabelled museum specimens or misidentifications. Despite over a decade of intensive field work, no evidence of their occurrence was found in southwestern New England. Collecting trips near the purported Opheodrys aestivus sites often yielded Opheodrys vernalis. Conant (1975:Maps 134-35) illustrated these two species having mutually exclusive distributions, which adds biogeographical and ecological evidence against the natural occurrence of Opheodrys aestivus (sympatrically with Opheodrys vernalis) in southwestern New England.

My data showed that snakes appeared to tolerate a greater variance of habitat conditions and elevation than did turtles. Only four species are near their range limit in southwestern New England, Agkistrodon contortrix, Carphophis amoenus, Elaphe obsoleta, and Heterodon platyrhinos. These species favor lower elevations, although Heterodon occurs at a few upland sites.

The elevational distribution of snakes in southwestern New England is determined in part by their reproductive strategies. The six oviparous species (Carphophis, Coluber, Diadophis, Elaphe, Heterodon and Lampropeltis) are rare in upland areas with the exception of Lampropeltis. Seven species are ovoviparous (Nerodia, two species of Storeria, two species of Thamnophis, Agkistrodon, and Crotalus). Five of these ovoviparous species are very successful in upland areas (two species of Storeria, two species of Thamnophis, and Crotalus) while two species (Agkistrodon and Nerodia) are rare. Opheodrys practices an intermediate strategy, approaching ovoviviparity, and occurs along a wide altitudinal gradient.

My data indicated many species of egg laying reptiles are restricted to lower elevations. The warm and longer summers at low elevations allows sufficient time for successful development of eggs outside the female's body. The evolution of ovoviviparity among snakes enables females to accelerate egg development via thermoregulatory behavior. Ovoviparous snakes have been able to colonize southwestern New England's upland areas far more effectively than turtles and egg laying snakes.

Eumeces fasciatus

Five Lined Skink

IDENTIFICATION:

Of the two lizards native to the New England biogeographical region, the five lined skink is the only species found in the New England states, reported from Connecticut, Massachusetts, and Vermont. The fence lizard (Sceloporus undulatus hyacinthinus) reaches its northern range limit on several cliffs along the Hudson River's east bank (Westchester, Putnam, and Dutchess counties, NY), in the extreme southwestern corner of my study area.

Skink field characters include several white, cream colored, or light brown dorsal stripes on a dark brown or black background. Juveniles have a bright blue tail. Males often have an enlarged, bright red head, especially noticeable during the breeding season.

DISTRIBUTION:

The five lined skink ranges over a large area of eastern North America from western New England and the Hudson Valley to northern Florida, westward to eastern Texas, Oklahoma, and Nebraska and northward to southern Illinois, eastern Minnesota, and southern Michigan. In Canada, they are restricted to Ontario Province. Disjunct populations occur at the periphery of their range, having been reported from both the midwestern and northeastern states. In southwestern New England, this species is at its northeastern range limit, occurring in small patches of rugged and inaccessible habitat.

I have documented skinks in three distinct sections of Connecticut. At least two populations are extant on the bluffs bordering the west side of the Housatonic River at Kent, in southwestern Litchfield County. Skinks occur on the ledges bordering the east side of the Housatonic River in northwestern New Haven County, as well as along the escarpment at the edge of the Central Connecticut Lowland in southwestern Hartford County. I have been unable to locate skinks on any of the basalt ridges in the Central Connecticut Lowland. Specimens collected in the 1870's at New Haven and Middletown probably came from basalt ridges, as these are the only major rock outcroppings in those areas. Despite repeated visits, I was unable to confirm persistent reports of skinks from West Rock (a large basalt ridge) in New Haven. Linsley (1844) provided second-hand reports of skinks from Trumbull (Fairfield Co.) and Salisbury (Litchfield Co.). Although within the Connecticut range of this species, I did not consider Linsley's reports sufficient documentation of their occurrence at these sites.

Skinks have been reported twice from eastern Massachusetts. Storer (1840) found one at Barre (Worcester Co.) and Allen (1870) reported a specimen collected in 1869 at New Bedford (Bristol Co.). Klemens (in press) considered them extirpated in eastern Massachusetts, but stated they may yet be found in western Massachusetts (Berkshire Co.), because skinks occur in southwestern Vermont and northwestern Connecticut.

Skinks have not been reported from Rhode Island. In southeastern New York, they occur at a few sites along the Hudson River in northern Westchester County. They appear more widespread west of the Hudson River in Rockland and Orange counties. Skinks were reported by Babbitt (1939) from the New York-Connecticut border between Dover (NY) and Kent (CT) and these populations are still extant.

LIFE HISTORY AND ECOLOGY:

I have observed this species only a few times in the course of my survey. They inhabit steep, rocky areas with patchy tree and shrub cover, rotten logs and duff, and large exfoliated slabs of rock. Generally these areas are warm, dry, sunny microhabitats surrounded by moist deciduous forest. Skinks were also found on a wooden building at the base of a steep escarpment. The few individuals I collected were found under exfoliated rock slabs, set into a matrix of soil and duff.

Hank Gruner has begun a long term mark and recapture study of one of the skink populations discovered during my survey. He has generously allowed me to use his unpublished life history and activity data which is the only information available on skink ecology at the northeastern limit of their range.

He marked 34 skinks in a population which appeared to occupy an area of less than one acre of a bald, scrubby rock outcropping surrounded by deciduous woodland. He did not find them in the surrounding woodland. The marked animals consisted of 11 males, 7 females, and 16 juveniles.

Skinks were active from April 12 through October 11. These dates fall within the range given by Fitch (1954:44) for Kansas skinks. Of 68 observations, 58 were found under cover, with only ten found active on the ground surface. These active individuals were predominantly males and were usually found during the spring. Peak activity occurred from April-June. Skinks were not found above ground in hot or rainy weather.

A gravid female was collected on 22 June. Newly hatched juveniles appeared August-September. Fitch (1954:44) found hatchlings from early July through early August in Kansas. Food habits inferred from observation and scat analysis included reptile scales (ingestion of own ecdysis?), flies, wood cockroaches, beetles, ants, spiders, and woody fragments (incidentally ingested?). These taxa were also recorded by McCauley (1945:46) from 25 skink alimentary tracts in Maryland. Three skinks were parasitized by ticks and mites.

Snout-vent length measurements of 34 skinks showed a range of 53-74 mm (average 64.1) for 11 males, 61-67 mm (average 64.7) for 7 females, and 35-50 mm (average 42.2) for 16 juveniles.

Skinks are rare and localized in southwestern New England. Collection does not pose a threat to their populations and their steep, inaccessible habitats are generally secure from development. Several populations are on protected land. However, the small size and fragmented nature of these populations leaves them vulnerable to ecological catastrophe. After fires in the spring and early summer of 1988 Gruner observed no juveniles in August-September 1988 or during the spring and summer of 1989. The fires coincided with the 1988 nesting season, consuming most of their favored nesting sites, rotten and fallen logs. The 1988 cohort of juveniles were probably killed in the egg and some adults perished also. Conservation efforts should focus on additional survey work to locate skink populations as well as monitoring known sites. Although fire may be beneficial, keeping bald areas open and thereby attractive to skinks, a succession of fires over several years may seriously affect the recruitment of young skinks into the population. This may be especially deleterious given the small size of these populations.

SPECIMENS EXAMINED

Connecticut

Hartford Co. (n=3): AMNH 130589-90; AMNH-MWK 7900

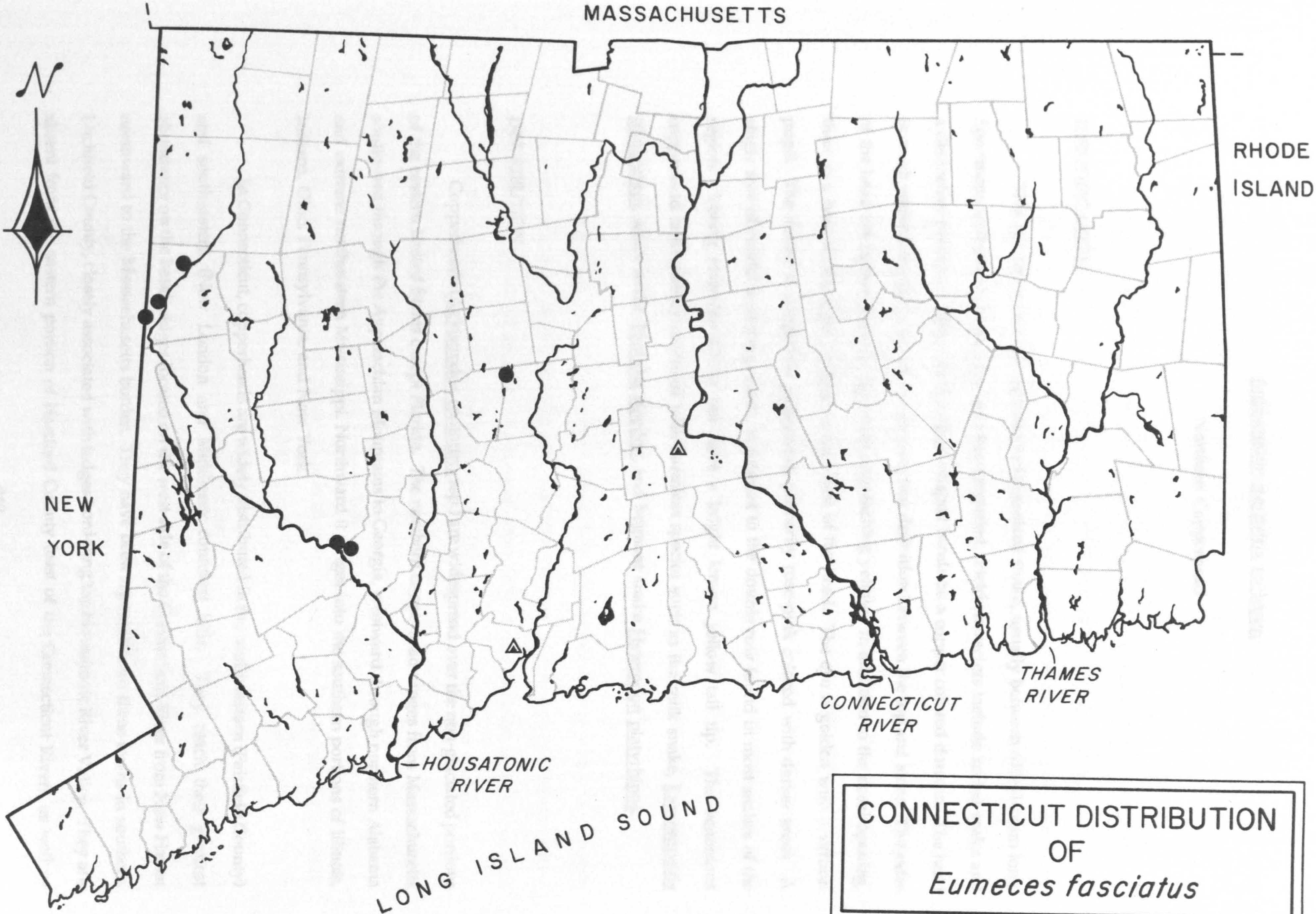
Litchfield Co. (n=3): AMNH 130031-33

Middlesex Co. (n=1): USNM 139203

New Haven Co. (n=3): AMNH 130034; UCS 5022; YPM 1154

New York

Westchester Co. (n=5): AMNH 75625, 116000, 130435, 133003-04



CONNECTICUT DISTRIBUTION
OF
Eumeces fasciatus

Agkistrodon contortrix mokasen

Northern Copperhead

IDENTIFICATION:

This is a heavy bodied, medium to large-sized snake, usually between 610-910 mm long. Specimens well over a meter long have been reported. Field characters include keeled scales and a distinctive pattern of yellowish hourglass shaped bands on a copper colored dorsum. The head is much wider than the neck, with a very angular definition between the top and sides. The sides of the head are lighter than the top, often approaching yellow. In addition to the nasal opening, there is a heat sensitive pit present on each side of the head. The eye is golden with a vertical pupil. The venter is irregularly pigmented, primarily rose-pink colored with darker areas. A single row of caudal scales is present, in contrast to the double row found in most snakes of the region. Young resemble adults but have a bright lemon yellow tail tip. The venomous copperhead is frequently confused with harmless species such as the milk snake, Lampropeltis triangulum, water snake, Nerodia sipedon, and hognose snake Heterodon platyrhinos.

DISTRIBUTION:

Copperheads (Agkistrodon contortrix ssp.) are widespread over the non-glaciated portions of the eastern United States except Florida. The northern copperhead ranges from Massachusetts southward through the Appalachian Mountains to Georgia, westward through northern Alabama and extreme northeastern Mississippi. Northward it ranges into the southern portions of Illinois, Indiana, Ohio, Pennsylvania, and New York.

In Connecticut, copperheads are widely distributed in the southwestern (Fairfield County) and southeastern (New London and Middlesex counties) hills. They reach their greatest abundance on the basalt ridges located on the west side of the Connecticut River from New Haven northward to the Massachusetts border. They have been reported from three towns in southern Litchfield County, closely associated with ledges bordering the Housatonic River Valley. They are absent from the eastern portion of Hartford County (east of the Connecticut River), as well as

Tolland and Windham counties. In Connecticut, copperheads favor hilly, relatively low lying areas. I made twelve collections between 100-700 feet elevation. Six were from below 500 feet, six from 500-700 feet.

In Massachusetts, this species is considered rare. On the basalt ridges of the Central Connecticut Lowland, they have been reported from only a few sites, ranging north to the Hampden-Hampshire county line. Disjunct populations were reported by Babcock (1926) south of Boston in the Blue Hills (Norfolk Co.), and north of Boston at Lynnfield (Essex Co.). The Lynnfield population is extirpated and although snakes are still found in the Blue Hills, they are much reduced in numbers.

To date, copperheads have not been documented from Rhode Island. There is a possibility that undetected population(s) may occur in the extensive granite ledges which extend into Rhode Island from southeastern Connecticut. Copperheads are known from several sites in this ledge system not far from the Rhode Island border. This distributional scenario has been documented for black rat snakes, (Elaphe o. obsoleta), which reach their northeastern range limit in southwestern Rhode Island. These snakes are restricted to the ledges and surrounding habitats, avoiding the sandy, coastal plain which encompasses most of Rhode Island.

In New York, copperheads are widespread in Westchester County where they remain reasonably abundant in the middle and northern sections of the county. James Oliver (unpublished data) found them at the following sites: North Salem (August 1947), Chappaqua (August 1955), Mianus River Gorge (September 15, 1955), DOR Sawmill River Parkway, 2.2 mi. S Hawthorne Circle (August 1959), and Nathan Straus Estate at Quarry Heights, ca. 6 mi. N of White Plains (spring 1960). More recently (1980's) they have been reported at North White Plains, near the White Plains Reservoir, and Teatown Lake in Ossining (E. Kanze, pers. comm.) and at Mountain Lakes Camp in North Salem (K. Soltesz, pers. comm.). I have collected and observed specimens at the Ward Pound Ridge Reservation.

Copperheads appear widespread in Putnam County, but are most prevalent along the Hudson River. Likewise, copperheads are distributed along the Hudson River in Dutchess County, where they were observed at Hyde Park in 1988. They are less common in eastern Dutchess County, but well known from sites in Dover, near the Connecticut state line (Kauffeld, 1957). The northern terminus of the copperhead's distribution between the Hudson and

Housatonic rivers may roughly correspond to a line drawn from Hyde Park (NY) to Dover Plains (NY) eastward to Kent (CT). They have been documented opposite Columbia County on the west bank of the Hudson River (Greene Co.). Therefore, I would not be surprised if additional field work located copperheads in the Columbia County portion of the Hudson Valley.

LIFE HISTORY AND ECOLOGY:

During my survey of Connecticut's herpetofauna I collected only incidental data on copperheads, as two colleagues were preparing a publication on Connecticut's venomous snakes (Petersen and Fritsch, 1986).

I found all but one copperhead on or near a basalt ridge. The snakes were found on talus slope (located midway up the ridge face) or in meadows at the base. These meadows were bordered by marshes, streams, or wooded swamps. Petersen and Fritsch (1986) found that copperheads showed a preference for traprock (basalt) ledges with extensive rock slides below, preferring a southerly exposure. They reported copperhead dens on the fringes of swamps, reservoirs, rivers, and streams in densely forested, damp habitats.

My copperhead collections were distributed as follows: May (2), June (5), July (2), August (1), and September (1). Petersen and Fritsch (1986) found them active from mid April through October.

I have no information on this species' reproduction. Finneran (1948) observed a mating pair on April 26 on Coon's Ledge at Branford (CT). On September 1 he collected three gravid snakes on Coon's Ledge, a 31 inch (787 mm) female contained twelve embryos, a 29 inch (737 mm) snake gave birth to ten young, and a 24 inch (610 mm) specimen gave birth to five young. Groups of newly born young were found at this den site on August 1, September 12, 14, and 23. Finneran (1953) found nine gravid females on September 7 and reported aggregations of gravid females on Coon's Ledge every summer during a seven year period. Petersen and Fritsch (1986) found copperheads producing between 3-10 young with broods of 4-6 most common.

Copperheads feed on a variety of rodents. I removed a <u>Microtus pennsylvanicus</u> from the stomach of a specimen collected at Southbury (CT). Petersen and Fritsch (1986) reported rodents, birds, reptiles, amphibians, and insects as prey items. Orth (1939) reported a New York specimen containing two hawkmoth caterpillars. Verrill (1870) reported a two foot copperhead found in the stomach of a black racer (Coluber) from Mount Carmel (CT).

I measured seven copperheads (5 males, 2 females) from southwestern New England as follows. The total body length of the males ranged from 712-942 mm (average 827.4), the two females measured 580 mm and 717 mm. Snout-vent length (SNVL) of the males ranged from 615-835 mm (average 720.6), tail length (TL) from 97-120 mm (average 106.8). SNVL of the two females were 500 mm and 630 mm with corresponding TL of 80 mm and 87 mm. Petersen and Fritsch (1986) reported the average length of copperheads to be 600-900 mm. They stated the largest recorded specimen of this subspecies (1300 mm) was collected at White Plains (Westchester Co., NY). Their largest Connecticut specimen (Hartford Co.) measured 1000 mm, but over a ten year period rarely found copperheads over 900 mm. Finneran (1948) found a 49 inch (1245 mm) copperhead in a cornfield near Coon's Ledge. If correctly measured, this would be the record size Connecticut specimen.

Copperheads remain abundant in parts of southeastern New York and Connecticut. They appear able to survive in close proximity to humans due to their cryptic coloration, phlegmatic disposition, and secretive, frequently nocturnal, habits. This is in marked contrast to Connecticut's other venomous snake, the timber rattlesnake, which has suffered a tremendous decline since colonial times. Rattlers are high strung, frequently alerting humans of their presence by rattling, which usually results in them being killed.

Ever increasing development around the trap rock ridges of the Central Connecticut Lowland threatens long term viability of copperhead populations by cutting off summer foraging grounds from the hillside den sites. Apart from reducing foraging areas, these developments create hazard zones which snakes must pass through several times a year without being killed by humans or traffic. Quarrying and highway construction has destroyed trap rock ridges resulting in large scale snake mortality.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=8): AMNH 57853, 77445, 123244, 135237; UCS 5043, 5161, 5181, 5317

Hartford Co. (n=28): AMNH 119292, 128125, 130111-12, 134295; AMNH-MWK 7903; UCS 1772-79, 3025, 5182, 5222, 6302, 6383, 6613, 6807, 6975, 7010, 7719, 7785-86; USNM 203401-02

Litchfield Co. (n=1): AMNH 125095

Middlesex Co. (n=5): AMNH 130113-16; UCS 6781

New Haven Co. (n=12): AMNH 119293, 134296; UCS 5023, 5221, 5251, 6731, 6768, 7705-06; YPM 435, 438, 533

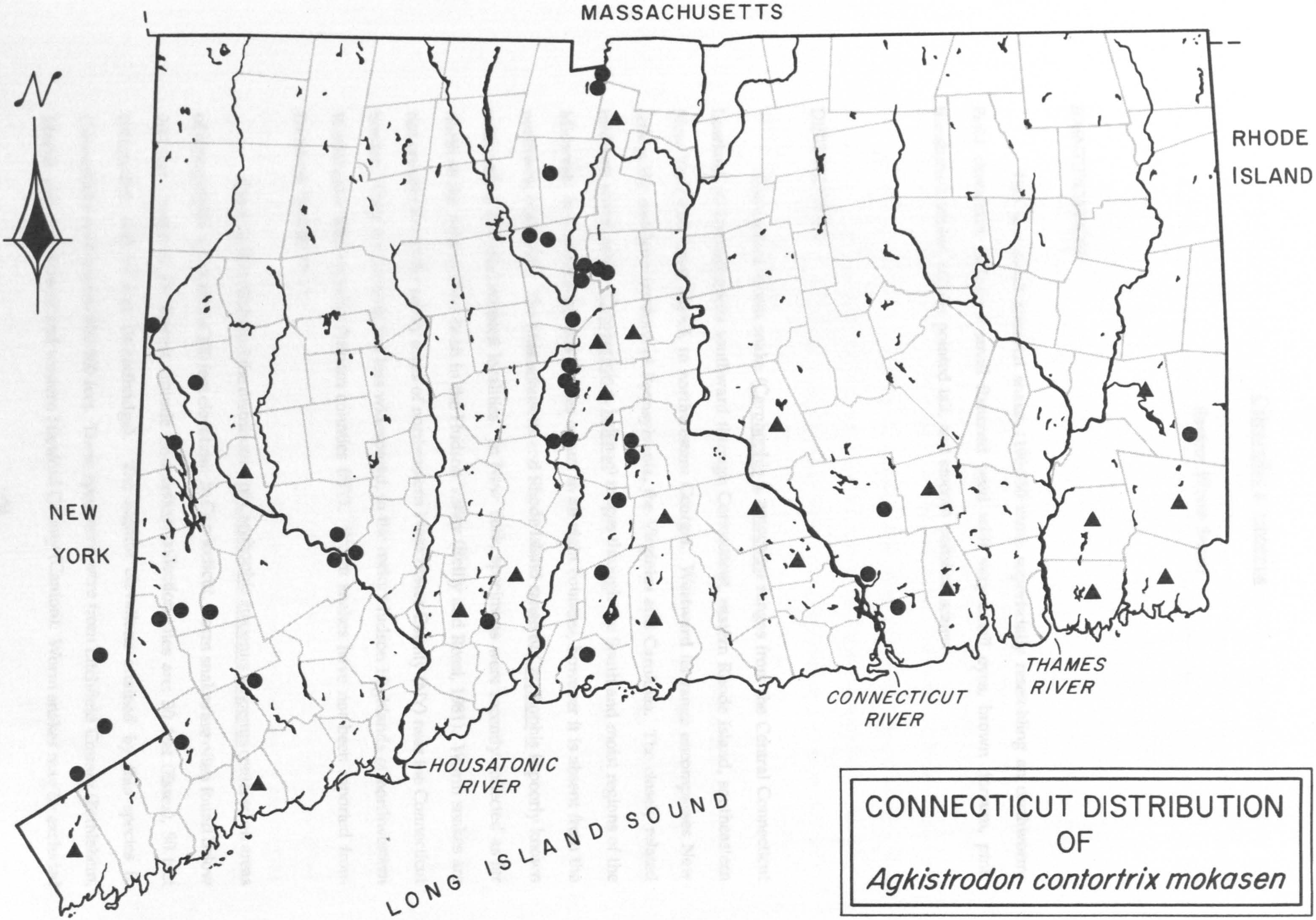
New London Co. (n=6): AMNH 5007; UCS 5368, 6472, 6750, 7184, 7608

New York

Dutchess Co. (n=7): AMNH 4007, 4009, 4012, 4129-31, 67101

Putnam Co. (n=2): AMNH 9682, 113607

Westchester Co. (n=13): AMNH 4132, 62945, 92710-15, 97247, 99989, 130183, 135234-35



CONNECTICUT DISTRIBUTION
OF
Agkistrodon contortrix mokasen

Carphophis a. amoenus

Eastern Worm Snake

IDENTIFICATION:

This is a small fossorial snake, (190-350 mm), superficially resembling an earthworm. Field characters include a small flattened head with very small eyes, brown dorsum, pink translucent venter, stubby pointed tail, and smooth polished scales.

DISTRIBUTION:

The eastern worm snake (Carphophis a. amoenus) ranges from the Central Connecticut Lowland of Massachusetts southward through Connecticut, eastern Rhode Island, southeastern New York and Long Island, to northwestern Georgia. Westward its range encompasses New Jersey, the southern portions of Pennsylvania, the Virginias and Carolinas. The closely related midwest worm snake (Carphophis a. helenae) ranges through the South and moist regions of the Midwest. In Connecticut, this species occurs in all eight counties, however it is absent from the northwest highlands. The Massachusetts and Rhode Island range of Carphophis is poorly known with only a few documented localities. In New York, specimens were recently collected as far north as the Albany Pine Bush in the Hudson Valley (Reilly and Rossi, 1981). Worm snakes are not uncommon in the sandy areas of northeastern Westchester County (NY) near the Connecticut border. They are present, but less widespread, in the rocky Hudson Highlands of northwestern Westchester and western Putnam counties (NY). Worm snakes have not been reported from Dutchess County (NY).

Clark (1970:105) found the distribution of Carphophis amoenus amoenus centered on areas of topographic uplift above 200 feet elevation. In Connecticut, worm snakes are often found below 200 feet. Some of the lowest altitude Connecticut collection sites are: 30 feet (Essex), 50 feet (Westville), and 90 feet (Woodbridge). The highest elevations attained by this species in Connecticut are between 800-900 feet. These specimens were from Litchfield County (Bethlehem, Morris, and Watertown) and western Hartford County (Canton). Worm snakes may be excluded from higher elevations by poorly drained and rocky soils, which are not suitable for burrowing, and by late spring and early autumn frosts. Sudden, hard frosts have proven to be a significant cause of mortality in a Kansas worm snake population (Clark, 1970:175).

LIFE HISTORY AND ECOLOGY:

Worm snakes are a diminutive burrowing species, extremely secretive and rarely collected. They are undoubtedly more widespread and abundant than my locality records indicate. I found worm snakes in well drained soils, often in or near deciduous woodland. Although I collected this species near large wetlands, the surrounding soils were usually porous and sandy. Two specimens were found in damp situations, one in a pile of decomposing wood chips, the other under a board in a pasture bordering a pond. Worm snakes were often dug up in gardens or found dead on the road.

Due to the subterranean habits of this species, I have little detailed information on its activity cycles in southwestern New England. Specimens were collected from late May through September, including the hot and frequently dry months of July and August. Sixty-four percent (14 of 22) specimens were collected or observed in late May and June. This is the only time of year when I found multiple specimens (up to four) at a site.

Clark (1970:114) plotted the collection dates of 96 preserved eastern worm snakes in museum collections. The distribution was bimodal with peaks in April-May and August. He suggested springtime movement of worm snakes to upper soil layers was correlated with earthworm (which he considered a major dietary item) concentrations. He hypothesized during the spring, moisture and temperature conditions were optimal for breakdown of accumulated leaf litter, causing earthworms to concentrate near the ground surface. During the summer, surface layers dry out and are moistened irregularly, resulting in less favorable conditions for earthworms. Although this may explain the April-May peak in his data, no explanation was provided for the August peak.

I hypothesize these springtime (April-May) surface concentrations were more likely thermoregulatory in function, while summer (August) collections may represent an increase in nocturnal surface activity. Connecticut worm snakes found during the summer (July-September) were usually dead, lying exposed upon the ground surface, while those found in the spring (May-June) were alive, under cover. I suspect these dead snakes are evidence of nocturnal surface activity as I never have collected a live worm snake exposed upon the ground surface during the day. Nocturnal activity would be favored in summer months as nights are sufficiently warm for reptilian activity, as well as humid with occasional thunderstorms. These moist nights would provide protection from desiccation and enhance surface activity of various prey species including earthworms and salamanders.

Basking appears to be done under debris or stones lying on the ground surface. Almost all live worm snakes I collected were found under stones or debris slightly imbedded in the ground's surface. Clark (1970:114-15) reviewed literature on worm snake sightings and concluded that snakes may be active during the day or at night. Barbour et al. (1969) used radioisotope tagging to trace the movements of ten worm snakes in Kentucky. They found daily activity peaks between 15-18:00 h with most movements initiated in the afternoon and early evening. Distances moved in a 24 h period varied from 0-45 meters.

Barbour et al. (1969) also calculated home ranges for these ten snakes which varied from 23 sq m for a small juvenile female to a maximum of 726 sq m for an adult male. The average home range of the ten snakes was 253 sq m.

Clark (1970:135) examined the reproductive tracts of 24 preserved female eastern worm snakes. He found two seasonal peaks in presence as well as quantity of sperm and concluded eastern worm snakes mate in the spring and autumn. He found the same pattern of two distinct mating seasons in his large sample (n=265) of western worm snakes.

A specimen (AMNH 133455) collected on May 30 at Hadlyme (CT) contained five eggs and (AMNH 130782) collected on May 26 at Pound Ridge (NY) contained four eggs. A 342 mm female from West Simsbury (CT) laid four eggs in captivity on July 8 and Lamson (1935) reported a captive Connecticut female laying four eggs in late June. Clark (1970:143) reported clutch sizes of eleven preserved eastern worm snakes from Maryland ranging between 2-5 eggs with a mean clutch size of 3.54 eggs. Barbour (1960:14) estimated the time of oviposition in Kentucky as mid June. Based on Lamson's (1935) and Barbour's (1960) data, egg deposition in southwestern New England could be expected from mid through late June. Clark (1970:151) summarized hatching dates of eastern worm snakes from the literature ranging between August 1 and September 15.

It would not be unreasonable to expect hatching in New England to occur in September, though confirmation is lacking.

Six Connecticut males ranged between 191-315 mm (average 272.6) total length while two females measured 327 and 342 mm. The snout-vent length (SNVL) of the males ranged between 158-255 mm (average 222.4) and tail length (TL) from 33-60 mm (average 50.2). The SNVL of the two females were 280 and 293 mm with corresponding TL of 47 and 49 mm. These data indicate that males are smaller than females, but have longer tails in proportion to their SNVL. These data agree with Clark (1970:99-103).

Connecticut worm snakes appear to vary little in coloration. I have no data on worm snake longevity from Connecticut. Clark (1970:184) reported on the age distribution of a sample of western worm snakes from his study area. He found 24% of males and 26% of females were older than four years.

Clark (1970:172) examined the intestinal tracts of 115 eastern worm snakes, 30 were empty, 76 had debris which "in most instances resembled soil such as found within earthworms", eight contained earthworms, and one a small salamander (Eurycea sp.). He concluded that worms were the major dietary item of worm snakes throughout their range. I question Clark being able to distinguish soil "found within earthworms" from incidentally ingested soil found within a snake's digestive tract. Although earthworms may comprise a major portion of the worm snake's diet, other soft bodied invertebrates may be ingested with quantities of surrounding soil, producing the residues he found in the digestive tracts of the snakes examined.

A specimen from Morris (CT) was killed by a cat. Clark (1970:175-76) listed the following as potential predators on worm snakes: snakes (copperheads, racers, milk snakes), opossums, short tailed shrews, and moles. Ernst (1962:266) reported insecticide poisoning of worm snakes when six percent chlordane dust was applied to soil for insect control.

An assessment of this snake's abundance is difficult. Sampling worm snakes by standard snake collecting methods such as debris turning, pit fall traps, and road kills are only effective if snakes are active at the ground surface. Potentially, the bulk of the population may be several feet below the ground surface, accessible only by destructive techniques such as excavation. Despite my fragmentary data, they appear widespread in Connecticut, occurring in suburban and rural areas. The urbanization of many low lying areas in Connecticut has resulted in a continual loss of the sandy, second growth deciduous woodland favored by worm snakes. However, worm snakes appear able to persist in small patches of habitat in relatively urban areas. Fortunately, large areas of habitat containing worm snake populations are protected in several state forests in central and eastern Connecticut. Worm snakes are found on several private sanctuaries within Connecticut and in a Westchester County (NY) park. Additional field work is needed in the mid Hudson Valley (NY), Massachusetts, and Rhode Island to clarify their distribution.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=7): AMNH 57688, 125025; UCS 1536-39, 7812

Hartford Co. (n=11): AMNH 123195, 127363; AMNH-MWK 7960; SIIAAS R-201; UCS 1816, 5183, 6386, 7461, 7607, 8281; USNM 1925

Litchfield Co. (n=4): AMNH 134263; AMNH-MWK 7959; UCS 4483, 8478

Middlesex Co. (n=3): AMNH 119294; ANSP 26579; UCS 7814

New Haven Co. (n=12): AMNH 130035; SCSC 444; YPM 29-31, 35-37, 6051-52; UCS 4238, 8655

New London Co. (n=6): AMNH 119295-96, 119644, 133454-55; YPM 33

Tolland Co. (n=10): AMNH 128034, 130591; AMNH-MWK 7907; UCS 1544, 3024, 4898-99, 7810-11, 8654

Windham Co. (n=7): AMNH 60666-67, 128035; UCS 1540-42, 7802

Massachusetts

Hampden Co. (n=1): YPM 32

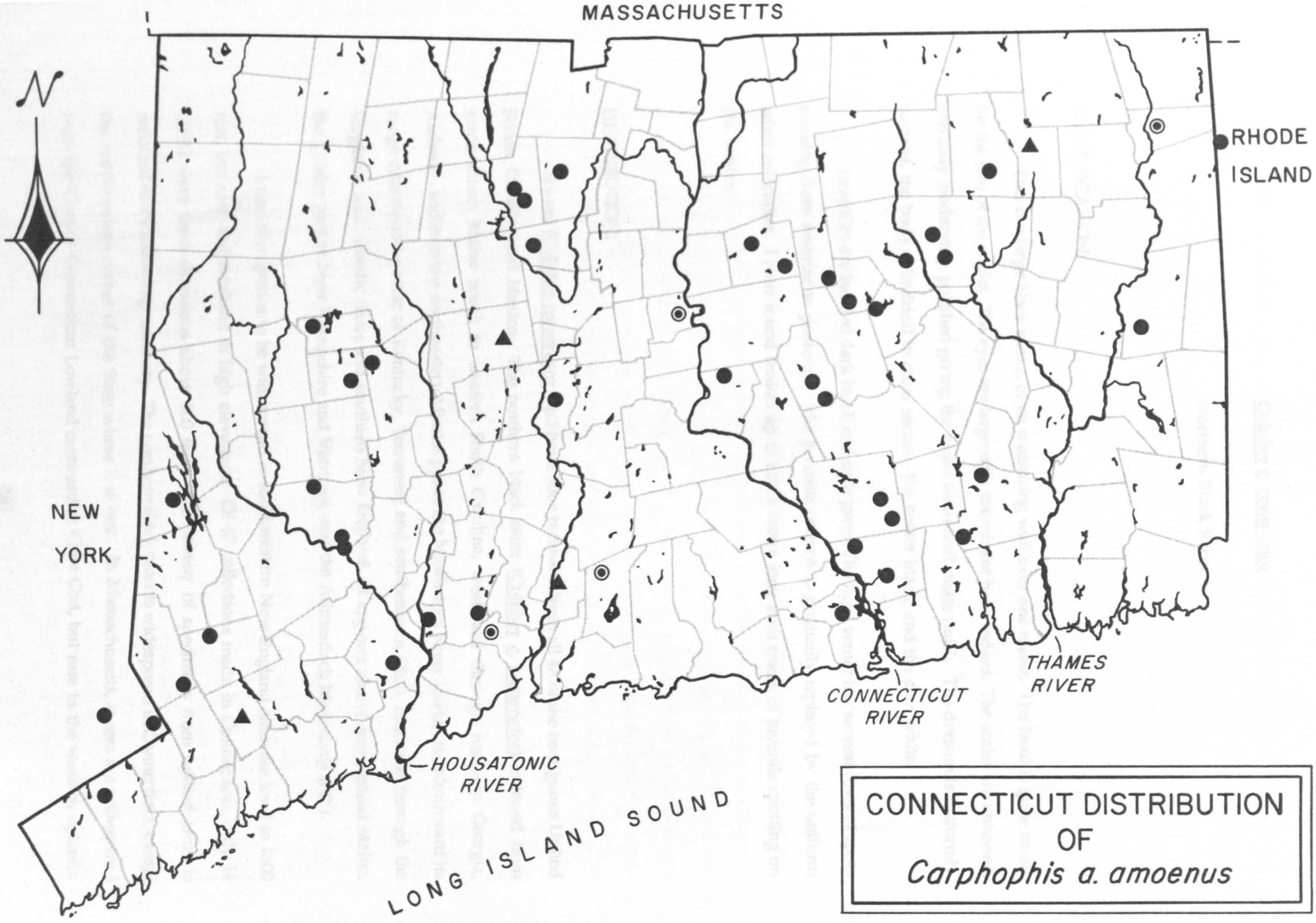
Rhode Island

Providence Co. (n=1): AMNH 129929

New York

Putnam Co. (n=1): AMNH 130934

Westchester Co. (n=7): AMNH 99990, 104479, 130445, 130779-82


MASSACHUSETTS
RHODE
ISLAND
N
NEW
YORK
HOUSATONIC
RIVER
CONNECTICUT
RIVER
THAMES
RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION
OF
Carphophis a. amoenus

Coluber c. constrictor

Northern Black Racer

IDENTIFICATION:

This is a large black snake, often measuring well over one meter. The head is quite small for the size of the snake. The eyes are large with prominent brow ridges. The scales are unkeeled and only moderately polished giving the snake an overall matte finish. The dorsum is uniformly colored, the body cylindrical in cross section, the venter black, and the chin white.

Juveniles are banded dark black and light grey. The light venter has several rows of spots running from anterior to posterior. The juvenile pattern is gradually replaced by the uniform adult coloration. I have found snakes up to half a meter long with traces of juvenile spotting on the venter.

DISTRIBUTION:

Racers (Coluber constrictor ssp.) have been recorded from all 48 of the contiguous United States, Canada, and Mexico. The northern black racer (Coluber c. constrictor) is found from southeastern Maine south to western South Carolina, westward through northern Georgia, Alabama, and extreme northeastern Mississippi to the Mississippi River lowlands. Northward its range encompasses most of Kentucky, Tennessee and southeastern Ohio, eastward through the Virginias, mid Atlantic states and southern New England. It appears absent from inland Maine, the greater part of New Hampshire and Vermont, and the Adirondack Mountains (NY).

I find this species to be widespread in southwestern New England from sea level to 1300 feet, but rare and localized at high elevations. Of 67 collections made in Connecticut, only 14 (21%) were from elevations above 500 feet. The paucity of specimens from upland areas is reflected in the following summary. The northern black racer is widespread in Connecticut, except the northwestern corner of the State where it is rare. In Massachusetts, racers are widespread from the Central Connecticut Lowland eastward to Cape Cod, but rare in the western uplands.

This species is common throughout Rhode Island. In New York, this snake is common in northern Westchester County, where sufficient undeveloped land still remains to support them. They are widespread in Putnam and Dutchess counties, particularly within the Hudson Valley. Black racers are scarce and localized in the eastern portions of Dutchess and Columbia counties. Fitch (1963) stated the continuity of this species' distribution and its range limits are poorly known. Although my work has confirmed their distribution in the lowland portions of southwestern New England, additional field work is needed to clarify upland distributions in areas including the Taconic uplift (CT, MA, and NY) and northern New England. I strongly suspect their occurrence in these areas is discontinuous, with snakes confined to small pockets of optimal habitat.

LIFE HISTORY AND ECOLOGY:

I collected black racers in a wide variety of habitats. They favor open or partially forested areas including meadows, fields, rocky slopes, woodland ecotones, old fields, and powerline cuts. I did not find them in heavily forested areas. Black racers thrive in areas that are periodically cleared or mowed. Large sheets of corrugated iron, plywood, automobile hoods, and other debris lying in dry grass or at the edge of woodlands are utilized as nocturnal retreats during the warm summer months. Racers return to den sites, frequently rocky areas characterized by deep fissures, to hibernate.

I collected racers between April 12 and October 18. The number of collections per month was bimodal, with maximum collecting success in May-June and a secondary peak in September. The September collections were strongly influenced by the flush of newly hatched racers which occurs in late summer.

Males are distinguished from females by their longer tail which has a distinct bulge posterior to the vent where the retracted hemipenes are housed. I observed racers engaged in courtship or mating on April 28 at Bethany (CT), May 3 at Bethel (CT), and May 6 at Stafford (CT). Racers can be quite aggressive in early spring. I surprised a racer in an open area at Windsor (CT) on May 8. It coiled, vibrated its tail, and struck repeatedly when I approached. Woods (1944) related a report of a racer found at Newington (CT) on May 7 by a 13 year old snake collector. As the collector attempted to catch the snake it moved toward him, grabbed onto his shirt, and held on. It was captured and then released, at which time it allegedly struck twice again, coming "clear off the ground" with each strike. Although I accept that racers can be quite aggressive toward humans, I find it difficult to believe a racer could strike with enough force to repeatedly become airborne. It is interesting that both Woods and my encounters with aggressive racers occurred in early May during the breeding season. This heightened aggressive behavior may well be a function of territoriality related to courtship activities.

Racer eggs have a distinctive granular surface, therefore it is easy to identify their eggshell fragments. I found hatched eggs under stones, rocks, boards, and buried in shallow holes, usually in sandy areas. A clutch of 12 racer eggs collected under a board in pitch pine barrens at Sterling (CT) on July 7 were artificially incubated. Eight eggs hatched between August 28 and September 2, the four unhatched eggs were dissected and proved infertile. The young (5 males and 3 females, AMNH 130042-49) measured from 190-243 mm SNVL (average 229). Fitch (1963) gave a clutch size of 7-31 (average 16.8) eggs for a sample of 14 Coluber c. constrictor.

Male racers become sexually mature at a total body length of 680 mm, females at 710 mm (Wright and Wright, 1957:135). Nineteen racers (11 males, 8 females) from Connecticut had the following measurements. Males ranged from 900-1657 mm (average 1306.3) total length, females from 846-1414 mm (average 1162.6). Snout-vent length (SNVL) of males ranged from 680-1275 mm (average 996.7) with tail lengths (TL) of 220-382 mm (average 309.5). SNVL of females ranged from 635-1087 mm (average 885.1) with TL of 211-352 mm (average 277.5). The average SNVL for either sex of this Connecticut sample exceeds Fitch's (1963) 806 mm average SNVL for a mixed sample of 34 sexually mature racers from New York. Babbitt (1932) reported a specimen measuring 6 feet, 1 inch (1854 mm) overall body length from Simsbury (CT).

Racers feed on a wide variety of vertebrates. Fitch (1963:396) gave a listing of food items. A racer from Norwich (CT) contained a garter snake (Thamnophis s. sirtalis) and a wood frog (Rana sylvatica), a specimen from Hebron (CT) contained a garter snake and two brown snakes (Storeria d. dekayi). Brown snakes were not included in Fitch's list of prey items. Verrill (1870) reported a racer from Mount Carmel (CT) disgorging a two foot long copperhead (Agkistrodon c. mokasen).

Racers are preyed on by a variety of vertebrates. I found portions of freshly killed racers but have no evidence as to what preyed upon them. Racers are often killed by automobiles and during mowing operations. Most humans recognize racers as a harmless species, therefore they are less frequently killed than blotched and banded snakes, the latter bearing a superficial resemblance to venomous species. Racers remain abundant in many areas. They are scarce in suburbanized areas of southwestern Connecticut due to habitat fragmentation and the dense forest cover of the remaining undeveloped land. Fitch (1963:Plate 22) noted that as habitats become densely forested they cease to be utilized as primary racer habitat. In forested areas of southwestern Connecticut the black rat snake (Elaphe o. obsoleta) is more common than the racer.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=7): AMNH 67143, 119233, 119645, 125026, 127364, 130592-93

Hartford Co. (n=11): AMNH 64427, 119646, 120494, 125027, 127365, 128036, 130036-37, 130594-95, 134264

Litchfield Co. (n=2): AMNH 119647, 130596

Middlesex Co. (n=2): AMNH 125028, 130038

New Haven Co. (n=10): AMNH 75630, 119297, 119648, 123196, 125029-30, 127366, 130039-41

New London Co. (n=7): AMNH 119298-300, 125031, 130597, 133456-57

Tolland Co. (n=5): AMNH 123197, 127367, 128037, 134265; AMNH-MWK 7870

Windham Co. (n=12): AMNH 125032, 128038, 130042-49, 133458, 134514

Massachusetts

Berkshire Co. (n=2): AMNH 130715, 133576

Franklin Co. (n=1): AMNH 134358

Hampden Co. (n=5): AMNH 133577-81

Rhode Island

Kent Co. (n=6): AMNH 129640, 134720-22, 134815-16

Providence Co. (n=2): AMNH 129642-43

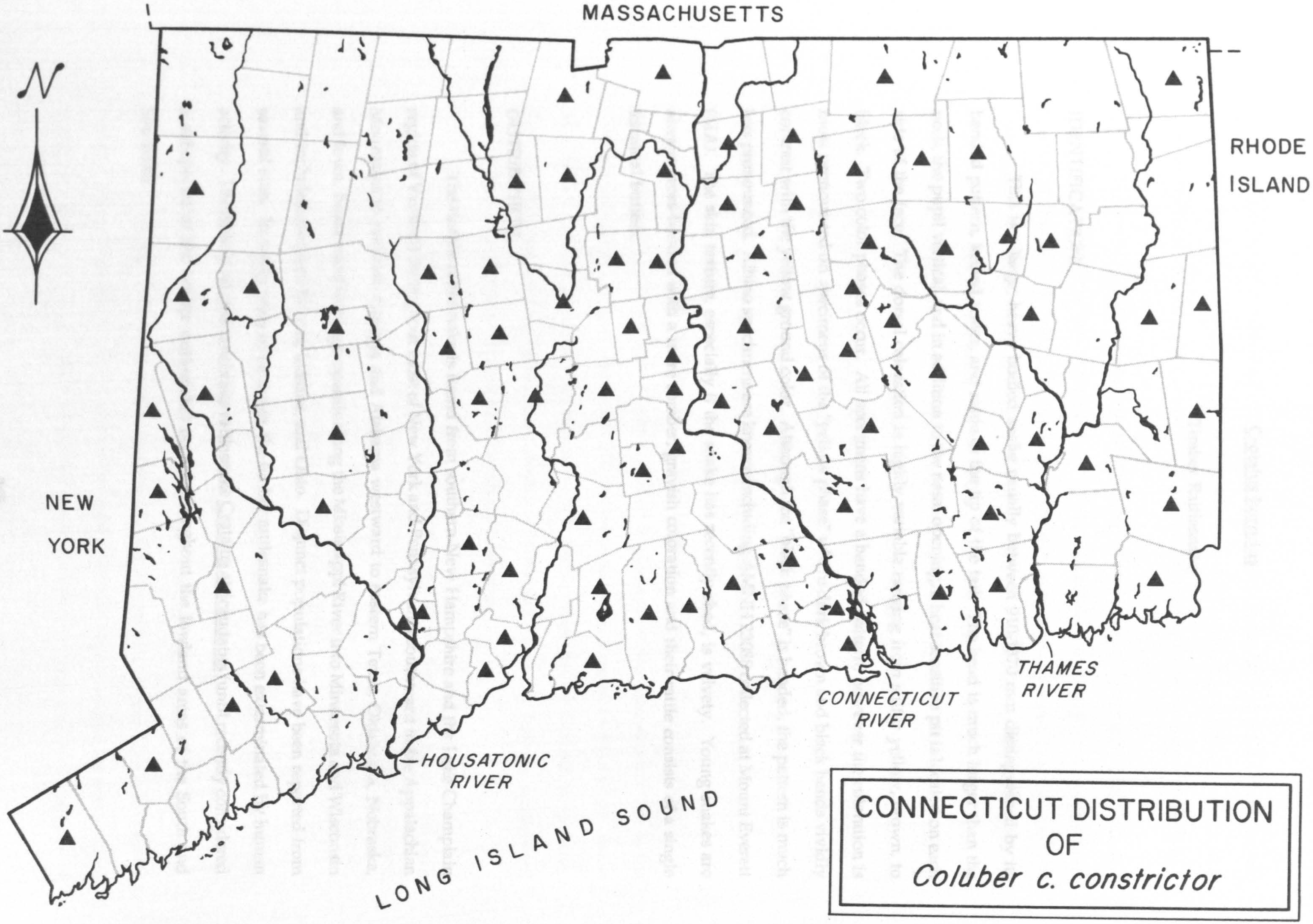
Washington Co. (n=4): AMNH 129930, 130675, 130884, 134726

New York

Dutchess Co. (n=6): AMNH 88669, 134478-82

Putnam Co. (n=1): AMNH 130185

Westchester Co. (n=7): AMNH 3409, 43280, 130186, 130783, 133021, 134576-77



CONNECTICUT DISTRIBUTION
OF
Coluber c. constrictor

Crotalus horridus

Timber Rattlesnake

IDENTIFICATION:

This is a large, heavy bodied snake usually between 910-1370 mm distinguished by its banded pattern, keeled scales, and rattle at the tip of the tail. The head is much larger than the neck, the pupil vertical, and in addition to the nasal opening, a heat sensitive pit is located on each side of the face. The dorsal coloration is highly variable ranging from sulfur yellow, brown, to black. Two color phases occur. All specimens have a banded pattern, however the coloration is most pronounced on specimens of the "yellow phase" where dark brown and black bands vividly contrast with the yellow ground color. Although the "black phase" is banded, the pattern is much less pronounced. Albino specimens are known including AMNH 23088 collected at Mount Everett (MA). The skin texture, especially if the snake has recently shed, is velvety. Young snakes are always cross-banded with a more somber, grayish coloration and their rattle consists of a single terminal button.

DISTRIBUTION:

The timber rattlesnake is found from southern New Hampshire and the Lake Champlain region of Vermont throughout most of New York and Pennsylvania southward in the Appalachian Mountains to northern Georgia and Alabama westward to eastern Texas, Oklahoma, Nebraska, and Iowa. Northward its range extends along the Mississippi River into Minnesota and Wisconsin and includes southern Illinois, Indiana, and Ohio. Disjunct populations have been reported from several sites. In many parts of its range, the timber rattlesnake has been exterminated by human activity. The closely related canebrake rattlesnake Crotalus atricaudatus (until recently considered a subspecies of the timber rattlesnake) occurs throughout the lowland areas of the South and Southeast.

In southwestern New England, this snake was much more widespread in colonial times, as indicated by historical accounts and numerous topographic features (e.g. mountains and brooks) named "rattlesnake". The latter occur in many areas where rattlesnakes are not presently found.

In Connecticut, this snake is presently confined to two areas. The rugged, mountainous terrain of western Litchfield County contains several large dens and could be considered the species' stronghold within the State. A cluster of smaller dens occurs in central Connecticut, with rattlesnakes reported in four abutting towns (East Hampton, Glastonbury, Marlborough, and Portland). Museum specimens from "near Bantam Lake" (Litchfield Co.), Southington (Hartford Co.) as well as Meriden and Northford (New Haven Co.) represent extirpated populations. Numerous reports of varying accuracy exist for other sites. Petersen and Fritsch (1986) listed five historical sites without specimen documentation. These are Cornwall and Roxbury (Litchfield Co.), Farmington (Hartford Co.), as well as Somers and Union (Tolland Co.). Linsley (1844) stated that although "not common in Connecticut" the rattlesnake was "found perhaps in more than half the towns in the state". He mentioned a "large den of them in Weston" (Fairfield Co.).

In Massachusetts, rattlesnakes are still regularly sighted in Berkshire County. A population occurs at Mount Tom, a basalt ridge on the Hampden-Hampshire county line in the Central Connecticut Lowland. Babcock (1933) reported specimens collected south of Boston in the Blue Hills (Norfolk Co.) where rattlesnakes are still found, albeit greatly reduced in numbers. Babcock (1933) also reported them north of Boston at Lynnfield (Essex Co.). Both the copperhead and rattlesnake populations at Lynnfield have been extirpated.

During the early colonial period rattlesnakes became such an annoyance that several towns voted to pay a bounty for snakes killed. Babcock (1925) reviewed historical information contained in town records for eastern Massachusetts. Rattlesnakes are no longer found in most, if not all, the towns discussed by Babcock (1925) in the following paragraph.

Medfield, Dedham, North Brookfield, and Canton all paid bounties to "whatsoever person or persons within this town bounds shall have sixpence a snake by bringing for evidence an inch of the snake's tail". Babcock (1925) illustrated a page from the Dedham town treasurer's book entitled "An account of the Snake tailes brought into the Treasury in ye year 1719". He further reported that rattlesnakes at Milford were at one time a terror in haying season, the mowers and haymakers having to wear leather moccasins reaching almost to their thighs. The town of

Arlington appointed a day in 1740 for a "general snake hunt and extermination", in 1844 rattlesnakes were very troublesome at Manchester, and in 1860 the town of Westborough organized a band of thirteen men to go to various outlying districts to kill rattlesnakes. Suffice it to say, that at one time rattlesnakes ranged throughout Massachusetts.

In northwestern Rhode Island rattlesnakes were reported from Foster (Providence Co.) by Drowne (1905). Sanford (1933) reported rattlesnakes from a granite ridge at Tiverton (Newport Co.). The latter was a well known locality documented by specimens. By 1978 the Rhode Island Audubon Society reported that despite conservation efforts the Tiverton population may be extirpated (Anon, 1978). Subsequent work by Raithel (pers. comm.) has not yielded any specimens or reliable reports since that time.

In New York rattlesnakes have fared slightly better than in New England and are still found, albeit very localized, in most of the downstate counties near New York City (Rockland, Orange, Putnam, and Dutchess). They are extirpated in Westchester County where they historically occurred at Katanoh as evidenced by a specimen (USNM 9973).

They also occurred on Long Island, a fact that has appeared to elude many students of rattlesnake distribution. Although Gloyd (1940) cited literature reports from Freeport (Nassau Co.) and Centre Islip (Suffolk Co.), Conant (1975) did not include Long Island within this species' range, possibly due to lack of specimen documentation. I recently received a copy of an obscure publication "The Old Oakdale History" published in 1983 with a press run of 500 copies which provides some of the best documentation to date for the historical occurrence of rattlesnakes in Suffolk County. A log of rattlesnakes killed between 1869 and 1888 is listed, often detailing the number of rattle segments. Between 1889-1899, 29 rattlesnakes were included on a list of "vermin" killed on the "upper Connetquot River", along with 26 puff adders (Heterodon) and 279 black snakes (Coluber), as well as various birds of prey, herons, and mammals.

LIFE HISTORY AND ECOLOGY:

During my survey of Connecticut's herpetofauna, I collected little data on rattlesnakes. The few specimens I received were salvaged after being killed by humans. Petersen and Fritsch (1986) spent many years studying Connecticut's rattlesnakes. The following information draws heavily upon their work.

Rattlesnakes favor remote mountainous terrain characterized by steep ledges and rock slides, the slides being formed by slabs that have broken off the ledges. Deciduous trees dominate rattlesnake den habitats, though stands of conifers may be present. Mountain laurel (Kalmia latifolia), blueberry (Vaccinium spp.), and huckleberry (Gaylussacia baccata) are the dominant shrubs. Rattlesnakes favor upland sites. My data indicate den sites and foraging areas are usually above 500 feet. Seven specimens were distributed as follows: 500-700 feet (4), 700-900 feet (1), 900-1100 feet (2). The central Connecticut den sites are roughly 700 feet in elevation, while the dens in Litchfield County are usually well over 1000 feet.

Petersen and Fritsch (1986) found snakes active from mid April through October. Eight salvaged specimens collected during my survey were distributed as follows: May (1), June (1), July (3), August (1), September (2). Most of these specimens were males foraging some distance from known den sites during the summer. Rattlesnakes feed primarily on rodents and birds, having a narrower range of food preferences than the copperhead (Petersen and Fritsch, 1986).

A snake from Sharon (CT) produced nine young and a Kent (CT) specimen (YPM 6541) gave birth to eight. Petersen and Fritsch (1986) reported broods of six, ten, and fourteen young.

The largest Connecticut rattlesnake collected by Petersen and Fritsch (1986) was 47 inches (1194 mm) captured in Hartford County. They reported a 60 inch specimen (1524 mm) collected in 1969 in Litchfield County and a captive specimen, also from Litchfield County, attained a length of 62 inches (1575 mm). Petersen and Fritsch (1986) reported that Ditmars collected a 74 inch (1880 mm) rattlesnake at Sheffield (Berkshire Co., MA). Snakes from northwestern Connecticut and the Berkshires achieve larger maximum sizes than their central Connecticut counterparts (Fritsch, pers. comm.). I was unable to obtain accurate measurements from my small sample of salvaged rattlesnakes, because they were variously damaged and decayed.

Timber rattlesnakes are an endangered species restricted to small pockets of optimal habitat within their former southwestern New England range. Disjunct populations at Lynnfield (MA) and Tiverton (RI) have become extirpated within the last 75 years. Rattlesnakes have also disappeared from several sites in Connecticut during the twentieth century including Meriden, Northford, Southington, and Bantam Lake. Disjunct populations at Blue Hills (MA) and in central Connecticut (East Hampton, Glastonbury, Marlborough, and Portland) have been greatly reduced in numbers as suburbanization encroaches upon rattlesnake habitat, bringing snakes in direct contact with humans, usually resulting in the snake's death. This environmental dilemma has been well publicized in Glastonbury (CT), an affluent suburb of Hartford, where housing developments have been constructed within the primary summer foraging range of rattlesnakes (Kelly, 1985; Winslow, 1987).

Rattlesnakes present a difficult public relations problem for conservationists. Although protected as an endangered species by state legislation throughout most of their northeastern United States range, killing of snakes encountered by farmers, homeowners, and outdoorsmen continues. Collecting rattlesnakes for the live animal trade is a pernicious problem at well known den sites. Their spring and autumn denning congregations leave them especially vulnerable to large scale collecting or killing. Individuals charged with protecting wildlife, including state foresters and game wardens, often fail to enforce prohibitions against killing and collecting rattlesnakes on state land.

The best hope for the rattlesnake's survival rests upon a combination of conservation and land use strategies. Education of the general public as well as game wardens and conservation officers, especially those living near rattlesnake dens, is the keystone to developing a perspective of rattlesnakes as "worthy" of protection. Educational topics could include the snake's role in a balanced ecosystem, its unique adaptations and morphology, its importance in both our history and folklore, and the statistically low risk of snakebite compared to many other hazards.

Prompt assistance should be provided to homeowners who encounter rattlesnakes on their property and wish to have them safely removed by game wardens or "designated agents". In 1989, four live rattlesnakes were removed from their summer foraging range in a housing development, and safely released some distance away at their den. This represents a major change in local attitudes, due in large part to educational efforts by conservationists. Previously, rattlesnakes were killed when encountered in this area.

Enforcement of protective legislation is difficult, both from a practical and public relations viewpoint. While prosecuting individuals who kill rattlesnakes on their own property is difficult, protective legislation should be strictly enforced in state parks and forests. Enforcement efforts should be primarily aimed at "professional" snake collectors. Rattlesnake killing by state employees and state contractors should not be tolerated. This is a continuing problem, prevalent among forestry and road work crews. In 1989, several rattlesnakes were killed by Connecticut Department of Transportation workers along a highway in Glastonbury. While education may offset some of these losses, in some instances punitive measures may need to be taken.

Brown et al. (1982) marked five rattlesnakes with temperature sensitive transmitters. One male moved 1400 meters from the den in his summer foraging route. I have received reports of rattlesnakes well over a mile from the nearest known den site in Berkshire County (MA). These data provide a challenging conservation problem. Although many den sites are in state forests, males and non gravid females disperse to summer foraging areas that are frequently on private property and often inhabited. As it is not possible or economically feasible to protect an area within a mile's radius from each rattlesnake den, innovative land use planning will be required to enable humans and snakes to coexist in southwestern New England. Although preservation of the few remaining disjunct populations (Blue Hills and central Connecticut) is very desirable, the encroachment of development upon these sites will remain a continual problem. Recent work by Fraser and Fritsch (1988) on a Glastonbury population in encouraging. They have documented population levels higher than anticipated, given the long history of depredations in that area. Continued study and habitat acquisition, coupled with an intensive local education program should be priorities at this site.

Regionally, efforts should be focused on the Taconic uplift area of New York (Dutchess and Columbia counties), Connecticut (Litchfield County), and Massachusetts (Berkshire County) where large tracts of open land, (forest and hayfields) still occur below rattlesnake dens. Development, including a vigorous second home market, is rapidly accelerating in this area. Now is the time to make land use planning decisions to ensure the rattlesnake's survival. These could include agricultural easements to preserve open hayfields, conservation easements to keep large tracts of land undeveloped, purchase of key tracts including dens and migration corridors, cluster zoning and other innovative land use plans to limit development to restricted portions of large land tracts, and siting development away from migration corridors and primary foraging areas. Assistance should be given to local townships by various state agencies in developing such plans.

Additional work is needed to locate dens and to determine areas of primary foraging activity. Radio telemetry may play a significant role in answering these questions.

SPECIMENS EXAMINED

Connecticut

Hartford Co. (n=14): AMNH 127461, 130649-51, 134297; UCS 1763-65, 5420, 7159, 8308; UMMZ 152985; USNM 139271; YPM 581

Litchfield Co. (n=47): AMNH 119301, 127462, 130117, 135238; UCS 1760-62, 1784-85, 2530-35, 6808; YPM 432, 493-95, 6233-53, 6255-56, 6311-12, 6541-42

Middlesex Co. (n=1): UCS 6486

New Haven Co. (n=1): YPM 394

Massachusetts

Berkshire Co. (n=4): AMNH 23088, 66592-94

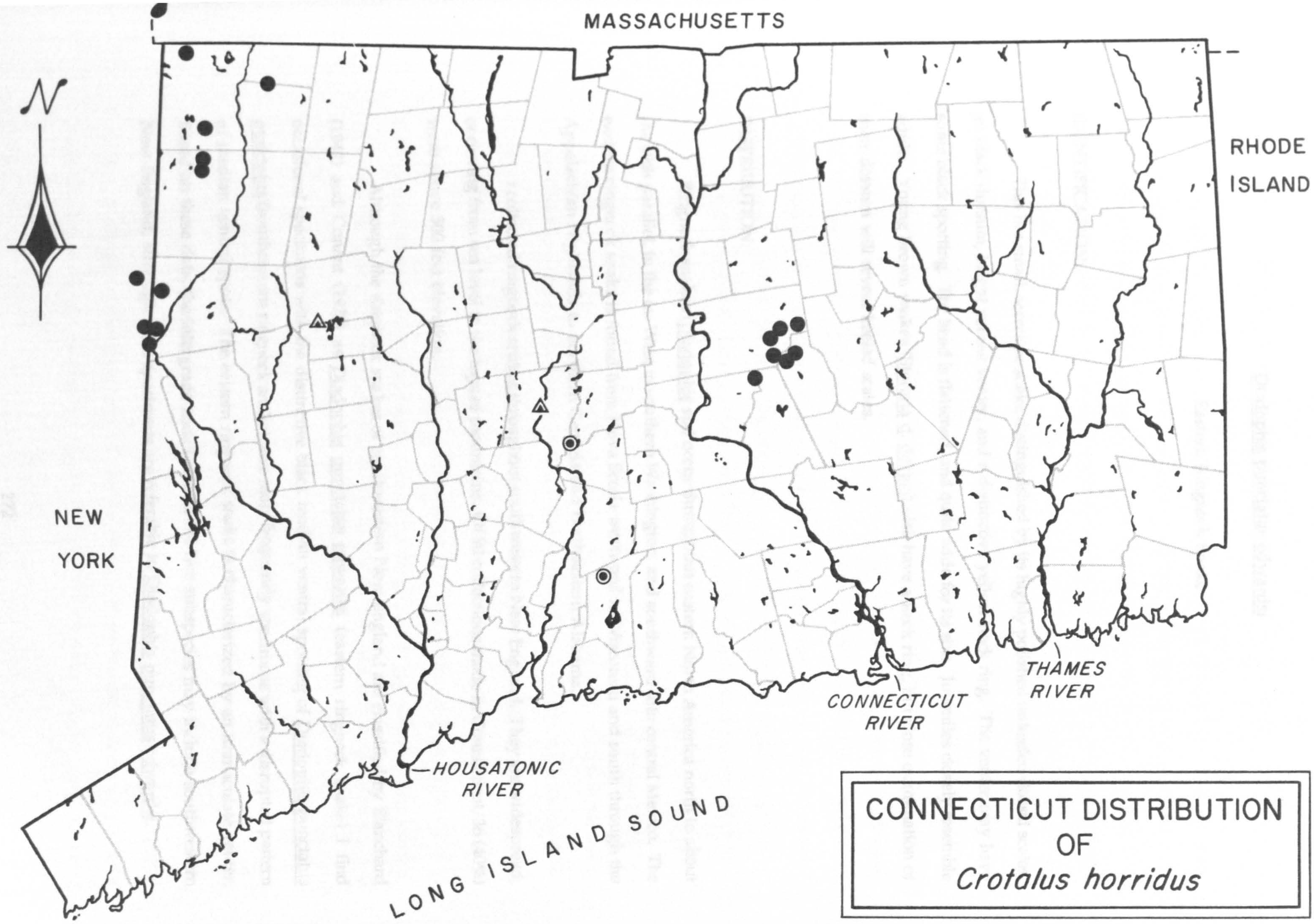
New York

Columbia Co. (n=1): AMNH 128165

Dutchess Co. (n=4): AMNH 64638, 64653, 99703, 130184

Putnam Co. (n=1): AMNH 129137

Westchester Co. (n=1): USNM 9973



CONNECTICUT DISTRIBUTION OF *Crotalus horridus*

Diadophis punctatus edwardsi

Eastern Ringneck Snake

IDENTIFICATION:

This is a small, secretive snake distinguished by its highly polished unkeeled dorsal scales, jet black dorsum, bright yellow venter, and a distinctive yellow neck ring. The venter may have some black spotting. The head is flattened, and quite wide for its size. Juveniles closely resemble adults. Young brown snakes (Storeria d. dekayi) also have a neck ring, but close examination of their dorsum will reveal keeled scales.

DISTRIBUTION:

Ringneck snakes (Diadophis sp.) occur throughout eastern North America north to about the 49th parallel, in the far West to southern Washington, and southward into central Mexico. The eastern ringneck snake is found from Nova Scotia westward to Wisconsin and south through the Appalachian Highlands to northern Georgia and northeastern Alabama.

I collected ringneck snakes throughout southwestern New England. They are widespread, occurring from sea level to the tops of mountains. Of 90 collections made in Connecticut, 36 (40%) were above 500 feet elevation.

Although the ringneck snakes of southwestern New England are classified by Blanchard (1942) and Conant (1975) as Diadophis punctatus edwardsi (eastern ringneck snake) I find occasional specimens with the distinctive black median ventral spotting of Diadophis punctatus punctatus (southeastern ringneck snake), and more frequently specimens with a disrupted pattern of median ventral spots. The eastern ringneck snake is characterized by an immaculate venter. Based on these data, the intergrade zone between the two subspecies may include southwestern New England, although most specimens are referable to Diadophis punctatus edwardsi.

LIFE HISTORY AND ECOLOGY:

I collected ringneck snakes in an incredible diversity of habitats including scarified, disturbed areas such as gravel pits and dumps, rocky slopes, mesic ravines with dense hemlock cover, pitch pine sand barrens, gardens, meadows, and deciduous forest. In summary, their habitats range from pristine to disturbed, from mesic to xeric, from open to completely closed canopy.

Although widely distributed, Diadophis appears very common in certain parts of southwestern New England and rare in others. For example, this snake is extremely common in eastern Connecticut and adjacent Rhode Island and in areas of south-central Connecticut (Middlesex Co.). These habitats are characterized by rocky outcrops, sandy soils, and deciduous forest. In these areas it is possible to collect twenty or thirty individuals in a day's field work. This differs markedly compared to collection success in northwestern Connecticut and adjacent Massachusetts, where I collected a few snakes per year. Ringneck snakes appear to increase in abundance as one moves eastward from the Hudson Valley, through Connecticut, into Rhode Island.

I found ringneck snakes active from May to September. Wright and Wright (1957:187) found them active from April 15 to October 15 in New York. My peak collection success in Connecticut was in May, with a steady decline through September. This was in contrast to some other species I collected (e.g. Coluber) which had a secondary peak of abundance in late summer. I rarely find these snakes in the open, as they prefer to bask under stones and debris. A favorite hiding spot is under a flat rock lying upon a larger rock. Both H. Gruner (pers. comm.) and C. Raithel (pers. comm.) have found ringneck snakes crossing roads at night during rainy weather. Although I have not observed nocturnal activity, I found road kills both in the morning and evening.

I have not observed ringneck snakes courting or mating. I found a communal nest of ten ringneck eggs inside a rotten railroad tie in pitch pine barrens at Coventry (RI) on July 7. Nine of these eggs were artificially incubated and hatched between August 17-21 (AMNH 129931-39). Six of these young had immaculate venters, one a lightly spotted venter, and two strongly spotted venters. Three eggs collected on July 11 under a stone on a powerline cut at Andover (CT) were artificially incubated and hatched on August 15 (AMNH 130605-07). These young measured between 105-118 mm total length (average 113). I found four newly hatched ringneck snakes and four egg shells under a flat rock resting atop a boulder at New Salem (MA) on August 27 (AMNH 134362-65). This represents the only hatching date I have under natural conditions. I found a neonate on September 22 at Woodstock (CT).

Blanchard (1942:110) reported a clutch size of 1-6 (average 3.5) for a sample of 130 eastern ringneck snakes. He reported communal nesting and found newly hatched young measuring between 110-135 mm. My limited data on clutch size, hatchling size, and incubation periods do not differ substantially from Blanchard's study.

Male and female eastern ringneck snakes are mature 220 mm overall body length (Wright and Wright, 1957:187). A sample of 71 sexually mature ringneck snakes (45 males and 26 females) from Connecticut had the following measurements. Males ranged between 233-414 mm (330.2 average) total body length, females 226-413 mm (average 343.3). Snout-vent length (SNVL) for males ranged between 180-314 mm (average 252.8) and tail length (TL) from 53-100 mm (average 77.5). SNVL for females ranged between 180-339 mm (average 272.1) and TL from 42-87 mm (average 71.2). These data indicate males and females do not appreciably differ in maximum size attained, but females on average are slightly larger, and males have longer tails relative to their SNVL than do females. These data compare favorably with Blanchard's (1942:106) study.

Blanchard (1942:110-111) confirmed wild eastern ringneck snakes feeding on redback salamanders (Plethdon c. cinereus) and redbellied snakes (Storeria o. occipitomaculata). He questioned unconfirmed reports of prey, including many insects, and reported earthworms were only reluctantly taken by captive specimens. I have no data on food habits to add from my collections. Like most small snakes, ringnecks are potentially food for a wide variety of predators. I found portions of partially eaten snakes, received several specimens killed by cats, and found a dead neonate entangled in a spider web. I frequently find these snakes in cellars and have received several found in houses during the winter. Stone walls are favored haunts, especially older walls in wooded areas that have accumulated duff in their crevices.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=10): AMNH 90535, 125033-36, 127368, 130598, 135239-40; AMNH-MWK 8008

Hartford Co. (n=14): AMNH 119302-05, 123198, 127369-70, 128039, 130050-53, 130599; AMNH-MWK 7962

Litchfield Co. (n=7): AMNH 38349, 123199, 125037-38, 128040, 130054; AMNH-MWK 7887

Middlesex Co. (n=12): AMNH 123200-02, 127371-74, 128041-42, 130055, 130600-01

New Haven Co. (n=9): AMNH 123203, 125039-40, 127375, 130056-60

New London Co. (n=15): AMNH 119306, 125041, 127376-84, 130602, 133459-60; AMNH-MWK 7855

Tolland Co. (n=17): AMNH 127385-86, 128043, 130603-07, 133461-63, 134266-70; AMNH-MWK 7902

Windham Co. (n=15): AMNH 119307, 125042-44, 127387-93, 128044, 134271-73

Massachusetts

Berkshire Co. (n=4): AMNH 133582-84, 134359

Franklin Co. (n=6): AMNH 134360-65

Hampden Co. (n=2): AMNH 133585-86

Rhode Island

Kent Co. (n=11): AMNH 129931-39, 130890, 133502

Providence Co. (n=10): AMNH 129647-48, 129940-47

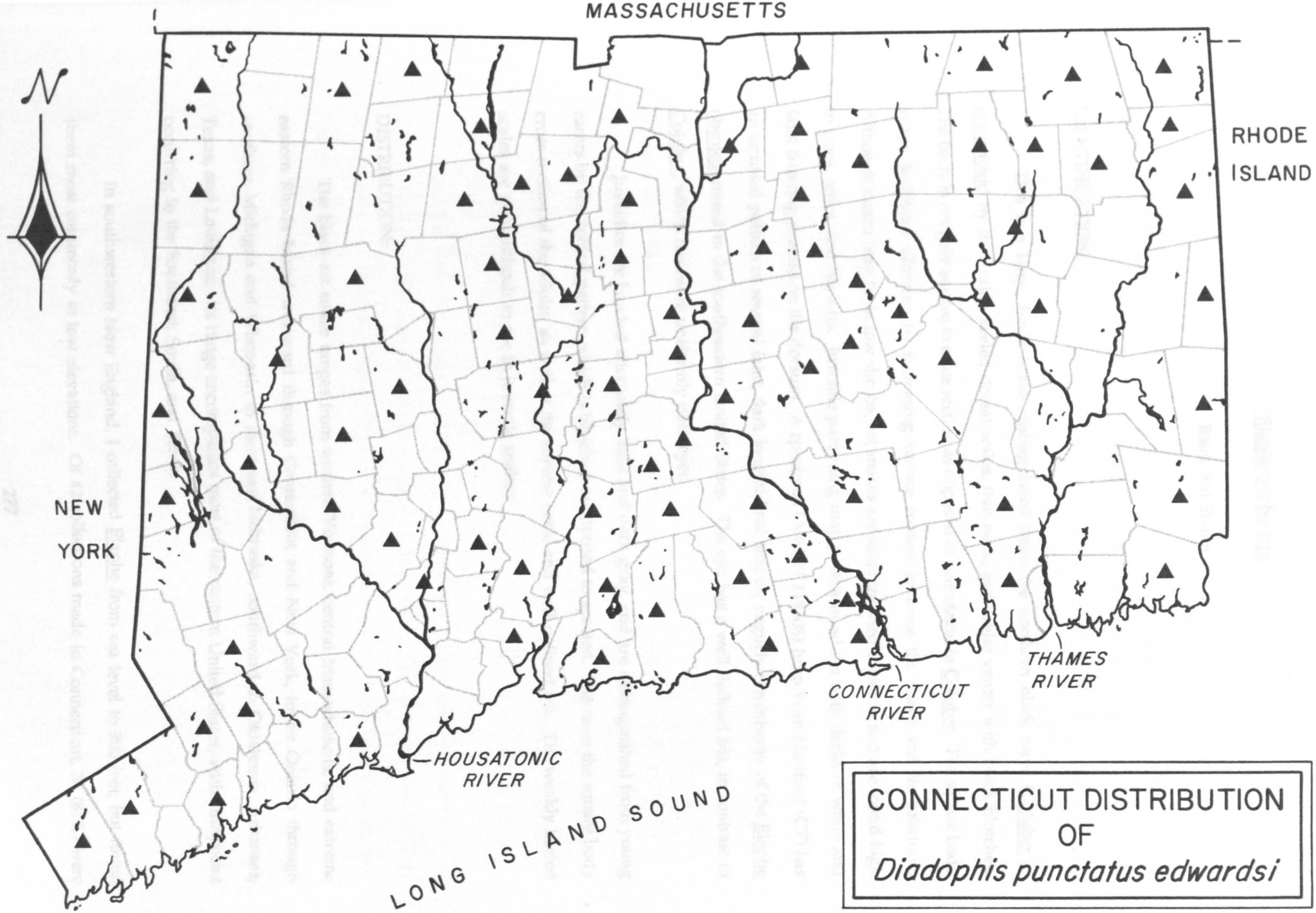
Washington Co. (N=20): AMNH 129650-52, 129948-54, 130676-83, 130894, 130896

New York

Dutchess Co. (n=8): AMNH 87397-99, 87995, 90621, 134483-85

Putnam Co. (n=1): AMNH 77441

Westchester Co. (n=6): AMNH 93677, 130187, 130784-85, 133023, 134486


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
THAMES RIVER
CONNECTICUT RIVER
HOUSATONIC RIVER
LONG ISLAND SOUND
CONNECTICUT DISTRIBUTION
OF
Diadophis punctatus edwardsi

Elaphe o. obsoleta

Black Rat Snake

IDENTIFICATION:

This is a large, black snake distinguished from the northern black racer (Coluber c. constrictor) by its weakly keeled dorsal scales, thin neck, and white venter with black blotches. The body is roughly square in cross section as opposed to cylindrical in Coluber. The square body shape facilitates climbing by increasing surface contact between the snake and its substrate. Although racers may lie in low shrubs, rat snakes are accomplished climbers and are found high in trees, attics, and haylofts. Juvenile patterning may persist in adults with flecks of white and faint banding present on the dorsum. A specimen (AMNH 119308) from West Hartford (CT) has an unusual pattern of several faint, dark longitudinal stripes, vaguely reminiscent of the Elaphe obsoleta found in the southeastern United States. The eye has a well defined iris, in contrast to Coluber, which has more uniformly dark eyes.

Juveniles are banded alternately light and dark gray, and are distinguished from young racers by the ventral pattern which is blotched as opposed to spotted. The have the square body cross section of the adults, as well as the narrow neck, and well defined iris. The weakly keeled scales are very difficult to see in juvenile snakes.

DISTRIBUTION:

The black rat snake ranges from western Vermont, central Massachusetts, and extreme eastern Rhode Island westward through Connecticut and New York, lower Ontario through southern Michigan and Wisconsin to southeast Nebraska, southward to Oklahoma, Arkansas, Texas, and Louisiana. Its range encompasses most of the eastern United States, with subspecies occurring in the Southeast, South, and Texas.

In southwestern New England, I collected Elaphe from sea level to 900 feet, but found them most commonly at low elevations. Of 42 collections made in Connecticut, 34 (81%) were below 500 feet. In Connecticut, this snake is widespread in the coastal counties (Fairfield, New Haven, Middlesex, and New London). It is uncommon in Litchfield County, where my records are from the Housatonic River valley as far north as Kent. James Oliver (unpublished data) recorded a specimen at Roxbury Falls in the Shepaug River valley (southern Litchfield Co.). Black rat snakes have a limited distribution in Hartford County, restricted to the trap rock ridges on the west side of the Connecticut River. A notable exception is a population on Compounce Mountain, in extreme southwestern Hartford County. Further field work is needed to determine the status of Elaphe in this area as well as the southern section of the Naugatuck River valley. Black rat snakes are absent from eastern Hartford County (east of the Connecticut River), as well as Tolland and Windham counties.

Recent field work (Raithel, pers. comm.) has confirmed Elaphe in extreme southwestern Rhode Island, in the ecological continuation of the granite ledge habitats of southeastern Connecticut (vicinity Pachaug State Forest). Moving eastward in Rhode Island, Elaphe disappears, corresponding to a marked habitat change from granite ledge to less rocky, coastal habitat.

In Massachusetts, Elaphe is confined to ridges (mostly trap rock) in the Central Connecticut Lowland. MacCoy (1930) recorded a specimen from as far north as Sunderland (Franklin Co.). These Massachusetts sites are northward continuations of Elaphe populations found on the trap rock ridges of western Hartford County (CT). These ridges form a fairly continuous strip of habitat from New Haven through Massachusetts. Additional field work is needed to clarify the species' current distribution and population status in central Massachusetts.

In New York, this species is widespread in Westchester County where sufficient habitat still remains to support them. The primary centers of abundance are the northern sections of the county and along the Hudson River. They are widespread in Putnam County and in the Hudson Valley of Dutchess County. In central and eastern Dutchess County they become less common, often confined to small river valleys and nearby ridges. My northernmost record for eastern Dutchess County is along Webatuck Creek, south of Amenia Union, and six miles north of Kent (see earlier description of Connecticut range). I have no records from Columbia County.

LIFE HISTORY AND ECOLOGY:

Elaphe favors rocky, partly open or wooded habitats, with rocky outcrops. They are quite partial to rugged, steep habitats. Unlike Coluber, they shun large open fields, but utilize small meadows adjacent to woodland. I found both species of black snake sympatrically at several sites. Some unusual sites where I collected Elaphe included the edge of a salt marsh at Branford (CT), in attics of inhabited old houses at East Haddam and Middletown (CT), and coiled inside a birdhouse at Bridgewater (CT). Elaphe appears particularly abundant along the Connecticut coast east of New Haven. They may have been equally widespread west of New Haven, but now much reduced due to suburbanization.

My earliest date of Elaphe activity is April 20 at Pound Ridge (NY) and latest October 13 at West Hartford (CT). Wright and Wright (1957:232-233) gave an early date (April 27) from New York and a late date (November 29) from Ontario Province, Canada.

Male black rat snakes are sexually mature at 1095 mm total body length, while females mature at 715 mm (Wright and Wright, 1957:233). Measurements of a sample of 11 Connecticut Elaphe (6 males, 5 females) are as follows. Total length of males ranged between 1265-1715 mm (average 1474), females ranged between 1158-1618 mm (average 1302.6). Snout-vent length (SNVL) for males ranged from 1040-1435 mm (average 1216.7), tail length (TL) from 225-287 mm (average 257.3). SNVL for females ranged from 966-1393 mm (average 1107.8), TL ranged from 160-225 (average 194.8). These total length measurements fall within the range given by Wright and Wright (1957:233) of 1095-1835 mm for males and 715-1800 mm for females.

I have no data on courting, mating, oviposition, or clutch size. I found neonate Elaphe from September through October. Measurements of three wild caught neonates (2 males, 1 female) were total length 340-365 mm (average 348.7), SNVL 278-297 mm (average 285.7), TL 58-68 mm (average 63). These total length measurements fall into the high end of the range of neonate measurements of 273-361 mm given by Wright and Wright (1955:234).

Elaphe remains common within its Connecticut and New York range. It thrives in areas that contain a mixture of houses, agriculture, and woodland, feeding on the increased rodent and bird populations the occur in patchwork habitats. Road mortality occurs, but I do not consider it a significant threat. Likewise, the collection of these snakes for pets is not significant, though it should be discouraged in protected areas such as the Ward Pound Ridge Reservation

(Westchester Co., NY). Ample Elaphe habitat is protected in state and county parks, state forests, as well as private sanctuaries. Many of the steep ledge and mountainous areas that Elaphe inhabit are unsuitable for intensive development, however large-scale quarrying has destroyed several sites within Connecticut's trap rock ridge system.

In Massachusetts, survey work is needed to assess the distribution of Elaphe in the Central Connecticut Lowland. Unfortunately, the entire Massachusetts range of Elaphe coincides with an area of extensive and increasing urban development. In Rhode Island, Elaphe appears to be limited to a few towns. Additional field work is needed to ascertain the northward and eastward extent of their Rhode Island range. Fortunately, large areas of their Rhode Island habitat are protected in state game management areas and the region is sparsely settled. Although their total Rhode Island range is much smaller, these populations may be more secure than those occurring within Massachusetts.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=7): AMNH 119649, 125045; UCS 1721, 5141-42, 5176, 8664

Hartford Co. (n=19): AMNH 119308, 119650, 125046, 130608-12, 133464, 134274-76; AMNH-MWK 7843; UCS 6392, 6713, 7087, 8107, 8663, 8665

Litchfield Co. (n=5): AMNH 49946, 97248, 125047; UCS 2481, 8666

Middlesex Co. (n=10): AMNH 123204, 125048, 128045; UCS 5762, 6476, 6973-74, 7058, 8288, 8639

New Haven Co. (n=10): AMNH 119309-11, 123205, 125049-50, 128046, 130061; SCSC 729; UCS 5130

New London Co. (n=15): AMNH 119312, 125051-52, 133465-68, 134277; MCZ 82868; UCS 5786, 6484, 7319, 8049, 8106, 8446

Rhode Island

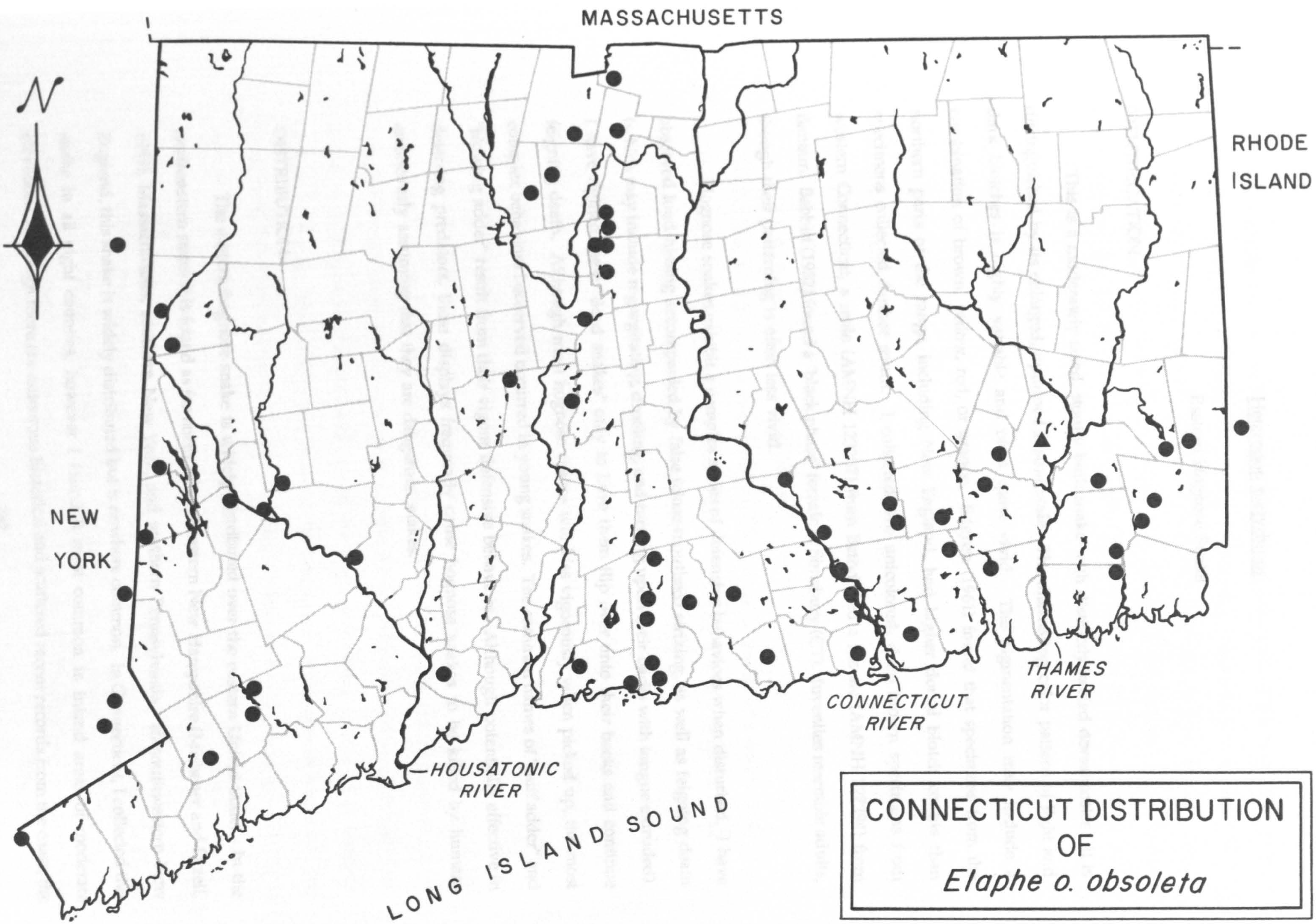
Washington Co. (n=4): AMNH 130897, 134737-39

New York

Dutchess Co. (n=4): AMNH 120078, 130188, 130786, 134487

Putnam Co. (n=2): AMNH 2174, 130189

Westchester Co. (n=7): AMNH 87405-06, 130190-91, 130787, 133024, 133624



CONNECTICUT DISTRIBUTION OF *Elaphe o. obsoleta*

Heterodon platyrhinos

Eastern Hognose Snake

IDENTIFICATION:

This is a moderately sized, stoutly built snake with distinctly keeled dorsal scales. It is distinguished by its enlarged, upturned rostral scale. The alternating color pattern of light and dark blotches is highly variable and often quite vivid. The pigmentation may include a combination of brown, yellow, red, or orange. Edgren (1961) found that specimens from the northern parts of the range, including New England, had higher dorsal blotch counts than specimens collected further south. I collected two unicolored, deep brown specimens from western Connecticut, a male (AMNH 123207) from Bethel and a female (AMNH 127394) from Bantam. Babbitt (1932) found a "black phase" female at Simsbury (CT). Juveniles resemble adults, though their patterning is often less vivid.

Hognose snakes exhibit a complex series of defensive behaviors when disturbed. I have observed loud hissing accompanied by false (close-mouthed) striking, as well as feigning death (which may include regurgitating, drooling, and turning upon their backs with tongue extruded). I have righted these "dead snakes" only to have them flip over onto their backs and continue feigning death. Although most hognose snakes will hiss vigorously when picked up, the most complex behaviors I observed occurred in young snakes. The common names of "puff adder" and "blowing adder" result from their vigour defensive behaviors. Although potentially effective in deterring predators, these displays frequently cause hognose snakes to be killed by humans erroneously assuming that they are dangerous snakes.

DISTRIBUTION:

The eastern hognose snake is widely distributed over the eastern United States. In the northeastern states it is found as far north as southeastern New Hampshire (Michener and Lazell, 1989), Massachusetts, southern New York, and northern Pennsylvania. In southwestern New England, this snake is widely distributed but is nowhere common. In Connecticut, I collected this snake in all eight counties, however I found it most common in inland areas of moderate elevation. Although there are numerous historical and scattered recent records from the coast, the bulk of my collections are from the higher elevations of the southwest and southeast hills as well as upland river valleys. Of 31 collections made in Connecticut I found none below 100 feet, 5 (16%) between 100-300 feet, and 23 (74%) between 300-700 feet. Also noteworthy are higher elevations attained by these snakes in Connecticut. Three specimens were collected above 700 feet as follows: New Fairfield (800 feet), Bantam (900 feet), and Hartland (1150 feet). These data contrast with the abundance of hognose snakes at low elevations on Cape Cod (MA) and Long Island (NY) which are close to sea level. The heavily developed Connecticut shoreline is characterized by rocky outcroppings interspersed with relatively small sand deposits. However, extensive areas of coarse glacial sand and gravel deposits are located further inland in areas that are still largely rural or lightly developed. As hognose snakes favor dry sandy areas and may be sensitive to human disturbance (see Life History and Ecology), it is not surprising that they are now most prevalent in the interior sections of Connecticut.

In Rhode Island, hognose snakes are widely distributed throughout the state. Rhode Island's shoreline is comprised of glacial sand and gravel and is ecologically analogous to Cape Cod and Long Island. As one would expect, hognose snakes have been collected (Raithel, pers. comm.) at both coastal and inland sites in Rhode Island.

Although hognose snakes are common on Cape Cod and other coastal areas of Massachusetts (Lazell, 1972), they become progressively rare as one moves westward. They have been reported from the Central Connecticut Lowland where Dunn (1930) considered them rare. He cited records from Williamsburg (Hampshire Co.) and Mount Toby (Franklin Co.). Stull (1926) examined specimens from Dunn's sites and from Hadley (Hampshire Co.) and West Springfield (Hampden Co.). In the vicinity of Springfield (Hampden Co.), Allen (1868) considered them "especially numerous on our dry sandy plains, where it is the most abundant species". I have not found them in western Massachusetts despite five years of intensive field work in southern Berkshire County. However, I have collected specimens from the northern sections of the Housatonic Valley in Connecticut. Therefore, I suspect hognose snakes may occur in the extensive sand and gravel deposits at Sheffield (MA), but additional field work is required to confirm their presence.

In New York, hognose snakes occur in rural areas of Westchester County. I have no current information on their status in Putnam County. In northeastern Dutchess County, I collected a single specimen in an area of glacial sand and gravel. They are well known from the

Albany Pine Bush (Stewart and Rossi, 1981) and may occur in the intervening areas of Columbia County, although I have no records.

LIFE HISTORY AND ECOLOGY:

Hognose snakes favor sandy, gravelly well drained soils which are a favored habitat of toads (Bufo), their preferred food. Specimens I collected in southwestern New England have regurgitated partially digested toads. Babbitt (1932) reported a specimen disgorging an adult spotted salamander (Ambystoma maculatum). They burrow, often using and enlarging subterranean runways of small mammals. I collected a large specimen at Manchester (CT) which had only the tip of its tail protruding from a sand bank.

Although widespread, in contrast to most snakes they are not found in numbers. I found one, very rarely two, per site. In eastern New England, Michener and Lazell (1989) found a maximum of two individuals in a day's field work. Throughout the course of my field work I collected fewer than five specimens per year. My collections usually were from dry ecotone areas near young, second growth deciduous woodland. Snakes were collected under cover and basking in the open. I collected a specimen on an open basalt talus slope at Southington (CT) basking near two copperheads (Agkistrodon c. mokasen). Another specimen was found in a scarified gravel pit at Burrillville (RI).

My earliest activity date was May 14 at Washington Depot (CT) and latest date October 10 at Sharon (CT). Platt (1969:305) found eastern hognose snakes active from April 17 through October 25 in Kansas. Studies by Abbott (1884), Neill (1948), and Guidry (1953) found eastern hognose snakes appearing earlier in the spring and disappearing later in the autumn than other sympatric snakes. In contrast, Platt (1969:307) found both Coluber and Thamnophis sirtalis had a longer annual activity period than sympatric Heterodon platyrhinos. My data from southwestern New England agree with Platt.

I found hognose snakes throughout the hot summer months as follows: May (5), June (7), July (5), August (5), September (7), and October (2). This distribution is weakly bimodal with peaks in June and September, though my sample is too small to be very meaningful. Platt (1969:308) (Kansas) and Brimley (1925) (North Carolina) found the annual distribution of

Heterodon platyrhinos bimodal, with peaks in early summer and autumn. Conant (1938) reported little seasonal fluctuation in numbers caught in Ohio, noting most were caught in July, followed by May and September, respectively.

I have no reproductive data on Heterodon. I found a pair in a brush pile at Bethel (CT). The female was boldly patterned while the male was unicolored. Babbitt (1932) reported a female from Simsbury (CT) depositing 28 eggs several months after capture. Clark (1952a, 1952b) reported clutch sizes of 22 eggs from South Kent (CT) and 19 eggs from Ashford (CT). A specimen (YPM 92) from Middlefield (CT) contained 27 eggs.

Wright and Wright (1957:309) found male eastern hognose snakes mature at 400 mm total length, females at 450 mm total body length. Eight Connecticut snakes (4 males, 4 females) had the following measurements. Males ranged between 593-698 mm (average 641.3) and females from 529-820 mm (average 677.5) total body length. Snout-vent length (SNVL) of males ranged between 473-582 mm (average 515) and tail length (TL) from 116-146 mm (average 126.3). SNVL of females ranged between 446-690 (average 569.6) and TL from 83-130 (average 108). My very small sample shows females averaging larger in total length and SNVL, but males averaging larger in TL. These data agree with Platt (1969:265,272).

The population status of hognose snakes throughout southwestern New England needs further study. Although collected at quite a few sites, the actual numbers of snakes found during my study has been quite low. Platt (1969:393) stated although this species is able to survive in proximity to humans in the southern portions of its range, its numbers have declined in many parts of the North since 1900. Additionally, he suggested they may be more sensitive to human disturbance near the limits of their range. There are specimens extant in museum collections (AMNH, USNM, and YPM) from southern Connecticut collected in the late nineteenth and early twentieth centuries from areas where this snake is now rare or extirpated. Babbitt (1932) considered them "common" in Connecticut citing localities where this snake still occurs. However, I do not consider them presently "common" at these localities. Given these data, some concern may be justified as to the future of Heterodon in many parts of southwestern New England, despite their occurrence in various protected habitats including state parks, forests, and game management areas as well as private sanctuaries.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=11): AMNH 18072, 18148, 46996, 123206-07, 125053, 135241; AMNH-MWK 8009; UCS 1625, 5231, 7921

Hartford Co. (n=17): AMNH 123208, 128047, 130062-63, 133469; UCS 6468, 6617, 6763, 6794, 7047, 7130-31, 7518, 7773, 7780, 8641, 8647

Litchfield Co. (n=17): AMNH 65790, 84327, 89396, 125054, 127394, 128048-50, 130064; AMNH-MWK 7836; UCS 1626, 3449-50, 4322, 5318, 7056; YPM 100

Middlesex Co. (n=10): UCS 6475, 6770, 7115; USNM 131730, 139208-10; YPM 92, 94, 96

New Haven Co. (n=20): AMNH 127395, 130065-66, UCS 6474; YPM 77-79, 81-85, 87, 93, 95, 102, 5983-86

New London Co. (n=5): AMNH 8871, 119313, 134278; AMNH-MWK 7909; UCS 7550

Tolland Co. (n=15): AMNH 119314; UCS 1618-24, 2985, 5735, 5801, 6740, 7176, 8648, 8681

Windham Co. (n=9): AMNH 125055; UCS 1627, 2487, 3624, 5406, 6599, 7398, 8307; UMMZ 152973

Rhode Island

Kent Co. (n=2): AMNH 134727, 134831

Providence Co. (n=2): AMNH 129659, 129955

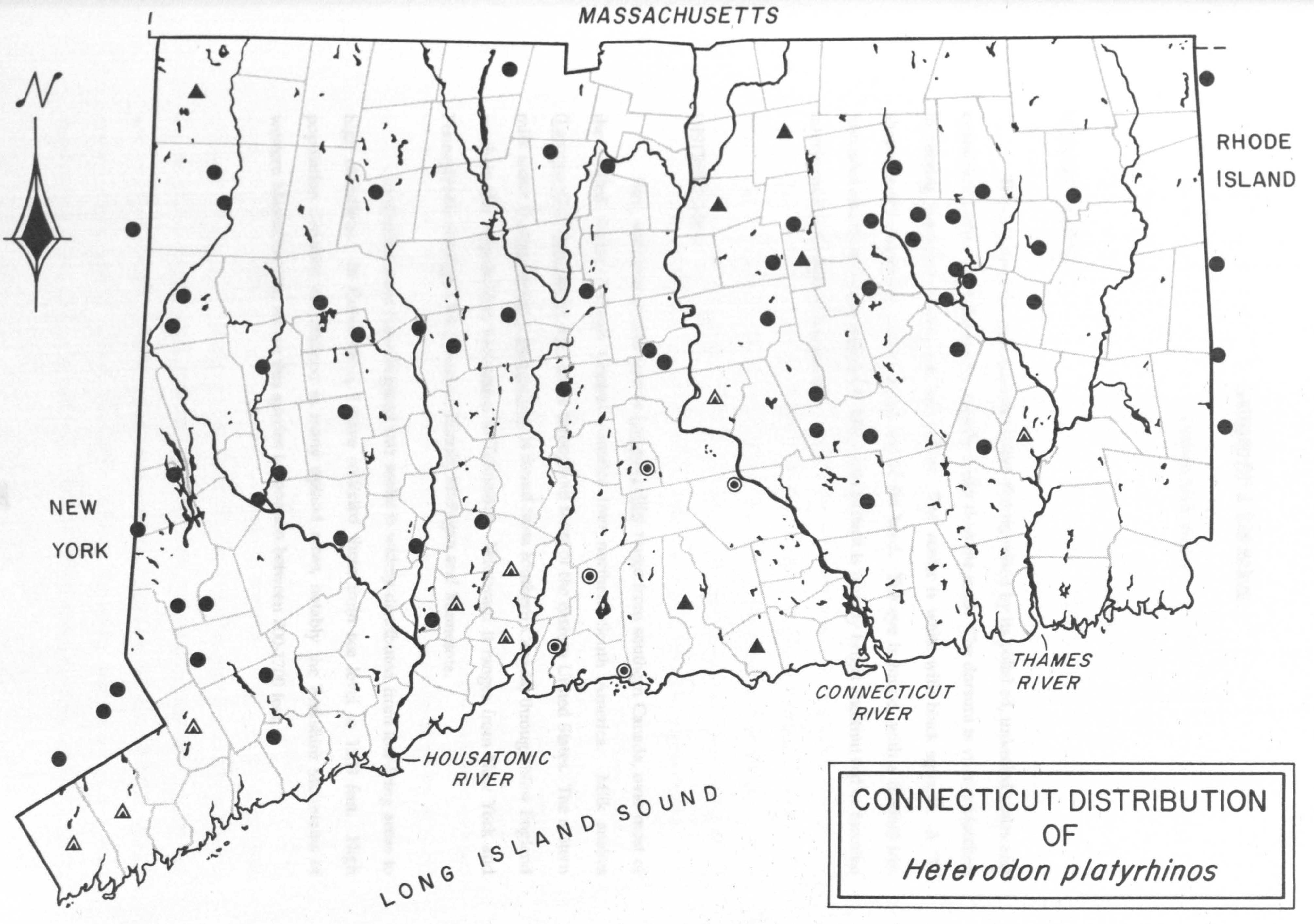
Washington Co. (n=1): AMNH 134325

New York

Dutchess Co. (n=2): AMNH 63421, 128164

Putnam Co. (n=2): AMNH 9034, 64079

Westchester Co. (n=10): AMNH 32379, 66097, 97219, 102468-70, 130192, 130450, 130788, 133025



CONNECTICUT DISTRIBUTION OF *Heterodon platyrhinos*

Lampropeltis t. triangulum

Eastern Milk Snake

IDENTIFICATION:

This is a medium sized, slender snake distinguished by its polished, unkeeled scales and cylindrical body. The head is only slightly wider than the neck. The dorsum is vividly blotched in varying shades of brown, tan, and yellow. The venter is white with black squares. A "Y" shaped mark frequently occurs on the top of the head. The eye is round, with a distinct iris. Juveniles closely resemble adults but the dorsal pattern is usually bright chestnut red or carmine interspersed with lighter coloration.

DISTRIBUTION:

King and milk snakes (genus Lampropeltis) range from southern Canada, over most of the United States, through Central America into northern South America. Milk snakes (Lampropeltis triangulum ssp.) occur throughout most of the eastern United States. The eastern milk snake (Lampropeltis t. triangulum) is found from southern Canada, through New England south in the Appalachian Mountains to Tennessee. Westward it ranges from New York and Pennsylvania through Ohio, Indiana, Illinois, Michigan and Minnesota.

In southwestern New England this snake is widely distributed from low lying areas to high elevations. In Connecticut, I have collected them from sea level to 1300 feet. High population densities are attained in many upland areas, notably the Berkshire Mountains of western Massachusetts, where this species is common between 700-1700 feet.

LIFE HISTORY AND ECOLOGY:

I found milk snakes in a wide variety of habitats, from wilderness areas bordering the Appalachian Trail (MA) to scarified vacant lots in suburban areas. They were also common in rural areas around barns and outbuildings, under debris in open fields, and along hedgerows and stone walls. They were collected in houses and cellars, especially older buildings with stone foundations. They enter buildings primarily in search of rodents, but a torpid specimen was found in January hibernating in a cellar at Berlin (CT). I dissected both deer mice (Peromyscus) and voles (Microtus) from milk snake stomachs. A specimen from Amenia (NY) contained a nursing Microtus pennsylvanicus and her four young.

My earliest record of milk snake emergence is a specimen found frozen to death at Pound Ridge (NY) on March 21. The latest date of activity was October 14 at Salisbury (CT). Wright and Wright (1957:371) found them active in New York from April 15 through October. Between 1975-1986, I made 50 collections in southwestern New England distributed as follows: March (1), April (4), May (16), June (12), July (7), August (4), September (5), and October (1). These data indicate a unimodal activity pattern, with maximum collection success occurring in May and June.

Milk snakes are both diurnal and nocturnal. During the day I find them basking or actively moving through open areas, as well as under cover. Nocturnal activity is probably an important component of their activity cycle, particularly in warm summer weather. I frequently find fresh road kills in the early morning, presumably killed the previous night. In our small cabin located in a steep, wooded ravine at Egremont (MA) I encountered milk snakes foraging at all hours of the night. Snakes which had recently fed (with distended stomachs) were observed basking both inside and outside the cabin. Basking accelerates digestion by increasing the body temperature.

I have meager reproductive data on this species. A pair collected on June 1 in an open grassy area at Hartland (CT) may have been engaged in courtship. A pair of milk snakes was collected under a piece of metal at Suffield (CT) on May 28 and another pair in a hollow log at Chester (CT) on May 31. As adults are usually solitary and potentially cannibalistic, I suspect they were engaged in some phase of reproductive activity. Wright and Wright (1957:371) found a mating pair on June 11 at Duck Lake (NY). I found five newly hatched snakes in a stone foundation at Bozrah (CT) on September 21. Three of these (2 males, 1 female, AMNH 130622-24) were preserved and measured. The total length ranged from 229-236 mm (average 233.3), SNVL from 195-203 mm (average 200.3), TL from 32-34 mm (average 33).

My sample of 18 subadult and adult Connecticut milk snakes >450 mm (8 males, 10 females) had the following measurements. Males ranged between 645-1017 mm (average 854.1) and females from 477-921 mm (average 740.1) total body length. Snout-vent length (SNVL) of males ranged from 550-885 mm (average 737), tail length (TL) from 95-132 mm (average 117.1). SNVL of females ranged from 408-800 mm (average 637.9), TL from 69-121 mm (average 102.2). Wright and Wright (1957:371) gave maximum total lengths of 1115 mm for males, 1007 mm for females. One male (AMNH 130070) from Ansonia (CT) was not included in the size analysis because he had an incomplete tail. Even with a stub tail this specimen was the largest milk snake collected in my survey with a SNVL of 925 mm and incomplete TL of 154 mm yielding an incomplete length of 1079 mm.

Milk snakes rank second in abundance to the ubiquitous garter snake (Thamnophis s. sirtalis) in parts of southwestern New England. They thrive in disturbed, human altered habitats and occur in most state parks, forests, and game management areas, as well as private sanctuaries. They are decidedly beneficial, eating large numbers of injurious rodents, often destroying an entire nest of young. The milk snakes inhabiting my cabin at Egremont (MA) keep the field mouse population under control.

Milk snakes superficially resemble the venomous copperhead (Agkistrodon contortrix mokasen), which frequently results in their being killed when encountered around human habitation. Few people believe the old myth that they suck milk from cow's udders, hence their common name "milk snake".

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=17): AMNH 9311, 19441, 64042, 105895, 119315-17, 119651, 123209, 125056, 127396-97, 130067, 130613-14, 135243-44

Hartford Co. (n=15): AMNH 119652, 120495, 123210, 128051-54, 130615-18, 133470-71, 134279; AMNH-MWK 7873

Litchfield Co. (n=13): AMNH 31847, 119653, 125057, 127398-402, 128055, 130068;

AMNH-MWK 7838, 7966; UMMZ 152974

Middlesex Co. (n=9): AMNH 36522, 119654-55, 127403-04, 130069, 130619, 130620-21

New Haven Co. (n=3): AMNH 127405, 130070-71

New London Co. (n=6): AMNH 119318, 128056, 130622-24, 134280

Tolland Co. (n=6): AMNH 128057-58, 130625; AMNH-MWK 7867, 7957; UMMZ 152975

Windham Co. (n=2): AMNH 125058, 130626

Massachusetts

Berkshire Co. (n=27): AMNH 73431, 128137-42, 130130-33, 130719-28, 133587-90, 134366-67

Rhode Island

Kent Co. (n=2): AMNH 134740,134833

Providence Co. (n=2): AMNH 130900-01

Washington Co. (n=3): AMNH 130685, 130902, 134834

New York

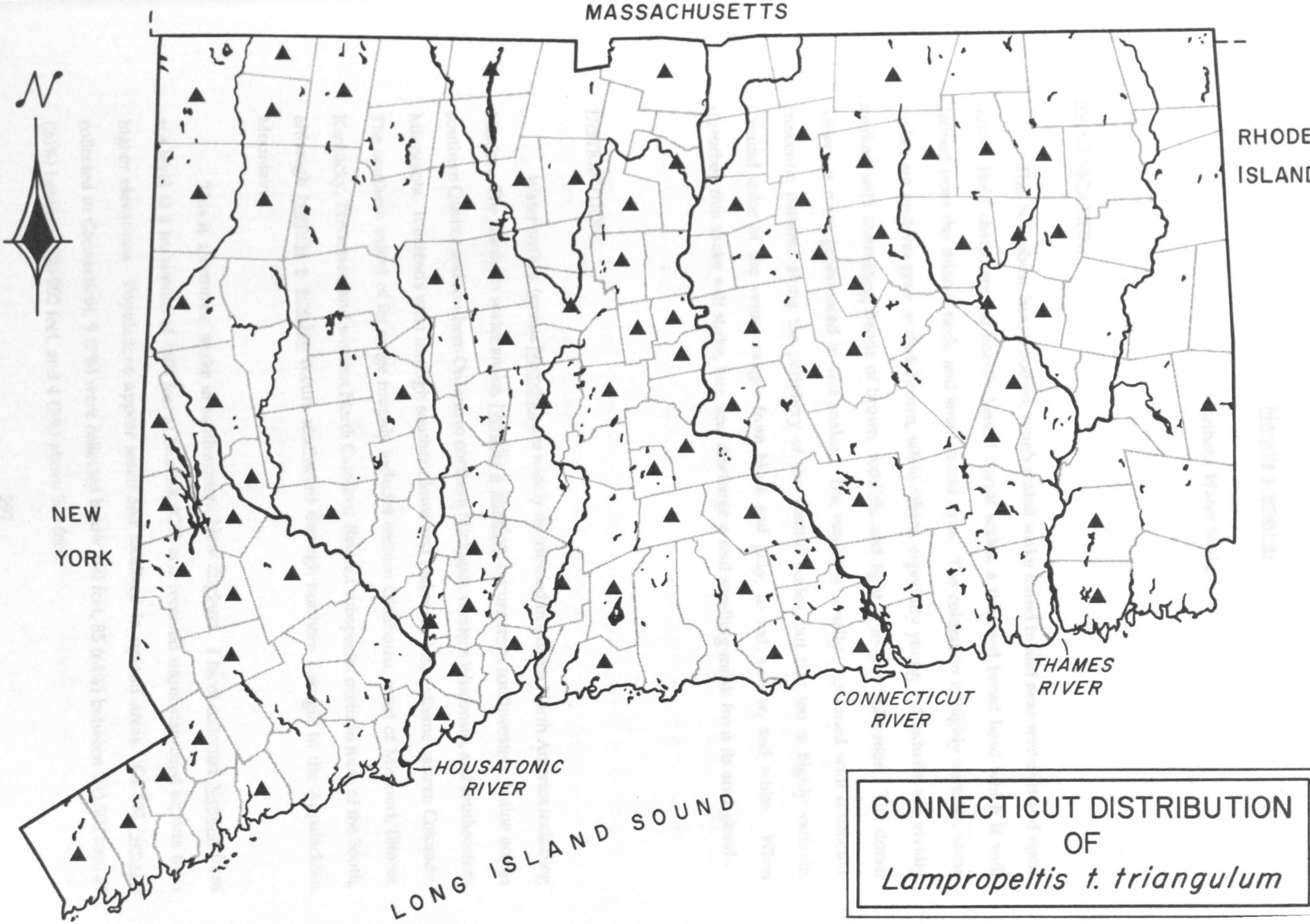
Columbia Co. (n=3): AMNH 130789-90, 134488

Dutchess Co. (n=11): AMNH 3741, 67100, 88670, 92961, 120607-08, 130791, 134489-91;

AMNH-MWK 7835

Putnam Co. (n=3): AMNH 16426-27, 97751

Westchester Co. (n=11): AMNH 2167, 3719, 3734, 49908, 110499, 120609-10, 127763, 130194, 130792, 131478



CONNECTICUT DISTRIBUTION
OF
Lampropeltis t. triangulum

Nerodia s. sipedon

Northern Water Snake

IDENTIFICATION:

This is a robust, heavy bodied, rough scaled snake found in and near wetlands and open water. Field characters are heavily keeled dorsal scales, a flattened broad head which is well defined from the thinner neck, and small round eyes. The coloration is highly variable, some snakes are uniform gray or dark brown, while others, especially young individuals, are vividly marked with alternating bands of brown, reddish, and light blue-gray coloration. The dorsal pattern is more pronounced in wet snakes. The venter is usually pigmented with distinctive crescentic patterns along the periphery of the ventral scales, but this too is highly variable. Ground color of the venter ranges from black and gray, to red, yellow, and white. When disturbed this snake will strike, bite, and discharge a foul smelling musk from its anal glands.

DISTRIBUTION:

Water snakes, (genus Nerodia), are widely distributed in eastern North America including Mexico. The northern water snake, Nerodia s. sipedon, occurs from southwestern Maine across southern Quebec and southern Ontario to northern Michigan, western Wisconsin, and southeastern Minnesota. It extends west through southern Iowa and Nebraska into extreme eastern Colorado. The southern extent of its range roughly includes eastern Oklahoma, most of Missouri, Illinois, Kentucky, Tennessee, and western North Carolina. Related subspecies occur in most of the South, although Nerodia s. sipedon occurs southward through northern Georgia in the Appalachian Mountains.

This is a common snake in southwestern New England. I have collected Nerodia from sea level to a maximum of 1400 feet at Norfolk (CT) and received unsubstantiated reports from higher elevations. Populations appear small and localized in upland areas. Of 133 Nerodia collected in Connecticut, 9 (7%) were collected below 100 feet, 85 (64%) between 100-500 feet, 35 (26%) between 500-900 feet, and 4 (3%) above 900 feet.

LIFE HISTORY AND ECOLOGY:

Nerodia inhabits a wide variety of aquatic habitats. I collected water snakes on dams and spillways, around the edges of all types of impoundments, ponds, lakes, and marshes, vernal pools, seasonal red maple swamps, fens, bogs, rivers, and swiftly flowing, rocky, high gradient streams. A young individual was observed swimming in a tidal creek at Groton (CT) by Robert Craig (pers. comm.). Almost any watercourse in southwestern New England with an adequate amount of cover and food could house Nerodia. I collected water snakes in remote and undisturbed beaver marshes as well as urban parks and golf courses.

My earliest date of water snake activity is March 10 (Merhoff, pers. comm.) at Griswold (CT) and the latest October 19 at Groton (CT). These dates fall within the range of annual activity given by various authors cited by Wright and Wright (1957:513). Collections of Nerodia made in Connecticut were distributed from April-October as follows: April (12), May (34), June (28), July (18), August (15), September (20), October (3). These data indicate a weak bimodal distribution, with maximum collection success in May and June and a small secondary peak in September.

Although this snake is often considered diurnal, nocturnal activity is not uncommon (Lagler and Salyer, 1947:172). I collected a juvenile female on April 1 at 20:30 h in a wooded swamp near Millbrook (NY). She swam from the bank into shallow water and hid at the base of a tussock. Lagler and Salyer (1947:171) citing Brown (1940) stated that Nerodia becomes torpid at 50 F. The snake I collected was quite active at an air temperature of 45 F.

I observed water snakes feeding on bullheads (Ictalurus) and various frogs (Rana spp.) and R. Schmidt (pers. comm.) has seen them eat sunfish (Lepomis) and madtoms (Noturus). Lagler and Salyer (1947) analyzed stomach contents of 188 Michigan water snakes and found their diet consisted of 80% fish and 20% amphibians.

I do not have any data on courtship or mating, however I found gravid females throughout the summer into September. Miller (1979) observed a mating pair at Plainfield (CT) on May 13. I collected a gravid female at Shelton (CT) on September 13 which gave birth within hours of capture. Another female captured at this site on the same day had recently given birth. She was emaciated with her skin stretched and hanging in folds along her sides. A female measuring 826 mm SNVL with an incomplete tail was collected on September 18 at Andover (CT). She contained ten fully developed young (5 males, 5 females) with a total body length range of 227-260 mm (average 243), SNVL 174-204 mm (average 185.4), and TL 50-63 mm (average 57.7).

Wright and Wright (1957:513) found male water snakes matured at 635 mm, females at 650 mm. A sample of 30 (14 males, 16 females) mature southwestern New England water snakes had the following measurements. Males ranged from 649-876 mm (average 746.3) and females from 655-1330 mm (average 984.2) total body length. Snout-vent length (SNVL) of males was between 482-690 mm (average 566.5), tail length (TL) was 125-215 mm (average 179.8). SNVL of females was between 515-1030 mm (average 767.8), TL was 140-300 mm (average 216.4). These measurements fall into the size range for northern water snakes given by Wright and Wright (1957:513) with the exception of one female. This specimen, (AMNH 119319) from Monroe (CT) measured 1330 mm total length, which exceeded the maximum female length of 1295 mm given by Wright and Wright. However, the Monroe female fell 16 mm short of Conant's (1975) record size of 1346 mm.

Block Island (RI) Nerodia have an unusual pattern. Dorsal banding is absent or greatly reduced and the venter lacks the distinctive crescent shaped markings usually found on the ventrals. The venter has a suffusion of fine, powderlike dark pigment. These snakes closely resemble those found on the islands of western Lake Erie, described as a distinct subspecies, Nerodia s. insularum, by Conant and Clay (1937). The Block Island water snakes may represent an undescribed subspecies, but more likely are a pattern morph selected for in two widely separated insular habitats. The morphological convergence of the Lake Erie and Block Island water snakes casts doubt on the taxonomic validity of Nerodia sipedon insularum.

King (1987) stated that selection pressure on the Lake Erie islands favor the unbanded over banded morphs. Unbanded snakes were more cryptically concealed on the barren, rocky shores of the islands. Block Island is well vegetated, with ample cover around the numerous fresh water ponds inhabited by Nerodia. The selection for the unicolor morph on Block Island may be a thermoregulatory adaptation. A dark unicolor snake should be able to heat more quickly than a light and dark banded snake. Block Island has a distinctly maritime climate, with cool summers and many foggy and cloudy days, therefore a snake able to raise its body temperature quickly would have a selective advantage on Block Island.

I have examined specimens of the unicolor "insularum morph" from eastern Long Island (NY) and Cape Cod (MA). The Block Island population is unique as the entire population appears to be unicolored, in contrast to mixed populations of both banded and unicolor snakes found on eastern Long Island, Cape Cod, and the Lake Erie islands. Present day migration of water snakes to Block Island from the mainland and Long Island is improbable as they would have to swim a minimum of ten miles over open ocean water. Migration to and from the Lake Erie islands and the Ohio mainland is discussed by Conant and Clay (1937). Long Island is sufficiently large to hold reservoirs of both banded and unbanded water snakes and Cape Cod is a peninsula receiving gene flow from the west. These migrations maintain mixed populations of banded and unicolor snakes.

The Block Island water snakes are a distinctive pattern morph and are uniquely homogeneous. Whether taxonomically distinct or not, from a New England biodiversity standpoint they should be made a conservation concern. Although areas of Block Island, including wetlands, are protected by public and private sanctuaries, the island is under heavy development pressure from second home construction and tourism. Land use planning on Block Island should consider the habitat of this species.

Water snakes are among the most common snakes in southwestern New England. They thrive in a wide variety of aquatic habitats and occur in most state parks, forests, game management areas, as well as private sanctuaries. Large numbers are killed by humans, who encounter them while fishing, swimming, and boating. Many individuals consider these snakes "cottonmouths", (Agkistrodon piscivorous), a venomous snake with similar habits and appearance to Nerodia. Cottonmouths do not occur north of southern Virginia. The pugnacious disposition of Nerodia furthers the belief that they are a dangerous species. Lagler and Salyer (1947:179) advocated control of Nerodia at fish hatcheries but also stated eradicating snakes in trout streams and other waters is biologically unwarranted.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=29): AMNH 50497, 119319, 119656-77, 123211-14, 135245

Hartford Co. (n=18): AMNH 69137-43, 119320-22, 119678-79, 125059, 127406, 128059-60, 130072, 130627

Litchfield Co. (n=14): AMNH 117940, 119680, 119996, 127407-08, 128061-62, 130073, 133472, 134281; AMNH-MWK 7837, 7879-81

Middlesex Co. (n=6): AMNH 67235, 123215, 125060-62, 128063

New Haven Co. (n=11): AMNH 119323, 123216, 125063-66, 127409-10, 130074-76

New London Co. (n=8): AMNH 119681-83, 127411-13, 133473; AMNH-FS 9854

Tolland Co. (n=9): AMNH 119325, 119684-86, 127414, 130628-29, 134282; AMNH-MWK 7866

Windham Co. (n=2): 119326, 127415

Massachusetts

Berkshire Co. (n=10): AMNH 130134-36, 133591-94, 134368-69; AMNH-MWK 7963

Franklin Co. (n=2): AMNH 134370-71

Rhode Island

Kent Co. (n=5): AMNH 133514, 134728-29, 134835-36

Providence Co. (n=1): 134734

Washington Co. (n=19): AMNH 129665-66, 129956-65, 131970-71, 134735-36, 134837, 134840-41

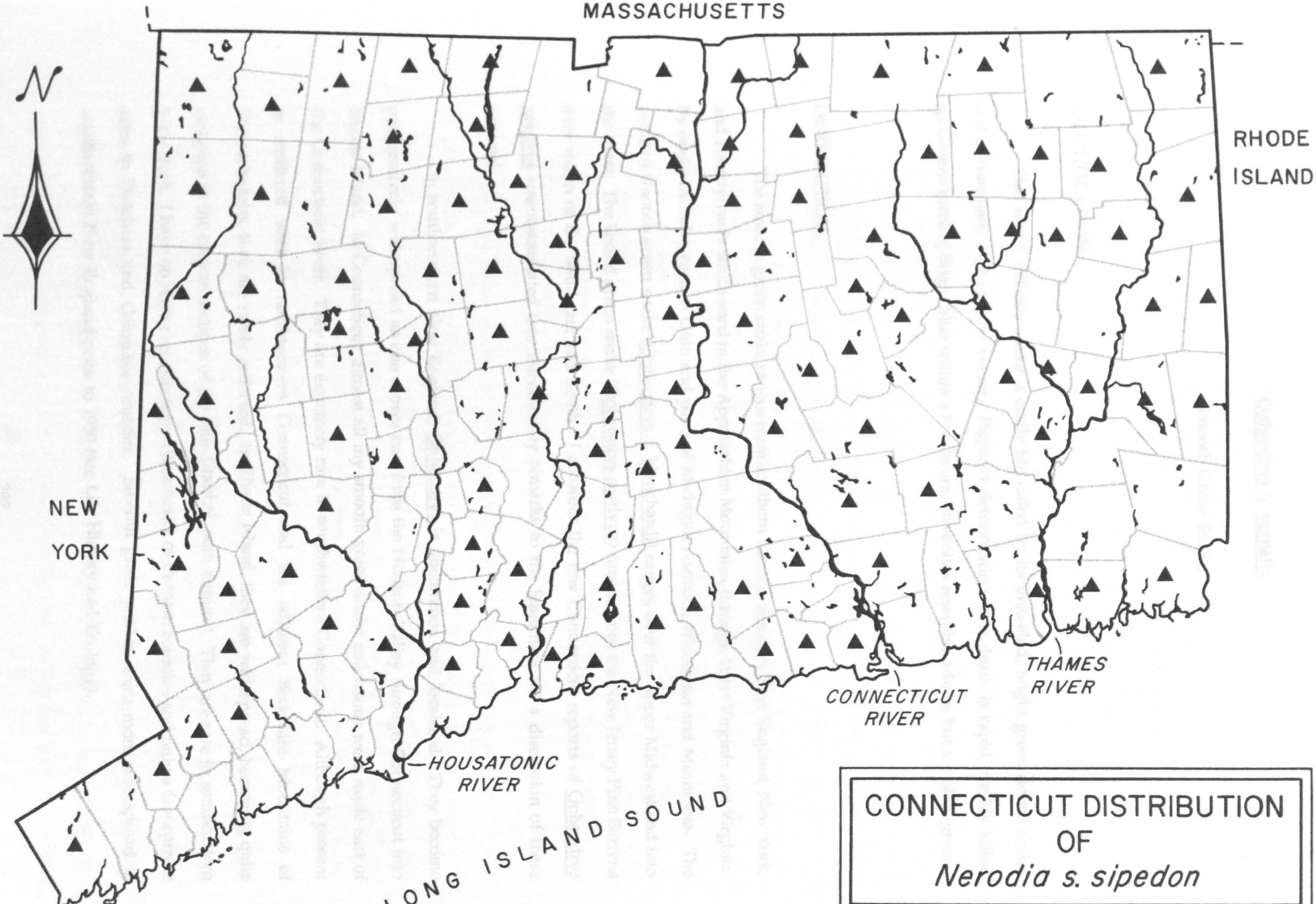
New York

Columbia Co. (n=1): AMNH 134492

Dutchess Co. (n=9): AMNH 88671, 90622, 134493-97, 135281; AMNH-MWK 7967

Putnam Co. (n=1): AMNH 9648

Westchester Co. (n=9): AMNH 75656, 77550, 97217, 120057-58, 127762, 130196-97, 133046



CONNECTICUT DISTRIBUTION
OF
Nerodia s. sipedon

Opheodrys v. vernalis

Smooth Green Snake

IDENTIFICATION:

This small, delicate snake is easily identified by its unkeeled, bright green dorsal scales and immaculate ivory-yellow venter. Pigment deterioration after death is rapid, freshly killed specimens turning bright blue within a few hours. Juveniles resemble adults, but are olive-green.

DISTRIBUTION:

The smooth green snake ranges from southern Canada through New England, New York, and Pennsylvania southward in the Appalachian Mountains through West Virginia and Virginia. Its range includes eastern Ohio and parts of Michigan northern Wisconsin and Minnesota. The western smooth green snake (Opheodrys v. blanchardi) ranges over the upper Midwest and into the West. The keeled green snake (Opheodrys aestivus) ranges from the New Jersey Pine Barrens over much of the Southeast and South. I consider the few Connecticut reports of Opheodrys aestivus unsubstantiated (see introductory remarks to the Squamata for a discussion of these reports).

In southwestern New England, Opheodrys is uncommon and localized. They become progressively widespread as one moves east from the Hudson Valley through Connecticut into Rhode Island. In Connecticut, almost all my smooth green snake collections were made east of the Connecticut River. They are extremely rare in southwestern Connecticut. Although present at scattered sites in northwestern Connecticut and the adjacent Berkshire Mountains of Massachusetts, they are rarely collected. In Rhode Island, they are widespread, becoming quite common in the eastern sections of the state (Raithel, pers. comm.). They are rare in southeastern New York. I have no recent records from Westchester or Putnam counties and only a few current sites in Dutchess and Columbia counties. Smooth green snakes were more widespread in southwestern New England prior to 1950 (see Life History and Ecology).

I collected smooth green snakes from sea level to 1100 feet. Of 27 collections, 63% were from low lying regions (500 feet or less). These collections were distributed as follows: 6 (22%) below 100 feet, 6 (22%) between 100-300 feet, 5 (19%) between 300-500 feet, 8 (30%) between 500-700 feet, and 2 (7%) above 700 feet. When compared with other snakes, a high percentage of specimens were collected below 100 feet, indicating an abundance in coastal areas.

LIFE HISTORY AND ECOLOGY:

Opheodrys vernalis favors open and partially open canopy habitats such as meadows, pastures, coastal grasslands, mountaintop "balds", as well as transitional habitats such as old fields containing grasses, scattered shrubs and trees. Although most common in rural areas, I have several records from urban and suburban areas. Raithel (pers. comm.) finds them in urban, disturbed, and scarified habitats in eastern Rhode Island. They are absent from many seemingly suitable habitats. Judging by the number of individuals who have observed green snakes 30-40 years ago in areas where they are presently not found, they have declined in southwestern New England since the late 1940's. Dowhan and Craig (1976) attributed green snake declines to power mowing equipment, however I do not consider this a plausible explanation as they have disappeared from many unmowed grasslands. In addition, other snakes are able to sustain losses in regularly mowed fields.

There has been a decline in open grassland in Connecticut over that last 100 years as agricultural land was abandoned reverting to deciduous forest. An examination of photographs in Nutting (1923) shows grassy, pastoral landscapes in areas that are presently forested. The current distribution of Opheodrys may be explained by two scenarios, a long term land use change and an ecological catastrophe. Together, they may have caused the extirpation of many small Opheodrys populations in the late 1940's.

The first scenario is that in precolonial times, Opheodrys was restricted to small natural grasslands, balds, forest glades, and open coastal habitats. After the forests were cleared and land converted to farm and pasture (1700's through the 1850's), Opheodrys underwent an explosive range expansion due to the tremendous increase of available grassland habitat. Conversely, after the 1850's Connecticut farmland was abandoned and began to revert to forests. Opheodrys populations became fragmented as the cycle of expansion reversed, contracting to areas of optimal habitat scattered around the State. The distribution of Opheodrys at the beginning of the twentieth century was undoubtedly quite different from their precolonial distribution.

The second scenario involves DDT, which was heavily applied throughout the Northeast in the 1940's and 1950's to control mosquitos and other insects. George and Stickel (1949) reported Opheodrys aestivus killed by DDT applications. The effects of DDT in the food chain are well documented, having been linked to declines in vertebrates, notably birds of prey. Opheodrys is the only snake in our region that feeds exclusively on spiders and insects. Therefore, it may have ingested far more DDT in the form of poisoned insects than other snakes. DDT may have eliminated some key food species of Opheodrys. Possibly a decline of insects coupled with the ingestion of contaminated food brought about the sharp Opheodrys declines of the late 1940's. Populations already fragmented by long term changing land use patterns may have been especially vulnerable to catastrophic extinction.

The present distribution of Opheodrys may still be affected by ongoing pesticide usage. The exceptional rarity of Opheodrys in southeastern New York and adjacent Connecticut may well result from the heavy pesticide applications used to maintain the park-like appearance of these densely populated, affluent areas.

I found Opheodrys active from May through November, the earliest date was May 6 at West Haven (CT), the latest November 4 at Essex (CT). Wright and Wright (1957:558) found New York snakes active from April 10 through October 20. My Connecticut collections were distributed as follows: May (4), June (7), July (2), August (4), September (7), October (2), November (1). These data, although a small sample, indicate a bimodal pattern of collection success.

I have no data on courtship or mating of Opheodrys. A specimen (UCS 3220) from Ashford (CT) contained eight eggs. Wright and Wright (1957:558) gave a range of 3-12 eggs. Two gravid snakes were found, on July 15 at Andover (CT) and on August 1 at Ellington (CT). Blanchard (1933) reported that Opheodrys from northern Michigan laid their eggs in the first three weeks of August and that these eggs hatched 4-23 days later. Stille (1954) reported Opheodrys v. vernalis x v. blanchardi deposited eggs several weeks earlier in Chicago. He attributed these differences to warmer May temperatures initiating egg development earlier than in Michigan, as opposed to accelerated development of the eggs in the warmer Chicago climate.

I cannot accept Stille's explanation because all other oviparous snakes in southwestern New England deposit their eggs in late May-June except Opheodrys. Opheodrys vernalis is adapted to cooler parts of North America, ranging from the northeastern United States and northern portions of the Midwest into Canada. "Retaining" eggs in cool areas would have a distinct advantage, enabling the female to control and accelerate incubation by "moving her eggs" into sunny areas. Opheodrys may be employing a transitional strategy between oviparity and ovoviviparity. Ovoviviparous snakes such as Thamnophis and Storeria are ubiquitous in cool, upland areas of northern New England as are two oviparous species, Opheodrys and Lampropeltis. Based on my sample of two gravid snakes, I suspect that Opheodrys employs this "retaining" strategy in southwestern New England.

Male green snakes are mature at 300 mm, females at 280 mm total body length (Wright and Wright, 1957:558). Eight mature Connecticut Opheodrys (3 males, 5 females) had the following measurements. The males ranged between 302-460 mm (average 407), the females between 432-630 mm (average 489.4) total body length. Snout-vent length (SNVL) of males ranged from 202-297 mm (average 264.7), tail length (TL) from 100-165 mm (average 142.3). SNVL of females ranged from 315-445 mm (average 353) and TL from 117-185 mm (average 136.4). This small sample is at the high end of the range of the size variation given by Wright and Wright (1957: 558) of males 300-650 mm and females 280-575 mm total length. One female, AMNH 119327 from Storrs (CT), measured 630 mm which exceeded Wright and Wright's maximum female length of 575 mm.

I collected Opheodrys killed on roads, and received specimens killed by cats, lawnmowers, and haying equipment. I received a reliable report of a green snake being captured by a hawk near Litchfield (CT). Although Opheodrys is secure in southwestern New England east of the Connecticut River, its status should be monitored due its recent drastic decline. Some Opheodrys habitats are on protected lands, but most sites are on private holdings. As Opheodrys requires open canopy habitats, its survival is closely tied to land management practices which maintain fields and meadows. Open fields and meadows in state parks, forests, and game management areas as well as private sanctuaries, where Opheodrys has been documented, should be maintained at their present seral stage. The current interest in preserving pastures and fields through agricultural easements may benefit Opheodrys.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=1): AMNH 135246

Hartford Co. (n=12): AMNH 67169-74, 119687-89, 120496, 130077; UCS 7368

Litchfield Co. (n=10): AMNH 31851, 125067, 127416-17, 130078; UCS 2560, 6542, 7721;
UMMZ 121088-89

Middlesex Co. (n=3): AMNH 119690, 123217; UCS 7186

New Haven Co. (n=4): AMNH 128064-65; SCSC 744; YPM 61

New London Co. (n=9): AMNH 123218, 125068, 127418-19, 130079; UCS 5419, 7510, 8454;
USNM 202761

Tolland Co. (n=16): AMNH 119327, 128066, 130080, 130630, 133474; AMNH-MWK 7869;
UCS 1691-92, 1710, 2454, 5814, 6567, 7577, 7581, 7694, 8112

Windham Co. (n=7): AMNH 125069; UCS 2559, 3220, 5417-18, 6753; YPM 7328

Massachusetts

Berkshire Co. (n=10): AMNH 50819-22, 73251+5

Hampshire Co. (n=1): AMNH 134372

Rhode Island

Kent Co. (n=5): AMNH 133518-20, 134842-43

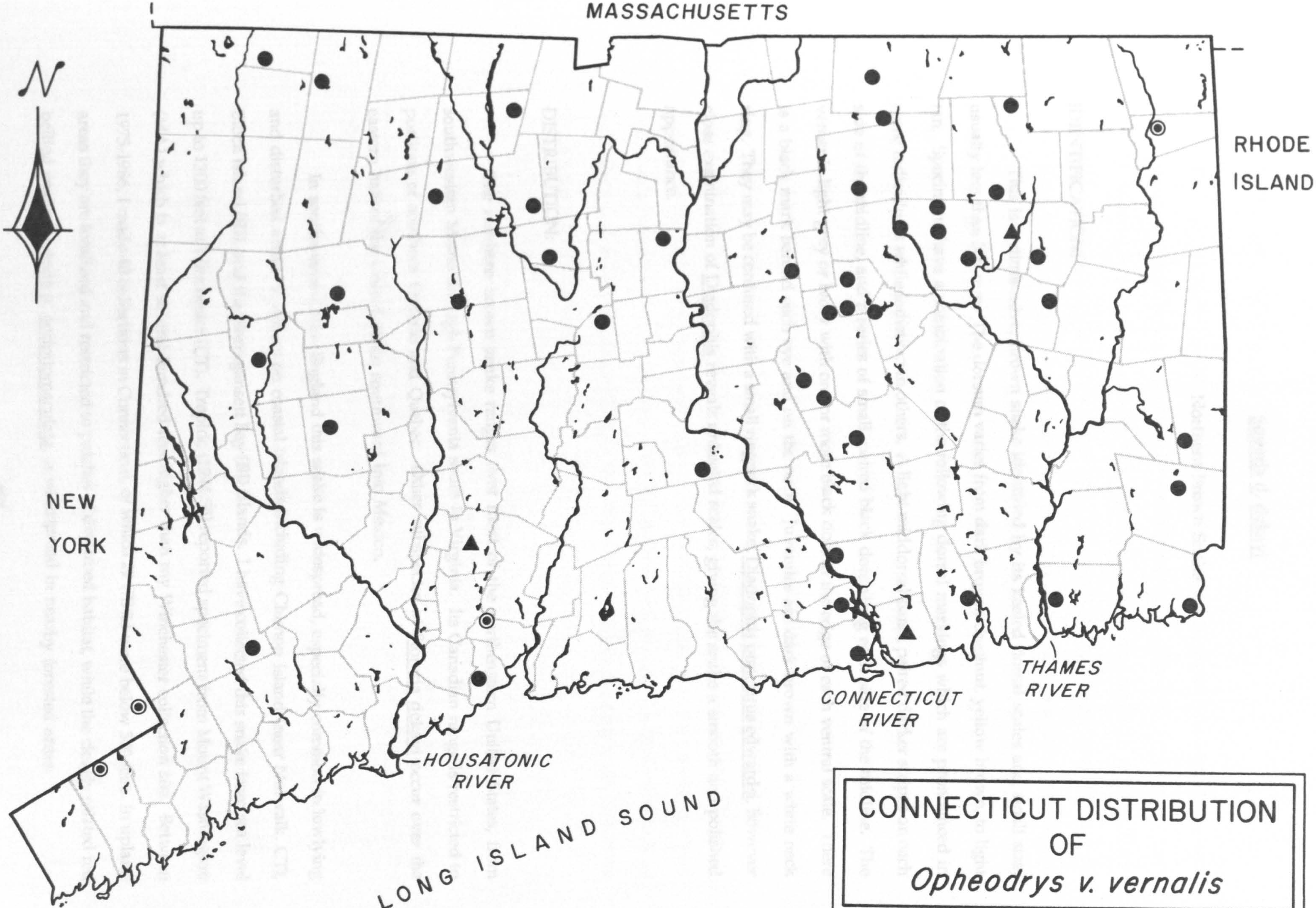
Washington Co. (n=2): AMNH 130907, 134753

New York

Columbia Co. (n=2): AMNH 38154, 130198

Dutchess Co. (n=2): AMNH 92999, 134498

Westchester Co. (n=1): AMNH 135247



CONNECTICUT DISTRIBUTION OF *Opheodrys v. vernalis*

Storeria d. dekayi

Northern Brown Snake

IDENTIFICATION:

This is a diminutive, brown snake identified by its keeled dorsal scales and small size, usually less than 300 mm. The dorsum varies from dark brown, chestnut, yellow brown, to light tan. Specimens have a combination of the following dorsal markings which are pronounced in some individuals while indistinct in others. A light middorsal band, paired darker stripes on each side of the midline, and a series of small, paired black dots along each side of the midline. The venter is light grey or ivory with one or more black dots at the edge of each ventral scale. There is a black mark behind each eye and on the neck. Juveniles are dark brown with a white neck ring. They may be confused with a small ringneck snake, Diadophis punctatus edwardsi, however close examination of Diadophis reveals unkeeled scales, giving the snake a smooth and polished appearance.

DISTRIBUTION:

The northern brown snake ranges over most of the northeastern United States, from southwestern Maine through Pennsylvania south to Virginia. Its Canadian range is restricted to portions of southern Ontario and Quebec. Other subspecies of Storeria dekayi occur over the eastern half of the United States southward into Mexico.

In southwestern New England this snake is widespread, especially common in lowlying and disturbed areas. It occurs on coastal islands including Chimon Island (near Norwalk, CT), Block Island (RI), and the Narragansett Bay (RI) islands. I have collected this snake from sea level up to 1300 feet at Winchester (CT). Trapido (1944:55) reported specimens from Mount Washington (MA) which is at least several hundred feet higher than my Winchester collection site. Between 1975-1986, I made 40 collections in Connecticut, of which 29 (73%) were below 500 feet. In upland areas they are localized and restricted to patches of disturbed habitat, while the closely related red bellied snake, Storeria o. occipitomaculata, is widespread in nearby forested areas.

LIFE HISTORY AND ECOLOGY:

The northern brown snake thrives in disturbed habitats, apparently favoring these over undisturbed sites. Although many species of snakes are found in disturbed areas, none appear to exploit these sites to the exclusion of other habitats as does this species. I ranked all my collection sites based on intensity and frequency of disturbance (See Materials and Methods) on a scale ranging from undisturbed to radically disturbed. My collections of northern brown snakes were distributed as follows: undisturbed 1 (2.5%), lightly disturbed 2 (5%), rural/agricultural 12 (31%), suburban 5 (13%), urban 7 (18%), radically disturbed 12 (31%). No other amphibian or reptile exhibited such markedly low percentages in the first two categories (undisturbed and lightly disturbed) in combination with such high percentages in the last two categories (urban and radically disturbed).

I found brown snakes active from March through November. My earliest date of activity was March 8 at West Hartford (CT) and my latest date November 27 at Orange (CT). Wright and Wright (1957:699-700) gave March 28 as their earliest date of brown snake activity and November 26 as the latest. Both these dates were from the New York City area. Therefore, my data extend this snake's known activity season in the Northeast by three weeks. My Connecticut collections were distributed as follows: March (1), April (2), May (6), June (7), July (2), August (6), September (9), October (4), November (2).

I have no data on courtship or mating of Storeria d. dekayi. I found gravid specimens as late as August 28. A specimen from Cornwall (CT) gave birth to 15 young and Timmerman (1973) reported an Ivoryton (CT) specimen producing 18 young. Data from three gravid snakes collected at Andover and Hebron (CT) and maintained in captivity until they gave birth is given in the following table.

TABLE 1

Brood Sizes of Brown Snakes

Female (Total Length)	Brood Size	Young (Total Length)
267 mm	9	84-90 mm (av. 85.6)
296 mm	13	81-92 mm (av. 86.1)
317 mm	14	96-107 mm (av. 102)

The number of young and their sizes fall within the ranges given by Wright and Wright (1957:701-02). Males are mature at 251 mm and females at 242 mm (Wright and Wright, 1957:700). Thirty-five (14 males, 21 females) mature Connecticut brown snakes had the following measurements. Males ranged between 273-329 mm (average 301.9) and females between 243-385 mm (average 327.1 mm) total body length. Snout-vent length (SNVL) of males ranged from 210-250 mm (average 229.9) with tail lengths (TL) of 63-86 mm (average 71.9). SNVL of females ranged from 192-312 mm (average 263.5) with TL of 47-79 mm (average 63.7). These data indicate females are on average larger than males, both in overall body length as well as SNVL. Males average longer in tail length than females. My data on total body length compare favorably with Wright and Wright (1957:700).

Brown snakes feed on earthworms, slugs, snails, insects, small tree frogs, and fish (Wright and Wright, 1957:702). Storeria d. dekayi is secure in southwestern New England. Although they have become extirpated in severely stressed habitats such as New York City's Central Park (Klemens, 1985), they still occur within the city limits of New York and most major cities in the Northeast. I expect this species to expand its range and population densities throughout southwestern New England as rural areas become increasingly urbanized.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=21): AMNH 7707, 119328-29, 127420-21, 128067-75; UCS 7841-45, 8314, 8672

Hartford Co. (n=22): AMNH 67175-76, 119330-32, 120497-98, 125070, 128076-77, 130081, 133475-76; AMNH-MWK 7914, 8013-14; SIIAS R-358, UCS 6741, 6795, 7050, 7584, 8284

Litchfield Co. (n=15): AMNH 123219, 125071-75, 127422, 128078, 130082-84, 134283;

AMNH-MWK 7854, 7911; UCS 4790

Middlesex Co. (n=7): AMNH 128079; UCS 1815, 6592, 6777-79, 6815

New Haven Co. (n=23): AMNH 119691, 123220, 127423, 128080-89; SCSC 451-52; TCWC 33956-62; UCS 1535

New London Co. (n=4): AMNH 123221, 127424, 134515; UCS 1534

Tolland Co. (n=15): AMNH 130631-33, 133477, 134284-85; AMNH-MWK 7871-72; UCS 1531-33, 2483, 8482, 8675, 8682

Windham Co. (n=11): AMNH 128090, 134286-89; UCS 910, 1530, 2915-6, 7493; YPM 7329

Massachusetts

Berkshire Co. (n=4): AMNH 130137, 133595-96, 134373

Hampden Co. (n=5): AMNH 130729-32, 134374

Rhode Island

Kent Co. (n=1): AMNH 134754

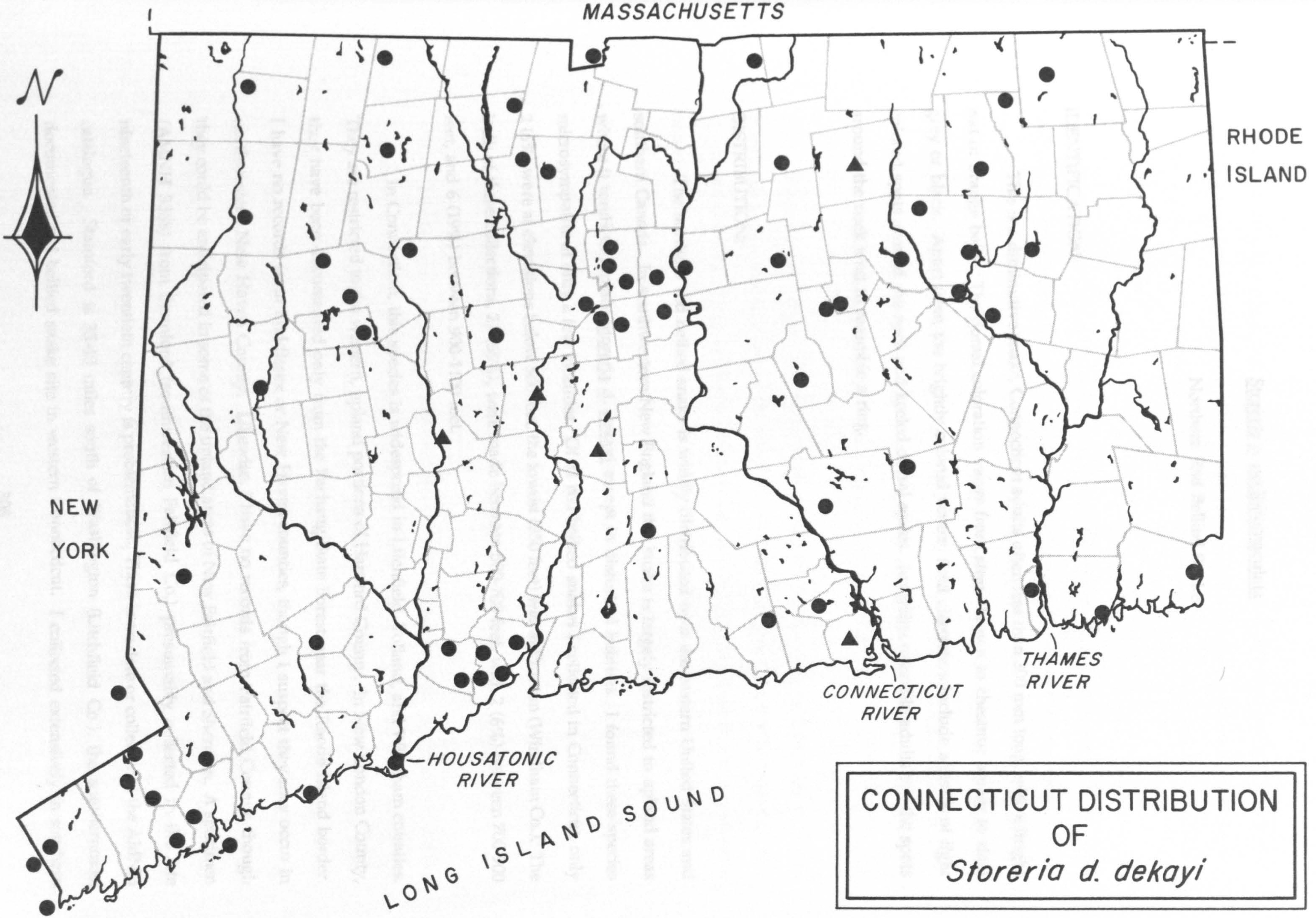
Washington Co. (n=19): AMNH 81893-96, 129693-94, 129968-76, 133527, 134757-58, 134846

New York

Columbia Co. (n=3): AMNH 130793, 134499-500

Dutchess Co. (n=2): AMNH 87396, 133064

Westchester Co. (n=9): AMNH 103825, 120059-60, 120611, 130200, 133063, 134582-84



CONNECTICUT DISTRIBUTION OF *Storeria d. dekayi*

Storeria o. occipitomaculata

Northern Red Bellied Snake

IDENTIFICATION:

This is a diminutive snake, Connecticut adults often less than 300 mm long, with a bright red or orange belly. The dorsal coloration varies from straw brown to chestnut brown to slate grey or black. Apart from the brightly colored venter, field characters include a series of light colored spots around the neck and keeled dorsal scales. Juveniles resemble adults but the spots around the neck tend to resemble a ring.

DISTRIBUTION:

The northern red bellied snake is widely distributed over the eastern United States and southern Canada. In southwestern New England this snake is largely restricted to upland areas where it tends to replace Storeria d. dekayi except in disturbed habitats. I found these species microsympatric at only a few localities. Of 31 red bellied snakes I collected in Connecticut, only 2 (6%) were at elevations below 500 feet, the lowest (350 feet) was at Putnam (Windham Co.). The bulk of these collections, 21 (68%), were made between 500-700 feet, with 2 (6%) between 700-900 feet, and 6 (19%) between 900-1100 feet.

In Connecticut, this species is widespread in Litchfield, Tolland, and Windham counties. They are restricted to the western, upland portions of Hartford County. In New London County, they have been documented only from the Pachaug State Forest near the Rhode Island border. I have no records from Middlesex or New Haven counties, though I suspect they may occur in northwestern New Haven County. Likewise, I have no records from Fairfield County, though they could be anticipated in some of the upland areas of New Fairfield and Sherman. A specimen (AMNH 3388) from Stamford (southwestern Fairfield Co.) presumably collected in the late nineteenth or early twentieth century is problematical. There is no date or collector in the AMNH catalogue. Stamford is 35-40 miles south of Washington (Litchfield Co.), the southernmost documented red bellied snake site in western Connecticut. I collected extensively in southern

Fairfield County and never found a red bellied snake, nor did I receive any reports of this species from the many naturalists who live in this area. Given the incomplete collection data and the distance of this "range extension", I question the accuracy of the locality data in the AMNH catalogue.

In western Massachusetts this snake is widespread, but rarely collected. I found specimens at several sites in Berkshire County and received a reliable report (F. Irish, pers. comm.) from the vicinity of Granville and Tolland in Hampden County. Trapido (1944:30) reported a Hampden County specimen from Chicopee and specimens from Goshen, Lake Norwich, and Worthington in Hampshire County. The type specimen of Storeria o. occipitomaculata, which is now lost (Trapido, 1944:21), was from Amherst, also in Hampshire County. I received a reliable report (D. Monette, pers. comm.) from New Salem in Franklin County.

Raithel (pers. comm.) has found them at several sites in the upland portions of Rhode Island near the Connecticut border. In New York they have not been reported from Westchester or Putnam counties. They are known from a few sites in Dutchess County and I received a reliable report (K. Schmidt, pers. comm.) from Hillsdale in Columbia County. This snake's secretive behavior and small size result in its being overlooked in many areas. I would expect them to much more widespread in New York and Massachusetts than my collections indicate.

LIFE HISTORY AND ECOLOGY:

I collected this snake in a wide variety of moist, upland habitats. Large concentrations were found at a limestone quarry and refining complex at Canaan (CT). These snakes were found under debris, especially damp wood, along the edges of the adjoining swamp, and on a moist, grassy powerline cut traversing the swamp. I have found them under the bark of fallen trees in a blow down area in mixed deciduous and coniferous forest at North Colebrook (CT). At Hartland (CT) I found specimens under fallen bark lying on the ground in a logged over pine plantation, at Egremont (MA) under debris in vegetable gardens and orchards, at Stafford (CT) under rusty metal in an old pasture, as well as killed on roads in forested areas of Voluntown and Cornwall (CT) and Mount Washington (MA). A desiccated juvenile (AMNH 130634) was removed from nesting material in a bluebird house at Sharon (CT). Two specimens were found together in insect galleries in dead wood (R. Schmidt, pers. comm.) at Simon's Rock College in Great Barrington (MA).

With the exception of the previously mentioned Canaan site, most of my collections were limited to one, rarely two or three snakes. I found these snakes microsympatric with Diadophis punctatus, Opheodrys vernalis, Storeria dekayi, and Thamnophis sirtalis. Although most specimens were taken under cover, I found snakes basking in late autumn on a railroad bed at Canaan.

In Connecticut, I collected red bellied snakes from May through October. My earliest date of activity is May 26 at Salisbury and latest October 20 at Canaan. I received a snake from Putnam collected "in April". Wright and Wright (1957:717) found them active from March 17 to October 22 at Ithaca (NY). My Connecticut collections were distributed as follows: April (1), May (4), June (8), July (4), August (5), September (6), October (3). This small sample shows a peak of collection success in June with fairly consistent yields through July-September, with a decline in October. Red bellied snakes feed on insects, slugs, earthworms, myriapods, and sowbugs (Wright and Wright, 1957: 719).

I have no data on courtship or mating. A snake collected on July 15 at Barkhamsted was gravid. Male red bellied snakes are mature at 182 mm and females at 211 mm total body length (Wright and Wright, 1957:718). Fourteen (5 males and 9 females) Connecticut Storeria o. occipitomaculata had the following measurements. Males ranged from 206-252 mm (average 223.2) and females from 220-286 mm (average 247.3) total body length. Snout-vent length (SNVL) of males was between 154-190 mm (average 168.4) with a tail length (TL) of 52-62 mm (average 54.8). SNVL of females was between 174-231 mm (average 197.8) with a TL of 46-55 mm (average 49.6). These data indicate that females average larger in overall body size as well as SNVL than males, but that males have proportionately longer tails. My findings on sexual size dimorphism agree with Wright and Wright (1957:718), however my size range for both sexes is considerably smaller than given by these authors. They gave a total body size range of 182-359 mm for males and 211-383 for females.

Storeria o. occipitomaculata is secure in southwestern New England. Although considered rare in Connecticut (Dowhan and Craig, 1976) my surveys have demonstrated that they are widespread in upland areas. Additional field work is needed to clarify its status in southeastern

New York. This snake occurs in several large state forests and game management areas in Connecticut and Rhode Island. The current forestry practices in these areas create clearings with logs, bark, and "slash" in which this species thrives. Several extensive private sanctuaries and research forests contain populations of red bellied snakes.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=1): AMNH 3388

Hartford Co. (n=5): AMNH 128091-94; UCS 6969

Litchfield Co. (n=26): AMNH 119692, 123222-24, 125076-79, 127425-27, 130085, 130634, 134290; AMNH-MWK 7904; UCS 6447-48, 7075, 7681-83, 8455-56; UMMZ 152970-71; YPM 6792

New London Co. (n=1): AMNH 130912

Tolland Co. (n=8): AMNH 127428-29, 128095; CU R-3499; UCS 8262, 8264, 8479; YPM 7318

Windham Co. (n=6): 128096-97, 130086, 134291-92; UCS 7073

Massachusetts

Berkshire Co. (n=6): AMNH 58064, 73432, 130733, 133597-99

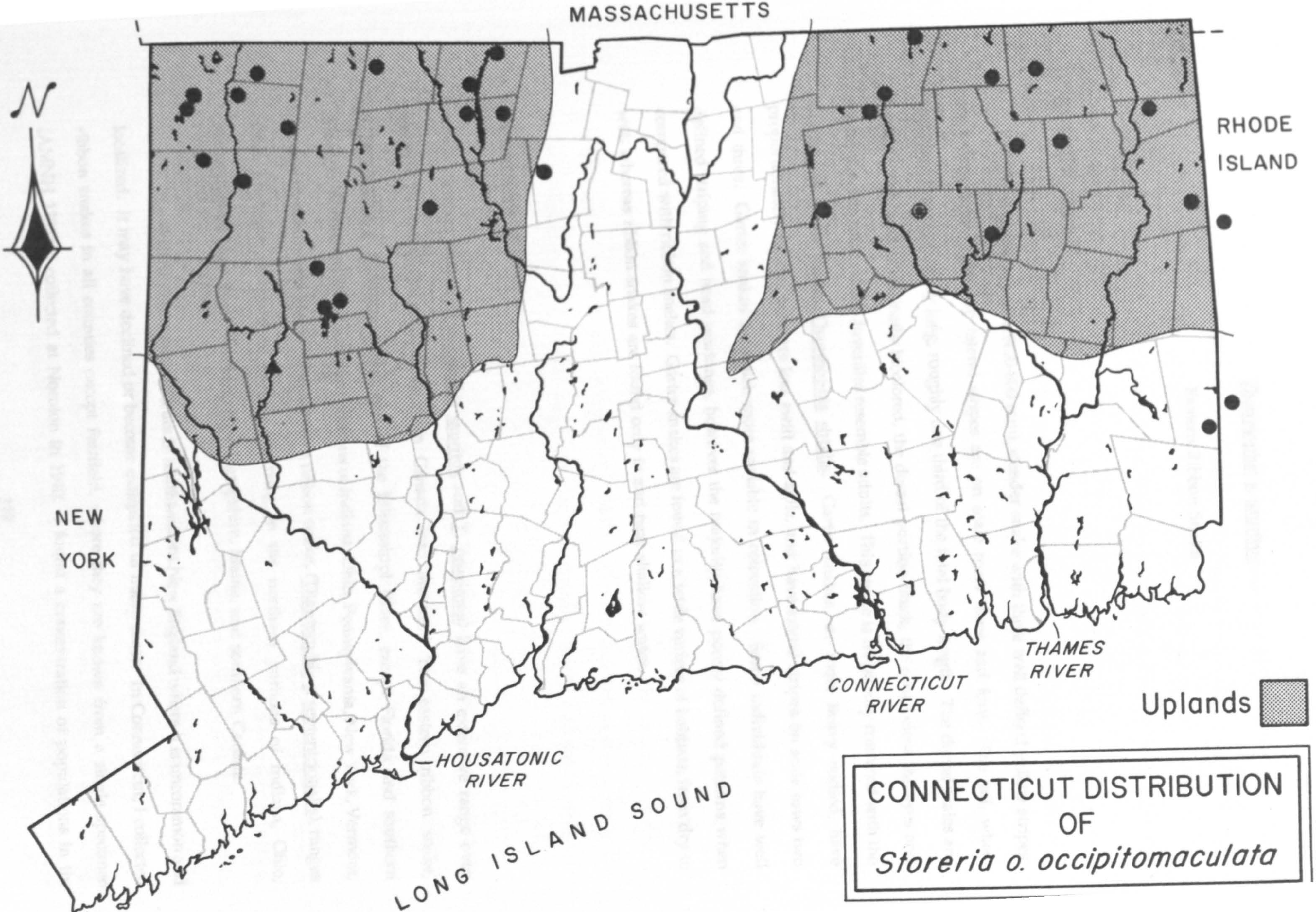
Rhode Island

Providence Co. (n=3): AMNH 130911, 134847-48

Washington Co. (n=3): AMNH 134760-62

New York

Dutchess Co. (n=2): AMNH 120077, 130201


MASSACHUSETTS
RHODE ISLAND
NEW YORK
N
HOUSATONIC RIVER
CONNECTICUT RIVER
THAMES RIVER
LONG ISLAND SOUND
Uplands
CONNECTICUT DISTRIBUTION
OF
Storeria o. occipitomaculata

Thamnophis s. sauritus

Eastern Ribbon Snake

IDENTIFICATION:

This a medium sized, (400-800 mm), slender snake with three well defined yellow stripes on a dark body. The two lateral stripes are on scale rows three and four. The tail, when complete, is exceptionally long, roughly one third of the total body length. The dorsal scales are keeled. The head is distinctly bicolored, the dorsal portion black, the area below the eyes and under the chin pure white. Juveniles resemble adults. This snake is frequently confused with the ubiquitous garter snake, Thamnophis sirtalis. Garter snakes are more heavy bodied, have proportionately shorter tails, are less swift and agile, and have lateral stripes on scale rows two and three. Garter snakes are much more variable in coloration. Some individuals have well defined striping and head markings, however the majority have poorly defined patterns when compared with ribbon snakes. Garter snakes are found in a wide variety of habitats, from dry to wet, whereas ribbon snakes are found only in and near shallow water.

DISTRIBUTION:

Ribbon snakes (Thamnophis sauritus and T. proximus) have an extensive range over eastern North America, from southern Canada into Mexico. The eastern ribbon snake, (Thamnophis s. sauritus), occurs east of the Mississippi River, except Florida and southern Georgia, northward to the southern portions of Indiana, Ohio, Pennsylvania, New York, Vermont, New Hampshire, and Maine. The northern ribbon snake, (Thamnophis s. septentrionalis), ranges from Michigan eastward to Maine, occurring in the northern portions of Indiana, Ohio, Pennsylvania, New York, Vermont, New Hampshire, Maine, and southern Canada.

The eastern ribbon snake occurs in southwestern New England where it is uncommon and localized. It may have declined or become extirpated in many areas. In Connecticut, I collected ribbon snakes in all counties except Fairfield, where they are known from a single specimen (AMNH 135248) collected at Noroton in 1940. I found a concentration of populations in the

Central Connecticut Lowland, in and near wetlands associated with basalt ridges. In western Massachusetts, I have scattered records from Berkshire, Hampden, and Franklin counties. Raithel (pers. comm.) rarely finds them in Rhode Island. In southeastern New York, I have a few recent records from Dutchess and Columbia counties, historical records from Putnam County, and no records from Westchester County.

I found ribbon snakes from sea level to 900 feet, but most frequently at low elevations. Of 32 Connecticut collections, 28 (88%) were below 500 feet. Ribbon snakes do achieve higher elevations in southwestern New England as shown by specimens (SIIAS R-382-83) collected at Mount Washington (MA) where most wetlands are above 1500 feet.

LIFE HISTORY AND ECOLOGY:

I found ribbon snakes in a wide variety of shallow water aquatic habitats. They favor open, grass or shrubby areas bordering streams and wooded swamps. I collected ribbon snakes in fens, sphagnum bogs, wooded swamps, and along the edges of streams, vernal pools, and small ponds, as well as on wet powerline cuts. Several collections were made in small ephemeral wetlands located in gravel pits. A specimen (AMNH 88434) was collected at the edge of a salt marsh at Westbrook (CT). Ribbon snakes were found at severely disturbed and scarified sites as well as in undisturbed areas.

The occurrence of these snakes follows no pattern that I could discern. There are areas where this snake can be reliably observed in numbers on each visit, as well as sites where I found only a single specimen after repeated visits. Many seemingly ideal habitats lack ribbon snakes whereas many marginal areas contain them.

In Connecticut, I found ribbon snakes active from April through September. My earliest collection was April 5 at Plainfield, the latest October 1 at East Granby. However, my Connecticut annual activity range was exceeded by snakes I collected on March 29 at Durham (NH) and on October 10 at Hillsdale (NY). These dates fall within the range given by Wright and Wright (1957:825) for New York ribbon snakes.

Thirty-two Connecticut collections were distributed as follows: April (7), May (7), June (10), July (1), August (1), September (5), October (1). Data from Connecticut, Massachusetts, and

New York indicate a bimodal collection success in southwestern New England. Collections were concentrated in the spring (April-June), followed by a marked drop off in summer (July-August), and a resurgence in autumn (September-October). Ribbon snakes appear to be cold tolerant. Among the first snakes to appear in the spring, they were frequently collected in early April.

I have no data on courtship or mating of ribbon snakes. I found gravid females throughout the summer and neonates in late September and early October. A 720 mm long (total body length) gravid female collected at Hebron (CT) was maintained in captivity until she gave birth. She produced 13 young ranging from 190-217 mm (average 207.8) total body length. The number of young falls within the range of 3-20 given by Wright and Wright (1957:826). These authors gave a size range of 8-9.2 inches (203-237 mm) for young. The average size of my 13 neonates falls in the low end of this range, with four slightly smaller (190, 196, 198, 199 mm) than Wright and Wright's minimum size of 203 mm.

Wright and Wright (1957:825) found males matured at 400 mm, females at 451 mm. Nineteen (3 males, 16 females) adult ribbon snakes from southwestern New England had the following measurements. Males ranged from 513-605 mm (average 550) and females from 534-806 mm (average 667.8) total body length. Snout-vent length (SNVL) of males ranged from 332-412 mm (average 365.3) with a tail length (TL) of 180-193 mm (average 184.7). SNVL of females ranged from 360-538 mm (average 450) with a TL of 174-268 mm (average 217.8). The total body length measurements of my sample fall within the range of 400-819 mm for males and 451-900 mm for females given by Wright and Wright (1957:825). Of thirty-two ribbon snakes I collected, 13 (41%) were excluded from measurement analysis because of incomplete tails. Their long and thin tails must be especially vulnerable to damage and predation. Wright and Wright (1957:826) list frogs, toads, salamanders, fish, spiders, insects, and mice as food items.

The status of ribbon snakes in southwestern New England is problematical. Although abundant at some sites, they appear rare at others. They may have declined or become extirpated in some areas judging by the number of older museum specimens and literature reports. For example, Dunn (1930) considered them "not rare" citing his observations near Northampton (MA) in 1917, 1918, 1923, and 1928. Likewise, Babbitt (1932) found them "fairly common is swamps and wet places" in Connecticut. He cited Canaan and Kent as two sites where he found them. In contrast, Finneran (1948) stated that "it does not seem to be common", as he found this species at only one site along a small grassy stream. Although I view all reports without a specimen or photograph as potentially suspect (this species is difficult to identify in the field), these authors are reputable observers and I have no reason to doubt these literature reports. My data on ribbon snake decline is largely circumstantial. This species should be monitored and additional data collected on its distribution and population structure. By creating a baseline of information, appropriate conservation action may be taken if the trends I have alluded to continue.

The wetlands inhabited by ribbon snakes often support amphibians and reptiles that have restricted regional distributions including: Clemmys guttata, Clemmys muhlenbergii, Rana pipiens, Ambystoma laterale, Ambystoma opacum, and Hemidactylium scutatum. Ribbon snakes may be indicators of high quality wetland habitats. Coupled with the general scarcity of these snakes, their occurrence in protected areas such as state forests, game management areas, powerline rights-of-way, and watershed properties should be taken into account when managing these sites.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=1): AMNH 135248

Hartford Co. (n=17): AMNH 119693, 128098, 130087-95; AMNH-MWK 7954; UCS 1593, 6600-61, 6747; USNM 124676

Litchfield Co. (n=11): AMNH 128099-100, 130635; TCWC 24847-48; UCS 4432-33, 4700, 6724, YPM 529, 546

Middlesex Co. (n=27): AMNH 88434, 128101, 130096-99; UCS 7069, 7182; USNM 9989-91, 123765-78, 139222, 139225

New Haven Co. (n=13): AMNH 128102-03; YPM 526, 528, 530-32, 542, 545, 547, 2884, 6409, 6421

New London Co. (n=4): AMNH 123225, 125080, 128104, 133478

Tolland Co. (n=23): AMNH 130636; AMNH-MWK 7910, 7915-28; UCS 1590-92, 5321, 6294, 7118, 8290

Windham Co. (n=10): AMNH 127430-31, 128105-06, 130637-38, 133479; UCS 1594, 8042, 8457

Massachusetts

Berkshire Co. (n=4): AMNH 130735, 133600; SIIAS R-382,R-383

Hampden Co. (n=3): AMNH 133601, 134375-76

Rhode Island

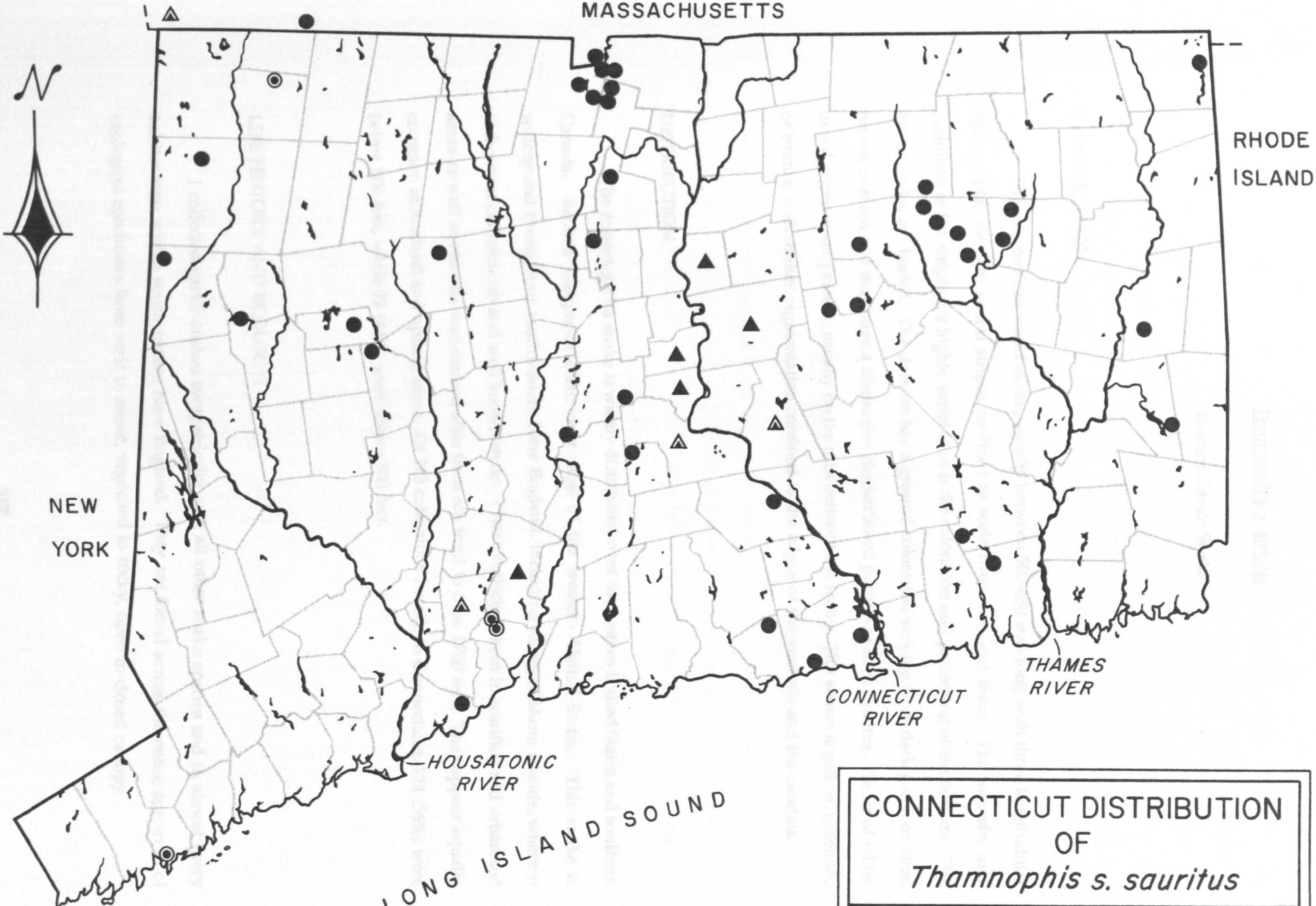
Washington Co. (n=1): AMNH 134849

New York

Columbia Co. (n=3): AMNH 134501, AMNH-MWK 7833-34

Dutchess Co. (n=2): AMNH 88668, 92719

Putnam Co. (n=2): AMNH 9654-55



CONNECTICUT DISTRIBUTION OF *Thamnophis s. sauritus*

Thamnophis s. sirtalis

Eastern Garter Snake

IDENTIFICATION:

This is a medium-sized snake, usually between 500-650 mm long with three longitudinal light stripes, the two lateral stripes confined to scale rows two and three. The intensity and definition of the striping is highly variable as is the coloration and patterning of the dorsum. The dorsal scales are keeled. The dorsum has a ground coloration varying from dark green or olive brown to black and may have a distinctive checkerboard pattern of dark squares. Flecks of white or red pigment are present, usually on the skin between the scales. The venter is yellow, greenish, or bronze with darker pigmentation confined to the edges of the ventrals and the caudals.

DISTRIBUTION:

The eastern garter snake is widely distributed over the eastern United States and southern Canada. Related subspecies occur over most of the western United States. This snake is widespread throughout southwestern New England, including many offshore islands, where it is the most conspicuous and well known snake. I have collected them in scarified and urbanized areas as well as remote, undisturbed sites from sea level to over 1700 feet. They appear equally common in lowland and upland areas. Of 223 collections I made in Connecticut, 124 (56%) were below 500 feet, while 99 (44%) were above 500 feet.

LIFE HISTORY AND ECOLOGY:

I collected garter snakes sympatrically with all other snake species and in almost every habitat type within southwestern New England. They are found across the entire spectrum of ecological conditions from xeric to mesic, vegetated to rocky, open to closed canopy.

I found garter snakes active from late February through October. The snakes collected in Connecticut were distributed as follows: February (1), March (1), April (15), May (51), June (48), July (27), August (20), September (44), October (9). My earliest collection was on February 27 at Manchester and the latest collections on October 20 at Manchester and Canaan. The February date is approximately two weeks earlier than the earliest appearance dates for New York and Massachusetts given by Wright and Wright (1957:837). These authors cite activity dates as late as December 10 for this species in New York. Finneran (1948) reported a specimen covered with iron oxide hibernating in a tin can, barely covered with icy, wet leaves at Branford (CT). I find this snake quite cold tolerant, active at air temperatures of 40-50 F, while other snakes are torpid. Like its congener, the eastern ribbon snake Thamnophis s. sauritus, I often find it active in early April. During the summer, Gruner (pers. comm.) has observed garter snakes active on wet nights.

I observed a mating aggregation of three males and one female on April 5 at Plainfield (CT). They were found at 09:00 h on a dry, sunny, sandy embankment along railroad tracks bordering pitch pine and deciduous woodland. The weather conditions were sunny and breezy with air temperature between 40-50 F. Gardner (1957) described a mating aggregation followed by copulation at Seymour (CT) in April. Miller (1979) reported an autumn mating aggregation of two males and a female on October 21 at Voluntown (CT).

I found gravid females throughout the summer into September. Five gravid Connecticut females collected at Farmington (n=1) and Andover (n=4) were maintained in captivity until they gave birth. The total body length of the mother, the number of young, and the total body size range of the offspring are given in the following table.

TABLE 2

Brood Sizes of Garter Snakes

Female (Total Length)	Brood Size	Young (Total Length)
623 mm	8	157-181 mm (av. 170)
585 mm	9	120-173 mm (av. 155.6)
540 mm	10	150-177 mm (av. 167.2)
511 mm	11	150-172 mm (av. 164.3)
567 mm	15	148-172 mm (av. 159.2)

Wallace (1938) reported a specimen from Lenox (Berkshire Co., MA) giving birth to 73 young. Wright and Wright (1957:840-41) gave a brood size range of 3-85 with neonates measuring from 4-9 inches (102-229 mm). My five Connecticut broods fall within the range of variation given by these authors.

I observed garter snakes feeding on earthworms, Ambystoma laterale, Ambystoma maculatum, Plethodon cinereus, Bufo americanus, and Rana sylvatica. These were all prey items listed by Hamilton (1951) for New York Thamnophis sirtalis except Ambystoma laterale. I dissected Ambystoma laterale from garter snakes collected at South Attleboro (MA) and Wilbraham (MA). These may represent the first records of garter snakes feeding on Ambystoma laterale.

Finneran (1948) observed a 65.5 inch Coluber swallowing a 21 inch garter snake at Branford (CT). Dissection of Coluber from Norwich (CT) and Hebron (CT) revealed garter snakes in their stomachs. Garter snakes are occasionally eaten by birds and preyed upon by a wide variety of mammals including cats. I found partially eaten snakes on woods roads, powerline cuts, and railroad tracks. Large numbers are killed on roads, especially in the spring and autumn.

Wright and Wright (1957:838) found males mature at 392 mm and females at 469 mm total body length. Ninety-eight (33 males, 65 females) mature garter snakes from southwestern New

England had the following measurements. Males ranged from 407-652 mm (average 522.7) and females from 471-1073 mm (average 633.2) total body length. Snout-vent length (SNVL) of males ranged from 310-490 mm (average 396.4) with a tail length (TL) of 97-162 mm (average 126.3). SNVL of females ranged from 368-860 mm (average 499.8) and TL from 92-213 mm (average 133.4). My sample falls with the size ranges given by Wright and Wright (1957:838) of a total body length of 392-764 mm for males and 469-1195 for females. This sample contained twice as many females as males, which is a highly disparate ratio when compared with my collections of other species of snakes.

Although garter snakes have disappeared from New York City's Central Park (Klemens, 1985) they occur within the city limits of most, if not all, northeastern cities. Gochfeld (1975) reported declines of garter snakes in a "rural residential section" of Westchester County (NY). My data on garter snake occurrence and habitat disturbance may support Gochfeld's results. Of 222 collections of garter snakes made in Connecticut only 14 (6%) were from lightly suburbanized habitats which are equivalent to his "rural residential" habitat. This contrasts with 102 (46%) from rural habitats and 5 (2%) from densely suburbanized habitats. Relatively undisturbed habitats accounted for 73 (33%) and severely disturbed (urban and scarified habitats) accounted for 28 (13%) of my collections.

SPECIMENS EXAMINED

Connecticut

Fairfield Co. (n=25): AMNH 90185, 119333, 119694-97, 123226-29, 125081-84, 127432-33, 127460, 128107-12, 130639, 133480

Hartford Co. (n=28): AMNH 66978-81, 119334-35, 119698-700, 120499, 123230-31, 125085-86, 128113-17, 130100-06, 130640, 134293

Litchfield Co. (n=30): AMNH 31850, 119336, 119701-06, 123232-39, 125087-89, 127434-41, 128118-19; UMMZ 152972

Middlesex Co. (n=17): AMNH 119707-16, 123240-42, 125090, 127442-43, 130641

New Haven Co. (n=13): AMNH 119337-38, 119717, 123243, 127444-47, 128120-21, 130107-09

New London Co. (n=17): AMNH 119339-41, 119718-23, 125091-93, 127448-50, 128122, 130642

Tolland Co. (n=7): AMNH 119342, 119724, 127451-53, 130643-44

Windham Co. (n=18): AMNH 119343-45, 125094, 127454-59, 128123-24, 130110, 130645-48, 134294

Massachusetts

Berkshire Co. (n=42): AMNH 120031-32, 128143-55, 130138-46, 130736-42, 133602-09, 134377-79

Bristol Co. (n=1): AMNH 130148

Franklin Co. (n=8): AMNH 120138-39, 130744, 134380-84

Hampden Co. (n=16): AMNH 128156, 130149-50, 130745-46, 133610-14, 134385-90

Rhode Island

Kent Co. (n=3): AMNH 130915-17

Providence Co. (n=6): AMNH 129981-86

Washington Co. (n=33): AMNH 81897-900, 89856, 124946, 127480-82, 129716-21, 129987-30002,

130924, 133533

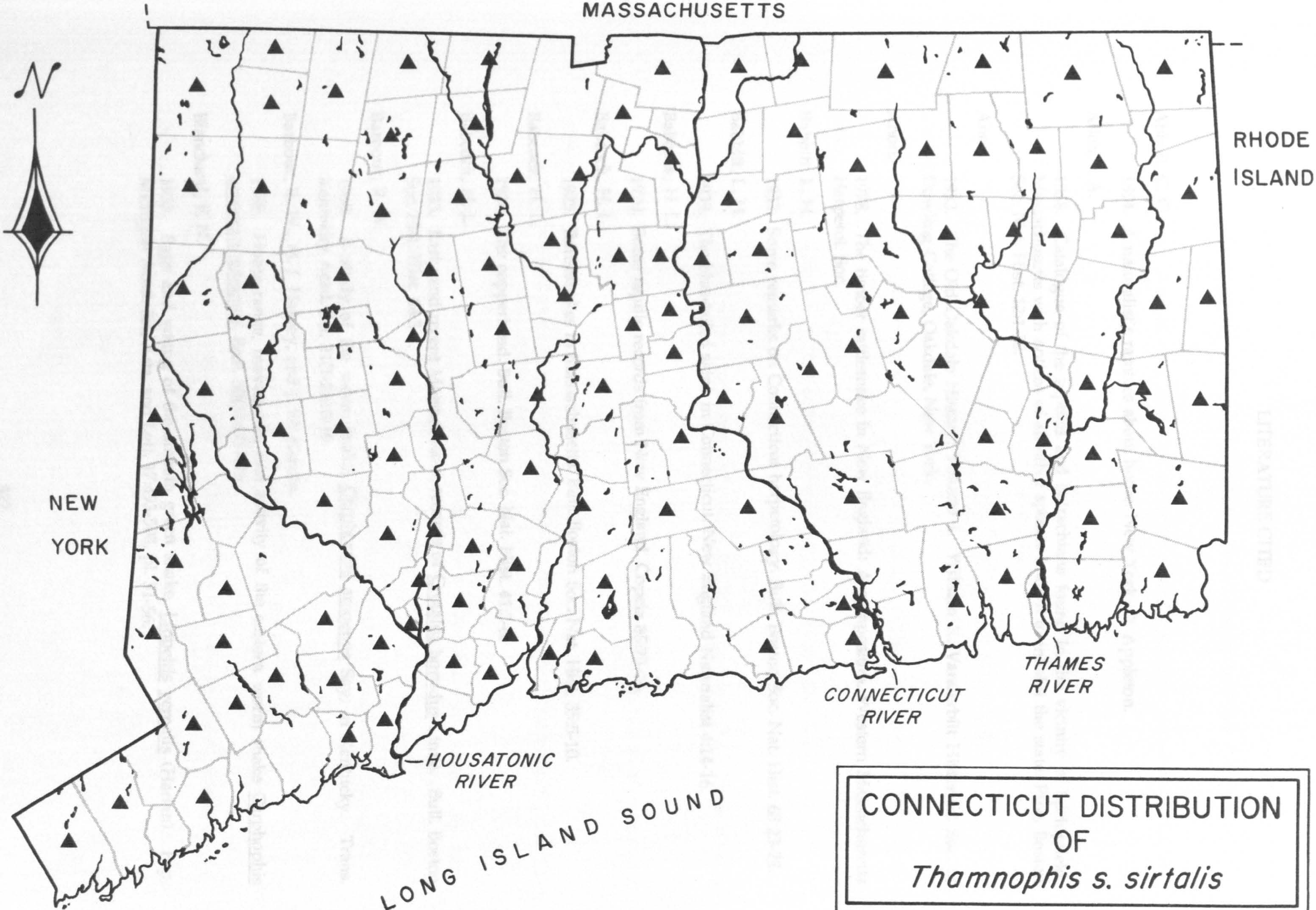
New York

Columbia Co. (n=2): AMNH 130202, 130794

Dutchess Co. (n=20): AMNH 87395+1, 88667+1, 90623, 125467, 125582, 127736, 134502-13

Putnam Co. (n=7): AMNH 4162, 9650-53, 130204, 130795

Westchester Co. (n=13): AMNH 3274, 12589, 97218, 120061-64, 130205-06, 130466, 134588-90



CONNECTICUT DISTRIBUTION OF *Thamnophis s. sirtalis*

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CHAPTER SEVEN: PRINCIPAL COMPONENTS ANALYSIS

INTRODUCTION:

Principal components analysis (PCA) is a multivariate statistical technique that transforms an original set of correlated variables into a new set of uncorrelated variables called principal components. These new variables are linear combinations of original variables derived in decreasing order of importance. The first component accounts for as much variation in the original data as possible (Chatfield and Collins, 1980). By default, the last component accounts for the least variation in the original data. Introductory discussions of this technique are found in Hope (1968) and Chatfield and Collins (1980). Pielou (1984) provided a discussion of this technique geared toward ecological problems.

PCA is available on SPSSx (Statistical Program for the Social Studies) and was implemented on the VAX/VMS system at the University of Kent to analyze my data. Hedderson (1987) provided a brief discussion of PCA in his introductory guide to SPSSx. Norusis (1986) gave details of data preparation geared for analysis using SPSSx including techniques for recoding and rearranging variables. Detailed discussion concerning implementation and interpretation of PCA using SPSSx is provided by SPSS Inc. (1988) and Norusis (1988a, 1988b).

Principal components analysis (PCA) was conducted on each species to determine the set(s) of variables contributing most to a species' presence. PCA is most frequently employed to find variables that are highly correlated. The number of variables can be then be reduced by eliminating redundant (=correlated) variables. This is accomplished by examining the linear relationships among variables in the first component (=factor). High scoring variables account for maximum variation within a sample and are usually correlated.

PCA also isolates variables exhibiting the least variation within a sample, which thereby influence a species' presence. This is accomplished by examining the linear relationships among the highest scoring variables in the last component(s). However, one must be careful in interpreting these data. For example, in my data set, PCA of aquatic species rarely listed the hydric (=hydrology) variable as important in determining a species' presence. This does not imply that aquatic habitat was not essential for these species, but that most aquatic species occurred in several types of wetlands. Likewise, although many reptiles were restricted to low elevations, elevation was rarely isolated by PCA as a key variable because a species would be distributed over several low elevational categories. In order for PCA to isolate elevation as a key variable, a species would have had to be largely restricted to one of the ten elevational categories. The strength as well as the weakness of this PCA last component scores technique was that it identified only those variables exhibiting little variance within a species.

PCA requires that variables increase and decrease in a linear fashion and that the intervals between values of a variable are approximately equal. In order to maximize my data set, I recoded and reorganized five variables to fulfill these criteria. Nine variables were not utilized in the analysis as they were strictly label information. Sixteen ecological variables were analyzed by PCA. These are elevation (elev), bedrock geology (bedgeo), month, time, weather, air temperature (airtemp), hydrology (hydric), surficial geology (surfgeo), topography (topogr), ground cover (grndcov), herbaceous vegetation (herb), low shrubbery (lowshrub), high shrubbery (hishrub), amount of tree cover (tree), canopy closure (canopy), and habitat disturbance (disturb). Detailed explanations of these variables and their values are contained in the Materials and Methods (Chapter 2).

RESULTS:

Of 44 species, 36 had adequate sample sizes (20 or more collections) for PCA, seven could not be analyzed due to their small sample size, and one could not be analyzed due to many highly correlated variables and missing data.

Initially, I ran a sixteen variable PCA on each of the 36 species which was not very enlightening. Almost all species had an equation of tree minus canopy or canopy minus tree as their highest scoring last (sixteenth) component. Eleven species calculated negative eigenvalues during the initial PCA run. SPSSx assigns negative values to the small eigenvalues which result from highly correlated variables or small data sets. Small data sets resulted from the utilization of cases with missing values, deleting the missing data in pairwise as opposed to listwise fashion. Deletion of missing data on a pairwise basis enables utilization of cases with missing values. However, if these missing values are disproportionately distributed among several variables, the sample sizes of these variables is greatly reduced. Though not a problem in samples of more than fifty cases, missing values were problematic in species with fewer than forty cases.

I had to devise another method of variable elimination in order to run PCA. My first attempt was to uniformly delete the canopy and tree variables from all species. This was followed by uniformly deleting herbaceous vegetation and ground cover (the next highest scoring last component variable pair for most species following canopy and tree). Several additional uniform deletions of variable pairs from all species produced similar results. These results were inconclusive because negative eigenvalues remained unchanged and the percent variance of the last components were high, frequently exceeding 0.9. In order to accurately indicate lack of variability, the variance of the last component should be less than one percent of the total variance. Ideally, the percent variance in the last component(s) should be several times smaller than the previous component. For example, in a comparison of sixteen variables the last three components have the following percent variance scores: 0.1, 0.2, and 0.8. The components with the variance percentages of 0.1 and 0.2 would be meaningful, however the component variance of 0.8 is four to eight times as large as the two previous scores. Since one is looking for components yielding the least variance within a sample, 0.1 and 0.2 are better indicators (by several orders of magnitude) of low variance than 0.8.

I needed to devise a system to delete variables on a species by species basis. Initially, I examined the last component scores and deleted the highest scoring variable and recalculated the PCA. I then examined the newly calculated last component scores repeating this procedure in a subtractive method until only four variables remained. Although this procedure deleted variables in sequences tailored to each species, it treated each component score as an independent value instead of part of a linear equation which was erroneous.

In order to examine variable correlations, a sixteen variable Spearman correlation coefficient matrix was produced for each species. The correlation matrix varied from species to species. Although the correlation between tree and canopy generally remained high, subsequent highly correlated variable pairs differed considerably. Variability occurred both in the correlation strength and the actual variables that were correlated. These correlation matrices revealed several conditions unique to species which calculated negative eigenvalues in the initial PCA run. These were an inability to compute correlations for certain variable comparisons, several variables with a perfect correlation of 1.0, and variables which had very small sample sizes due to missing data.

Stepwise deletion of highly correlated variable pairs on a species by species basis yielded useful results. In many cases, several variable pairs could be eliminated before the variance of the last component exceeded 0.9. In some instances, several last components had variances of less than 0.9. I was able to develop linear equations (in addition to tree and canopy) of last component variables for nineteen species. Of these nineteen, my field observations classified sixteen of these as ecologically specialized and/or as having a limited distribution within my study area. In most cases, negative eigenvalues were eliminated after one or more subtractions of variables that were either highly correlated, had small sample sizes, or had noncalculable correlation coefficients. The various steps and their resultant factors are contained in Appendix I.

DISCUSSION:

The presence of Ambystoma jeffersonianum as determined by PCA is governed by five variables. These are a ratio of low and high shrubbery and the amount of ground cover, type of surficial geology, and specific hydric conditions. Ambystoma jeffersonianum has a restricted range within my study area confined to upland areas with little disturbance. In contrast, I isolated only two variables affecting the presence of Ambystoma laterale, bedrock geology and quantity and height of the herbaceous vegetation. My data indicated that although uncommon, Ambystoma laterale has both a wider distribution and a broader ecological tolerance, occurring in pristine, agricultural, and disturbed sites. The wider range of habitats utilized by Ambystoma laterale may be reflected in the lower number (n=2) of key variables determining its presence compared with the greater number (n=5) required by the more specialized Ambystoma jeffersonianum.

The presence of Ambystoma maculatum, the most widespread Ambystomid within my study area, is determined by forest habitat. Forest habitat is controlled by two highly correlated variables, tree cover and canopy closure. I found that forest habitat was the only factor governing the presence of many of the widespread amphibians within my study area. The PCA of Ambystoma opacum illustrates that this autumn breeding species requires specific amounts of tree cover, herbaceous vegetation, ground cover, topography, elevation, hydric conditions, and bedrock geology. Although I noted that Ambystoma opacum was irregularly distributed within the low elevation sections of my study area, I was unaware that its occurrence was governed by such a complex set of interrelationships between variables.

I was unable to conduct PCA on three Plethodontid salamanders due either to insufficient sample size (Gyrinophilus porphyriticus and Plethodon glutinosus) or unresolved negative eigenvalues (Hemidactylium scutatum). The remaining three species Desmognathus fuscus, Eurycea bislineata, and Plethodon cinereus require forested habitats. Unfortunately, PCA did not differentiate between the ecological requirements of these widespread salamanders. The terrestrial eft stage and aquatic adult stage of Notophthalmus viridescens were analyzed separately. The eft stage required forested habitat, whereas the presence of the aquatic stage was determined by air temperature, a ratio of canopy closure and tree cover, and amount of herbaceous vegetation and ground cover within its aquatic habitat. I noted that adult newts favor open canopy, shallow, weed choked bodies of water which appears to have been confirmed by PCA.

Bufo americanus is widely distributed within my study area. PCA determined that a ratio of trees and canopy closure, i.e. forested habitat, is required for its presence. In contrast, the presence of Bufo woodhousii fowleri is determined by time of year, weather, air temperature, and amounts of trees, canopy closure, herbaceous vegetation, and ground cover. I only found this species during warm weather (May through September). This comparatively narrow activity range may be reflected in the PCA by the variables month, air temperature, and weather. I also noted that this species favored open, sandy, scarified areas which could be reflected in the following variables: trees, canopy closure, herbaceous vegetation, and ground cover.

Hyla crucifer is one of the most common frogs in my study area. PCA confirmed that forested habitats influenced its presence, but like most widespread species, Hyla crucifer occurs in such a wide variety of habitats that no additional variables could be isolated by PCA. In contrast, Hyla versicolor yielded a complex series of equations involving quite a few variables. Although widespread, I found Hyla versicolor quite localized. Some of the key variables determining its presence were equations linking vegetational variables. I noted that Hyla versicolor favors shrub swamps containing a mosaic of vegetational communities which appears to be reflected in the PCA.

PCA demonstrated that the presence of four common Ranid frogs, Rana catesbeiana, Rana clamitans, Rana palustris, and Rana sylvatica all depended upon a ratio of trees and canopy closure. I noted these frogs occur in a wide variety of habitats. PCA confirmed their wide distribution as other key variables influencing their presence could not be isolated. In contrast, I found Rana pipiens to be an ecologically specialized floodplain species with a restricted range within southwestern New England. PCA isolated elevation and bedrock geology as important in determining its presence as were the variables affecting trees, ground cover, canopy closure, and disturbance. Floodplains are specialized, low elevation habitats, which are often underlain by calcareous bedrock in southwestern New England. They are periodically "disturbed" by inundation and have a distinctive vegetational community. PCA appears to have discerned these specializations. I was unable to analyze Scaphiopus holbrookii due to its small sample size.

Only a ratio of canopy closure and tree cover influenced the presence of southwestern New England's most common turtles, Chelydra serpentina and Chrysemys picta. The presence of Clemmys guttata was determined by a combination of variables influencing canopy closure, amount of tree cover, air temperature, and month. Clemmys guttata becomes active in early spring, prior to other turtles. I found Clemmys guttata active as early as late February and rarely collected them after June. The key variables of air temperature and month isolated by PCA reflect their activity season confined primarily to the spring and early summer.

The presence of Clemmys insculpta is governed by a complex set of interrelated variables including air temperature, time of day, month, weather conditions, habitat disturbance, canopy closure, high shrubbery, low shrubbery, surficial geology, and topography. I noted that Clemmys insculpta was irregularly distributed within my study area, uncommon or absent in disturbed habitats but common in rural areas. Their activity peak was later in the season (June and July) than other turtles. During the summer they favored fields and scrubby habitats. Some of these observation are reflected in the variables isolated by PCA.

I was unable to analyze the Clemmys muhlenbergii data set as the variable correlation coefficient matrix contained numerous uncalculated coefficients as well as several perfect correlations. When all the variables were eliminated, the remaining data set was too limited for a PCA comparison. The Malaclemys terrapin data set was too small to conduct a PCA.

PCA of Terrapene carolina yielded only canopy and closure and amount of trees as key variables. I noted that Terrapene was an edge species, favoring ecotones and old fields, which would be reflected in these variables. The key variables for Sternotherus odoratus all involved amount of vegetational cover in their aquatic habitat. These were the amounts of canopy closure, tree cover, ground cover, and herbaceous vegetation.

I was unable to analyze four species of Squamata (lizards and snakes) due to their small sample sizes or negative eigenvalues. These were: Eumeces fasciatus, Agkistrodon contortrix mokasen, Crotalus horridus, and Opheodrys vernalis.

PCA of Carphophis amoenus indicated that surficial geology was the most important variable determining this snake's presence. I noted that this fossorial species was restricted to well drained, dry soils hence the importance of surficial geology. Coluber constrictor was widely distributed, favoring open habitats which included fields, ecotones, and rocky screes. PCA isolated the amounts of canopy closure, tree cover, and ground cover as key variables. The presence of the widespread Diadophis punctatus edwardsi was influenced only by the variables affecting canopy closure and tree cover. The presence of Elaphe obsoleta, which occurs on many steep sloped, scrubby basalt ridges, was influenced by the variables governing the amount of low shrubs and the slope (=topography).

In contrast, PCA of Heterodon platyrhinos produced a complex series of key variables including month, ground cover, disturbance, low shrubbery, herbaceous vegetation, surficial geology, and bedrock geology. My field observations indicate that this species favors open fields and ecotones characterized by sandy, well drained soils. This may be illustrated by the vegetational, ground cover, and surficial geology variables. Ecotones including powerline cuts, road edges, and agricultural fields have similar disturbance regimes. This may result in disturbance being included in the PCA equation. I collected Heterodon from late spring through the autumn, with peak success in May, June, and September. This relatively restricted time period may have resulted in inclusion of month variable in the PCA equation.

I considered Lampropeltis triangulum widespread and common, occurring in a wide range of habitats and ecological conditions. I was surprised that PCA indicated that complex interrelationships between the following variables determined its presence: topography, surficial geology, weather, time, month, ground cover, canopy closure, high shrubbery, low shrubbery, tree cover, hydrology, and habitat disturbance. In contrast, the presence of the widespread Nerodia sipedon appeared tied only to a ratio of tree cover and canopy closure.

PCA demonstrated the presence of Storeria dekayi appears dependent on air temperature, habitat disturbance, ground cover, hydrology, high shrubbery, and elevation. I noted that this species exhibits a decided preference for disturbed, dry, scrubby, and scarified areas, which may be accounted for by PCA in the variables habitat disturbance, high shrubbery, hydrology, and ground cover. As I found this species from March through November and at lowland and upland sites, I cannot explain the inclusion of elevation or air temperature in the PCA equations. The presence of the closely related Storeria occipitomaculata is influenced by variables governing habitat disturbance, low and high shrubbery, and weather. I noted that this species was restricted to upland regions and inhabited less disturbed sites than Storeria dekayi.

The presence of Thamnophis sauritus is controlled by the following variables: weather, high shrubbery, air temperature, month, and herbaceous vegetation. These variables can be broken down into two categories. Those determining weather, air temperature, and month may result from my collecting this species primarily in the spring or autumn. My collections may be biased by my inability to capture or observe this swift and wary snake except early or late in the season when it may be less active. This species favors grassy, shrubby wetlands which is reflected in the high shrubbery and herbaceous vegetation variables isolated by PCA. The presence of the ubiquitous Thamnophis sirtalis is dependent upon a ratio of trees to canopy closure. As with most widespread species it occurs in too great a diversity of habitats to isolate any further variables by PCA.

In summary, PCA was of limited use in analyzing my data. The main drawbacks were the high correlations between many variables, the truncation of data sets due to missing data, and the inability of PCA to isolate key variables clustered around several values. The latter was quite serious as it obscured some pivotal distributional scenarios, e.g. restriction of many reptiles to lower elevation.

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CHAPTER EIGHT: DISCRIMINANT ANALYSIS

INTRODUCTION:

Discriminant analysis is a multivariate statistical technique which forms linear combinations of variables to discriminate between the occurrence of two or more species. As with principal components analysis, variables must be ordinal i.e. increasing or decreasing in a linear fashion. Equal distance between variable values as well as multivariate normality are assumed.

Introductory discussions of this technique are found in Hope (1968) and Klecka (1980). Information concerning the implementation and interpretation of discriminant analysis utilizing SPSSx (Statistical Package for the Social Sciences) is available in Hedderson (1987), Norusis (1988a, 1988b), and SPSS Inc. (1988). SPSSx was implemented on the VAX/VMS system at the University of Kent to perform discriminant analysis on my data.

Discriminant analysis proved most useful in comparisons of two species or in small groups of three to five species. Species groups to be compared were carefully selected using the following criteria. Congeneric species were compared as were species that overlapped in habitat, diet, or other ecological parameters. Theoretically, discriminant analysis could be conducted on widely differing species, for example between frogs or snakes or between salt marsh and terrestrial turtles. The models produced would prove the obvious, discriminating efficiently between widely separated taxonomic groups or species occurring in divergent habitats. The strength of discriminant analysis is in distinguishing between taxonomically related or ecologically similar species.

Thirty-one comparisons involving 36 species were conducted utilizing discriminant analysis. Discriminant analysis requires a minimum sample size of 15-20 cases, therefore the following seven species were excluded due to insufficient sample size: Plethodon glutinosus, Necturus maculosus, Scaphiopus holbrookii, Malaclemys terrapin, Eumeces fasciatus, Agkistrodon contortrix mokasen, and Crotalus horridus. In addition, Notophthalmus viridescens and Lampropeltis triangulum were excluded as they were not ecologically convergent or congeneric with any other species.

Missing values were prevalent in the variables air temperature, weather, and time. In several species, these missing data lowered sample sizes to fewer than ten cases with complete data. By eliminating air temperature, weather, and time from the analyses of those species, I maintained adequate sample sizes to produce accurate discriminant models.

Sixteen ecological variables were considered in these analyses: elevation (elev), bedrock geology (bedgeo), month, time, weather, air temperature (airtemp), hydrology (hydric), surficial geology (surfgeo), topography (topogr), ground cover (grndcov), herbaceous vegetation (herb), low shrubbery (lowshrub), high shrubbery (hishrub), amount of tree cover (tree), canopy closure (canopy), and habitat disturbance (disturb). Explanation of these variables can be found in Chapter 2, Material and Methods. Five variables were recoded and reorganized to fulfill the assumption of ordinal linearity.

If two or more variables are highly correlated, a condition called multicollinearity occurs. This creates unstable coefficients which can affect the accuracy of discriminant analysis (Hedderson, 1987). To eliminate this problem, a Pearson correlation matrix was created for each group of species comparisons. If two variables correlated above 0.70, one of these was arbitrarily eliminated from the analysis. For example, tree and canopy were highly correlated in every analysis, therefore canopy was deleted from all these analyses.

Discriminant analysis is divided into two phases. The analysis phase produces a set(s) of variables called functions. Each function is comprised of the standardized coefficients of its variables which are called "predictor variables". As the dependent variable (species) is a nominal measurement, these standardized coefficients cannot be considered as positive or negative associations (Hedderson, 1987). Therefore, the signs (+ or -) of these coefficients have no bearing is these analyses. Within each function, the variable with the largest coefficient has the greatest discriminating power between species, while the lowest coefficient has the least effect. The correct assessment of a variable's importance requires that all variables in a function are considered. For example, in a comparison of species A and B the discriminant function has scores of .70 for elevation, -.72 for bedrock geology, .33 for herbaceous vegetation, and -.42 for disturbance. The correct interpretation of these data are that within this function the following variables discriminate between species A and B in descending order of importance: bedrock geology, elevation, disturbance, and herbaceous vegetation.

Three statistics accompany each discriminant function which, when considered together, give an indication of the function's strength. They are eigenvalue, Wilk's lambda, and significance. The eigenvalue is the variance between species divided by the variance within a species. An eigenvalue of 0.0 indicates the variance between species is the same as within a species. A low eigenvalue indicates that a function does not discriminate strongly between species. Wilk's lambda is the sum of squares within the species being compared, divided by the total sum of squares (all species). Wilk's lambda ranges from 0.0 to 1.0. As Wilk's lambda decreases, the strength of the model increases. For example, a Wilk's lambda of 0.12 indicates 88% of the differences between the species being compared are a result of variance between the predictor variables. The significance level is produced in association with Wilk's lambda. A significance level of 0.001 indicates in one case out of 1000, the Wilk's lambda score would occur by chance. I found it necessary to examine all three scores, eigenvalue, Wilk's lambda, and significance to determine the strength of the discriminant function.

Wilk's lambda can also be utilized to build a discriminant model by entering variables in a stepwise sequence. It is desirable to assess the importance of individual variables in producing a function. By removing certain predictor variables from a function, then recomputing the discriminant model, one can gauge the importance of the removed predictor variable. This procedure is time consuming, especially when more than a few predictor variables are concerned. SPSSx has an option of stepwise addition and subtraction (minimizing Wilk's lambda) of variables into the discriminant analysis. At the first step, the computer program examines all the variables, entering the variable accounting for the greatest between species variance (i.e. the lowest Wilk's lambda score). The program then recalculates all remaining variables and enters the variable with the lowest Wilk's lambda at the second step. This procedure continues until the discriminant model is constructed. Variables that do not meet Wilk's lambda criteria for entry (those variables whose within species scores do not differ substantially from between species scores) are discarded. The resultant model is comprised of fewer variables and has increased discriminant accuracy. By including fewer variables, the interpretation of the discriminant function is facilitated.

The second step in discriminant analysis is classification. Classification tests the discriminant model's strength. The species which make up the model are classified into groups, utilizing the model. The percentage of species correctly classified tests the strength of the discriminant model. For example, in a comparison of two species, 55% of the cases are correctly classified. This is a very poor model as its discriminates only 5% higher than chance (50%). In a comparison of five species, a 55% correct classification indicates a strong model correctly classifying over 2.5 times greater than chance (20%). I found it necessary to examine the percent of cases correctly classified for each species as well as the overall classification. In several instances the model had high overall classification accuracy, but the accuracy varied between species. For example, one or more species were correctly classified in excess of the overall rate, while one species had a much lower accuracy rate.

SPSSx provides a classification option where the sizes of known groups can be specified weighting the classification procedure. For example, species A has 50 cases, species B has 50 cases, species C has 100 cases, and species D has 300 cases, their sample size ratios are 1:1:2:6. By specifying these ratios in the program commands, the classification accuracy of species D was improved, however the accuracy of species A,B, and C declined. By assuming equal probability for all species, the analysis produced discriminant models with higher accuracy for small samples when compared to a large sample. I found this useful as large samples represented widespread species, whereas small samples were rarer species. I was primarily interested in determining discriminant functions of rarer species to test hypotheses I had developed explaining their irregular occurrences.

RESULTS:

The functions, classification models, and accompanying statistics are provided in Appendix II.

1. Mole Salamanders (Ambystoma)

1.1 Comparison of A. jeffersonianum, laterale, maculatum, opacum

Four species of mole salamanders occur within my study area. The most widespread is A. maculatum. Although not uncommon, A. opacum is irregularly distributed. A. jeffersonianum is localized, confined to regions west of the Connecticut River, and A. laterale occurs throughout the region but is very localized. All four species favor seasonally inundated areas for breeding. I observed A. maculatum and A. opacum utilizing the same wetlands for breeding with either A. jeffersonianum or A. laterale. I never found the two latter species sympatric.

The first function accounted for 45% of the between species differences and the second function for 22%. Although this model discriminated strongly for A. jeffersonianum and quite well for A. opacum, its performance was weaker for A. laterale, and only slightly better than chance for A. maculatum. The two high scoring variables in the first function, air temperature and weather are indicators of seasonal Ambystoma activity. A. jeffersonianum and A. laterale are early breeders, active at near freezing temperatures. A. maculatum has a protracted breeding season beginning several weeks later than the previous two species and unlike the two previous species can be found under debris into early summer and again in the autumn. A. opacum is an autumn breeder with activity beginning in late August, peaking in September. The weather is frequently quite warm during their breeding period.

The explanation of bedrock geology as the third highest scoring variable in the first function is more difficult. All four Ambystoma occur on the three types of bedrock geology. A. opacum is most abundant on the trap rock (basalt) ridge system of the Central Connecticut Lowland and very rare in limestone areas. The first function discriminates well for A. opacum, possibly a resulting of bedrock geology. The inclusion of topography and elevation in function two makes some sense when separating A. jeffersonianum and A. opacum from the other Ambystomids. A. jeffersonianum is an upland species with an elevational range to well over 1,000 feet and is rarely found below 500 feet. A. opacum ranges to 1,300 feet, but is common only at low elevations. Both species frequent steeply graded, rocky terrain.

1.2 Comparison of A. jeffersonianum, laterale

This is a very powerful model accounting for 73% of the variance between them. The most important variables in this discriminant function are bedrock geology, topography, elevation, and disturbance. A. jeffersonianum is an upland species, favoring steep to moderately graded rocky slopes and breeding in discrete vernal wetlands. A. laterale is a swamp species, inhabiting flat or gently rolling terrain, associated with riparian wetlands. Although I found both species in western Connecticut's calcareous limestone valleys, A. jeffersonianum is far more common in this region. A. laterale is most common in sandy lowlands underlain by bedrock that is neither calcareous or basalt. A. jeffersonianum is restricted to the uplands of western Connecticut which are some of the least disturbed areas of the State in contrast to A. laterale favoring lowlying areas which are heavily populated and disturbed. Disturbance in the discriminant function may not reflect species preference but two divergent land use patterns which coincide with the zoogeographical distributions of the two species.

1.3 Comparison of A. jeffersonianum, laterale, opacum (the three Ambystoma with irregular distributions).

The first function accounted for 79% of the differences between species, the second function 46%. This model discriminates well between all three species, but most strongly between A. jeffersonianum and the other two species. I have never found A. jeffersonianum and A. laterale in the same habitat. A. opacum is more frequently found with A. laterale than A. jeffersonianum, reflecting a shared preference for lowlying, sandy areas. The most important variables are bedrock geology, air temperature, weather, hydric conditions, and elevation. Bedrock geology accounts for the prevalence of A. opacum in basalt areas, the scarcity of A. opacum and A. laterale in limestone areas, and the prevalence of A. laterale in generalized bedrock areas. Air temperature and weather reflect the seasonality of A. jeffersonianum and A. laterale contrasted to A. opacum. The elevational preferences of the three species have previously been discussed. Hydric conditions may reflect the xeric, sandy habitats inhabited by A. opacum or the dry conditions in late summer and early autumn when most A. opacum are observed. The second function includes topography, hydric conditions, air temperature, and bedrock geology. These effect of these variables on these three species has been discussed previously.

1.4 Comparison of A. maculatum, opacum.

The function accounted for only 27% of the between species differences with an overall classification rate of 23% above chance, lower than the two previous models. Although good discriminant models can be constructed for A. jeffersonianum, A. laterale, and A. opacum, A.

maculatum is too ecologically generalized to be classified. The presence of A. maculatum in discriminant models reduces their efficiency.

2. Stream and Brook Salamanders

(Desmognathus, Eurycea, and Gyrinophilus)

Within southern New England, three Plethodontid salamanders occur in springs, streams, and seepage areas. The most abundant and widespread species is Eurycea bislineata. This is the only stream salamander occurring in many coastal areas of southern New England. Desmognathus fuscus is widely distributed within the region except along the coast. Based on historical information, Desmognathus may be declining in disturbed areas. Desmognathus and Eurycea frequently occur within the same stream and are often microsympatric. Desmognathus favors streams characterized by mosses, mud, and seepage areas. The region's rarest species is Gyrinophilus porphyriticus, a large species feeding on Desmognathus, Eurycea, and aquatic insects. It is confined to cold, clean, highly oxygenated streams and springs in upland areas. It becomes progressively widespread northward in Vermont and New Hampshire.

2.1 Comparison of Desmognathus, Eurycea, and Gyrinophilus.

Overall this analysis does not have strong discrimination ability accounting for only 16% of between species differences. However, it discriminates well between Gyrinophilus and the other species. I would expect Gyrinophilus to be most easily separable from the other species as it is the most ecologically specialized. Analysis of these three species in couplets produced stronger discrimination models.

2.2 Comparison of Desmognathus and Eurycea.

This model is only 9% more effective than chance. The eigenvalue was low, Wilk's lambda high, and the significance high compared to other models. Although there are distributional differences between these species they appear attributable to parameters not measured by the variables. These may include water temperature, dissolved substances, presence of different prey items, or water pH.

2.3 Comparison of Desmognathus and Gyrinophilus.

This analysis produced a fairly robust model. Although the function accounted for only 19% of the between species differences, it correctly classified three quarters of the cases. The four variables in the discriminant function were herbaceous vegetation, elevation, tree cover, and disturbance are all compatible with my field data. Herbaceous vegetation results from Desmognathus preferring mossy and vegetated streams or seepage areas. The high gradient streams frequented by Gyrinophilus are usually scoured of most vegetation and organic debris by spring floods. Gyrinophilus is not found below 500 feet. It is common at high elevations favoring heavily forested ravines. Desmognathus, while preferring shade, can be found in partially sunlit and disturbed areas, occurring over a wide altitudinal range. Gyrinophilus is restricted to rugged, upland terrain in southern New England. These areas are heavily forested and among the most sparsely settled sections of southern New England. Consequently, human created disturbances are quite limited.

2.4 Comparison of Eurycea and Gyrinophilus.

This analysis produced a model with strong classification abilities. Although accounting for only 13% of the between species differences, it correctly classified almost three quarters of the cases. The important discriminating variables are elevation, herbaceous vegetation, and tree cover. Elevation is more important in discriminating between Eurycea and Gyrinophilus than between Desmognathus and Gyrinophilus. This may be a function of the many low elevation localities for

Eurycea near the coast where the other two species are rarely found. Herbaceous vegetation and tree cover are important as Eurycea occurs in open grassy streams, a habitat never utilized by Gyrinophilus and rarely by Desmognathus.

3. Small Terrestrial Lungless Salamanders

(Hemidactylium scutatum and Plethodon cinereus)

Plethodon cinereus is the most common salamander in southern New England, inhabiting a wide variety of habitats. Hemidactylium scutatum, although rarer, is often found microsympatrically with Plethodon cinereus. Hemidactylium breeds in wooded swamps and produces aquatic larvae. Plethodon cinereus is a terrestrial breeder which undergoes direct development within the egg. At Montauk Point, Long Island (New York) I found Hemidactylium ecologically replacing Plethodon cinereus. As Hemidactylium is the only terrestrial woodland salamander present at Montauk, it attains population densities approaching Plethodon cinereus.

This model correctly classified 67% of my small sample of Hemidactylium (n=15). These results should be cautiously interpreted due to the sample size. The presence of tree and shrubbery variables may result from Hemidactylium occurring in and near wooded shrub swamps. As most wooded swampland is flat or gently rolling, topography may separate Hemidactylium from Plethodon cinereus, the latter occurring over a wide range of topographic variation. Elevation is important in the distribution of Hemidactylium. Although found at high elevations, most collection sites are from lowland areas in contrast to Plethodon cinereus which has a wide altitudinal range. I made many of my Hemidactylium collections at night during spring or autumn rainfall, therefore time may also be an important discriminating variable.

4. Toads (Bufo)

Three species of toads inhabit southern New England. Scaphiopus holbrookii is extremely rare. It could not be included in this analysis due to small sample size. Two species, Bufo americanus and Bufo woodhousii fowleri, are more common. Bufo americanus is ubiquitous throughout the region. Bufo woodhousii fowleri is less common, restricted to xeric, sandy, open microhabitats associated with coastal regions and inland river valleys. B. woodhousii fowleri breeds in late spring or early summer and is active only during warm weather from May through September. It is a southern coastal plain species which has colonized warm, lowlying areas of southern New England.

The model produced was very weak with a low eigenvalue, high Wilk's lambda, and comparatively high significance level. It correctly classified Bufo woodhousii fowleri slightly better than chance. Despite the weakness of the model, the two variables appearing in the discriminant function, herbaceous vegetation and month, are readily explained by my data. Herbaceous vegetation is a reflection of Bufo woodhousii fowleri favoring open, sparsely vegetated areas dominated by grasses and forbs. Month is linked to its comparatively restricted annual activity pattern.

5. Tree Frogs (Hyla)

Two tree frogs occur in southern New England. Hyla crucifer is one of the most common amphibians in the region, found in a wide range of habitats. It occurs in very disturbed habitats and even breeds in brackish water. Hyla versicolor, although widespread, is far more localized and less tolerant of disturbed areas and salinity.

This first model produced was unreliable because the sample size of Hyla versicolor was too small. This analysis was rerun eliminating air temperature, a variable with a lot of missing data, which doubled the sample size. The resulting model indicated some discrimination ability in the disturbance and hydric variables which may result from the narrower ecological tolerance of Hyla versicolor. Month also discriminates between these species. Hyla crucifer is found from March through November while Hyla versicolor most usually found from May through September. Weather may discriminate possibly based on the prevalence of Hyla versicolor activity during warm and humid summer weather and the discrimination ability of low shrubbery results from the prevalence of Hyla versicolor breeding in shrub swamps. I am at a loss to explain the discriminant importance of either bedrock geology or surficial geology in this function.

6. True Frogs (Rana)

Five species of Rana occur in southern New England. Frequently several species are sympatric, therefore they are ideal candidates for discriminant analysis. The following four species are widespread. Rana catesbeiana favors permanent water, although juveniles are mobile and found in temporary pools. Rana clamitans melanota tolerates a wide range of water conditions and is the most abundant frog in southern New England. Rana palustris is widespread, favoring open canopy, wet grassy meadows. Rana sylvatica is a moist woodland species breeding in temporary water.

Rana pipiens is rare and localized in Connecticut, occurring in grassy meadows, usually with its close relative, Rana palustris. However, Rana pipiens is restricted to meadows on the floodplains of moderate to large-sized rivers. Rana pipiens has two centers of distribution within Connecticut, the Connecticut River and its tributaries and the Housatonic drainage basin located in the limestone valleys of western Connecticut.

6.1 Comparison of R. catesbeiana, clamitans, palustris, pipiens, and sylvatica.

Two functions were produced by this model which most effectively classified Rana pipiens and Rana sylvatica, the two species with the most ecologically divergent or specialized requirements. Rana pipiens a floodplain species and Rana sylvatica, a terrestrial inhabitant of moist woodlands. Rana catesbeiana was also classified effectively, probably due to its restriction to permanent water. The two remaining species, Rana clamitans melanota and Rana palustris, which occur in a wide variety of habitats, were not classified. When a species group is compared using discriminant analysis, widespread and generalized species usually yield the lowest classification rates. A similar result occurred when I compared the four species of Ambystoma. The widespread A. maculatum was the only species that I was not able to effectively classify. To clarify the relationships of the five Rana, I divided them into smaller groups for comparison.

6.2 Comparison of Rana catesbeiana, clamitans, palustris.

This model had a low eigenvalue, high Wilk's lambda, and comparatively high significance level indicating that it had little discrimination ability. The overall classification rate was 42%, nine percent higher than chance (33%). Correct classification for Rana catesbeiana was 55%, Rana clamitans 40%, and Rana palustris was 34%.

6.3 Comparison of Rana catesbeiana, clamitans.

As in the previous comparison the eigenvalue is too low and Wilk's lambda too high to accurately discriminate. The overall number of correctly classified cases is 61%, eleven percent greater than chance (50%). Correct classification for Rana catesbeiana is 63% and for Rana clamitans melanota 60%.

6.4 Comparison of Rana palustris, pipiens.

This model discriminates strongly between these two closely related species of meadow frogs accounting for 37% of the between species variance. The variables for ground cover, high shrubbery, low shrubbery, and herbaceous vegetation indicate a vegetational community dominated by shrubs and tall grasses found on the floodplain inhabitated by Rana pipiens. While Rana palustris is found on floodplains, unlike Rana pipiens it is not restricted to these areas. Topography is part of the function, and may discriminate between low topographic relief of floodplains contrasted to the moderate or strongly graded wet hillsides, seepage areas, and brooks where Rana palustris is also found. The function variables governing bedrock geology, disturbance, and elevation may illustrate the restricted range of Rana pipiens, confined to two regions of Connecticut, each with a distinctive elevation, bedrock geology, and disturbance factor. This contrasts with the wide range of habitats, elevations, bedrock, and disturbance factors encompassed by Rana palustris.

7. Aquatic Turtles

(Chelydra serpentina, Chrysemys picta

Sternotherus odoratus)

Although these three species belong to different families, they frequently occur within the same aquatic habitats. Chelydra and Chrysemys are found throughout Connecticut, common in a wide variety of aquatic habitats. Sternotherus is restricted to rivers, streams, and associated wetlands such as impoundments. Sternotherus is common in Connecticut's coastal areas, inhabiting many of the small rivers that drain directly into Long Island Sound. This species is very localized in western Connecticut's highlands, but common in the State's eastern uplands. Although these turtles have different niches within aquatic ecosystems, discriminant analysis was conducted to discover additional ecological segregation between them.

7.1 Comparison of Chelydra, Chrysemys, and Sternotherus

The model produced was weak, discriminating well for Chelydra but only slightly above chance for Chrysemys and Sternotherus. Only 15% of the between species variance is accounted for by the model. The amount of herbaceous vegetation and type of waterbody were the most important discriminating variables.

7.2 Comparison of Chelydra, Chrysemys

The model produced was weak, accounting for 10% of the between species variance. Its eigenvalue is low, indicating the difference between these species was not greater than the differences within either species. The most important variable produced by this function is bedrock geology, which is not supported by my observations. I found Chrysemys and Chelydra with equal frequency in all bedrock types. In summary, this model is misleading and has no value discriminating between these species.

7.3 Comparison between Chelydra, Sternotherus

This model provides surprisingly strong discrimination between these two species. It has a high eigenvalue and the Wilk's lambda ascribes 30% of the between species variance to the function. This is the best model for any of the aquatic turtles comparisons, classifying the two species well in excess of chance. The strongest discriminating variable is herbaceous vegetation. I cannot support or refute this from my field data as both species are found in eutrophic waters which are heavily vegetated. Hydrology discriminates well which is supported by my field observations which indicate Sternotherus is restricted to drainage systems and impoundments, whereas Chelydra is found in all types of wetlands. Disturbance also discriminates well between these species. I noted that Chelydra occurs in many urban and polluted habitats whereas Sternotherus is most frequently found in impoundments and reservoirs, which are usually less disturbed and polluted. Discrimination by elevation is strongly supported by my field data which indicates Sternotherus is restricted to low elevations, i.e. 900 feet or less whereas Chelydra attains elevations over 1600 feet. Tree cover, shrubbery, and weather have lesser discriminating ability between these species which I cannot reconcile with my field observations.

7.4 Comparison of Chrysemys, Sternotherus

The model produced was poor with a low eigenvalue, a very high Wilk's lambda, and a comparatively high significance level. Although the model correctly classified 68% of Chrysemys and 66% of Sternotherus, it has no discrimination value based on the statistics of its discriminant function. As the analysis between Chelydra and Sternotherus was so revealing, I had hoped for similar results with Chrysemys and Sternotherus.

In summary, these four analyses showed little discrimination in any of the comparisons involving Chrysemys. The discrimination between Chelydra and Sternotherus was surprisingly strong.

8. Shallow wetland and semi-terrestrial turtles (Clemmys)

The genus Clemmys is comprised of three species, each adapted to specific a specific habitat niche. Clemmys muhlenbergii is the rarest and most ecologically specialized, in danger of extinction over much of its range. It is restricted to open canopy wet meadows between 500-700 feet in calcareous valleys of western New England. C. muhlenbergii is restricted to fragile and specialized wetlands and usually when habitat is disturbed, C. muhlenbergii disappears. Its surficial geology and hydric requirements are narrow, requiring a muddy, soft substrate overlain by very shallow, gently flowing clean water. In summary, this species has a narrow range of values for most variables.

Clemmys guttata is widely distributed within southern New England to an elevational maximum of 1100 feet. It inhabits a wide variety of shallow wetlands, including tidal creeks, temporary woodland pools, wet meadows, and vegetated margins of large water bodies. By utilizing a diversity of shallow water habitats, it is quite evenly distributed throughout Connecticut. Because shallow water habitats are easy to drain and fill, it has become scarce in urbanized and suburbanized areas. It occurs with C. muhlenbergii, though often preferring deeper water areas within the same meadow.

Clemmys insculpta is the largest and most terrestrial of the three species. It requires clean rivers and streams, with bordering tracts of woods and pasture. It remains in or near these rivers most of the year, except during summer, when it becomes terrestrial. Unlike its two congeners, it is not restricted to low elevations as I have made several collections between 1500-1700 feet. C. insculpta has a large home range, often moving several kilometers in a season. It has become scarce in developed areas due to subdivision of its home range with resultant heavy road mortality.

8.1 Comparison of C. guttata, insculpta, muhlenbergii

This comparison produced two functions. The first function accounted for 86% of the between species differences with the second function accounting for 45%. The most important variables in the first function are topography, disturbance, herbaceous vegetation, ground cover, and air temperature. Topography may be explained by the hilly terrain frequented by C. insculpta contrasted to gently sloping or level wetlands inhabited by C. guttata and muhlenbergii. Disturbance tolerances vary between species, C. muhlenbergii tolerates the least disturbance, C. insculpta is scarce in areas of intensive land use, and C. guttata has the widest tolerance for habitat disturbance. Herbaceous vegetation and ground cover are accounted for by the varied vegetational parameters of each species, particularly open, grassy meadows required by C. muhlenbergii. Air temperature may indicate that C. guttata is active at low temperatures compared to C. muhlenbergii. C. insculpta is also tolerant of low temperatures, though not as frequently collected in cool weather as C. guttata.

The most important variables in the second function are bedrock geology, hydrology, elevation, and ground cover. Bedrock geology separates C. muhlenbergii, which is restricted to calcareous wetlands. Hydric conditions separate the species by tolerance of varying wetland habitats. C. muhlenbergii has the narrowest ecological requirements, C. insculpta is intermediate, and C. guttata inhabits a wide range of wetland types. Elevation also discriminates between species. C. muhlenbergii generally occurs in a narrow band between 500-700 feet, C. guttata is most common below 600 feet, and C. insculpta has a wide elevational range.

8.2 Comparison of C. guttata, insculpta

This is a strong model, accounting for 45% of the between species variance. Hydrology is the most important variable in this function. C. guttata occurs in a wide range of wetland habitats contrasted to C. insculpta which is generally confined to riparian habitats. Air temperature and month are accounted for in the function by the concentration of C. guttata activity in spring and early summer, contrasted to C. insculpta which is most often found in midsummer. The presence of bedrock geology is puzzling as both species occur on all types of bedrock. There may be disparate occurrence frequencies on certain bedrock types, reflected in the discriminant function. Time of day is significant although I have not noted any divergent daily collection patterns between either species. Disturbance would be important in discriminating between these species as C. guttata is more tolerant of disturbance than C. insculpta. Ground cover and high shrubs may be accounted for by prevalence of C. guttata in shrubby swamps and meadow or by the occurrence of C. insculpta in terrestrial ecotones including old field habitat.

8.3 Comparison of C. guttata, muhlenbergii

This is a very strong model accounting for 78% of the between species variance. This can be expected when comparing the most generalized with the most specialized species. Disturbance figures prominently into the discriminant function, resulting from the wide tolerance of C. guttata to disturbance, when contrasted to C. muhlenbergii. Air temperature and month result from early spring emergence of C. guttata when contrasted to C. muhlenbergii which becomes active in late April with peak activity in May. Bedrock geology is important as C. muhlenbergii is largely restricted to limestone wetlands. Although C. guttata occurs in limestone areas, it is widespread on all types of bedrock. Herbaceous vegetation may be accounted for by the restriction of C. muhlenbergii to grassy meadows. Although C. guttata favors such meadows, it commonly occurs in vernal pools, which are devoid of herbaceous vegetation. Although C. guttata favors swamps and meadows with little topographic relief, it is found in pools set in steep, rocky ledge areas. C. muhlenbergii is restricted to low relief, mucky bottomed wetlands. These differences may be accounted for by the variables topography and surficial geology.

8.4 Comparison of C. insculpta, muhlenbergii

This a very strong model, accounting for 98% of the between species differences. Although C. insculpta and C. muhlenbergii occur in the same watersheds, I have never found them to be microsympatric. Bedrock geology is the most important discriminating variable. I have collected C. insculpta in limestone valleys, but it is most abundant in the granitic uplands of eastern Connecticut. Ground cover, herbaceous vegetation, as well as low and high shrubs are accounted for by the specialized open canopy meadow habitats utilized by C. muhlenbergii, contrasted to the varied habitats of C. insculpta. C. muhlenbergii is less tolerant of environmental disturbance than C. insculpta, therefore disturbance is included in the function. I cannot explain time and weather except that there must be differences in the distribution of variable values between these species.

9. Terrestrial Turtles

(Clemmys insculpta, Terrapene carolina)

These are the only turtles in my study area that can be considered terrestrial. C. insculpta, although spending the autumn, winter, and springs in rivers and streams, becomes terrestrial in the summer. It is sympatric with T. carolina in many lowland areas. T. carolina is a lowland species, not occurring above 800 feet whereas C. insculpta is widely distributed, but is less tolerant than T. carolina of disturbed areas. In many upland sections of Connecticut, C. insculpta is the only terrestrial turtle.

This model discriminates well for T. carolina but no better than chance for C. insculpta. This may result from the ecological requirements of T. carolina being a subset of those of C. insculpta. If one envisions the set of C. insculpta ecological requirements as a circle, the requirements of T. carolina are a smaller circle contained within the large circle. Therefore, the discrimination model works well for T. carolina but not for C. insculpta. This is reasonable as the geographical distribution of T. carolina within Connecticut is contained within the range of C. insculpta.

T. carolina is distinguished from C. insculpta by the amount of ground cover and hydrology. Although C. insculpta occurs in fields and woodlands with T. carolina, it also inhabits rivers and streams. These riparian waters are frequently stony, without vegetated ground cover. T. carolina is never found in flowing water except at the edges of small streams. T. carolina is rare in limestone valleys, but abundant on basalt ridges whereas C. insculpta is found in limestone valleys but rarely on basalt ridges. Therefore, bedrock geology may effectively separate the species in many areas. T. carolina also tolerates a wider range of environmental disturbance than C. insculpta, largely due to its small home range requirements which enable it to survive in patchwork habitats. In addition, T. carolina is restricted to lowland areas, which tend toward greater amounts of development and disturbance.

10. Fossorial Snakes of Sandy Areas

(Carphophis and Heterodon)

Carphophis amoenus and Heterodon platyrhinos, although differing in size and food habits, favor lowlying, sandy, open habitats. Carphophis is a small, fossorial species which feeds on worms. Heterodon is a stocky, medium sized semi-fossorial species which feeds on toads. Discriminant analysis was conducted to determine if any habitat parameters could differentiate these species. The model produced should be used cautiously, as the sample sizes may be too small to produce accurate results.

The model accounts for 60% of the between species differences. The amount of tree cover is an important discriminating variable, as are low shrubs, herbaceous vegetation, ground cover, and disturbance. Heterodon tends to be found both in open woodland and treeless areas. Carphophis is frequently found in treeless areas and only occasionally at woodland edges. Carphophis favors agricultural land, whereas Heterodon is most common in less disturbed woodlands and ecotone areas. Both species favor sandy, well drained soils. Carphophis is restricted to lower elevations than Heterodon and is usually collected only in late spring and early summer. Heterodon is found throughout the warm months with peaks of collection in early summer and early autumn.

11. Large Black Snakes

(Coluber constrictor and Elaphe obsoleta)

The two large black snakes of southern New England present an interesting ecological problem. Elaphe has range restricted to within fifty miles of the coast, with a northward extension along the basalt ridges of the Central Connecticut Lowland. It favors a mixture of open areas and trees, with rugged topography and is well adapted for arboreal existence. Elaphe is absent at high elevations. Coluber is far more widespread, occurring throughout Connecticut but rare at high elevations. It prefers more open habitat than Elaphe, although in many areas the two occur microsympatrically. Both species feed on small vertebrates.

This model accounts for 48% of the between species differences, classifying both species above chance. The model is stronger for Elaphe, the more specialized of the two species. Two important variables distinguishing the species are topography and surficial geology which may indicate a preference of Elaphe for rocky and steep terrain. Tree cover is also an important variable, reflecting the preference of Elaphe for forested areas contrasted to Coluber which favors fields and open habitats. Elevation figures less prominently in the discriminant function than the previous variables. Although both species are rare at high elevations, Elaphe was not found above 1000 feet while I collected Coluber up to 1300 feet. High shrubs have a minor effect on the function. They could indicate either scrubby field habitats inhabited by Coluber, or the shrubby basalt ridges inhabited by Elaphe. I was surprised that month was included in the function. Both species have bimodal annual distributions, with peaks of occurrence in spring and autumn.

12. Small Snakes of Forest, Ecotone, and Field

(Storeria dekayi, Storeria occipitomaculata, Diadophis punctatus edwardsi, and Opheodrys vernalis)

The two Storeria species provide a fascinating study in ecological separation, not unlike the black snakes. S. occipitomaculata is an upland species, confined to the eastern and western uplands of Connecticut, and is not found below 300 feet. I have collected them in forest clearings, ecotones, and gardens. S. dekayi reaches its greatest abundance in disturbed areas and is most prevalent along the coast and in the Central Connecticut Lowland. In upland areas, S. dekayi is found at field edges, in quarries, and along railroad tracks. Both species feed on gastropods and I found them microsympatrically at only a few sites in Connecticut.

Storeria are occasionally found with two other diminutive snakes. Diadophis punctatus edwardsi is a small salamander and snake eating species distributed in a wide variety of habitats, varied elevations, and a wide of range of disturbance levels. Opheodrys vernalis is a field and grassland species which feeds on insects and spiders.

12.1 Comparison of S. dekayi, occipitomaculata

This model discriminates well between the two species. I am surprised that bedrock geology was the strongest discriminating variable, as I had not noted that either species had an affinity for a particular bedrock geology. The topography and elevation variables indicate the rugged upland terrain inhabited by S. occipitomaculata contrasted to more level, lowland habitats favored by S. dekayi. The function variables tree and herbaceous vegetation indicate forested areas inhabited by S. occipitomaculata as opposed to open areas favored by S. dekayi. Surprisingly, disturbance is not included in the discriminant function.

12.2 Comparison of Diadophis punctatus edwardsi, Storeria dekayi, occipitomaculata

The model accounts for 66% of the between species differences and produces strong discrimination, i.e. twice that of chance. Disturbance, topography, and elevation are important in discriminating among species. S. occipitomaculata is an upland species occurring in rugged terrain in relatively undisturbed areas. Diadophis has a wide range of tolerance for all three variables. S. dekayi favors moderately to severely disturbed sites and is often concentrated at lower elevations in relatively flat habitats. The various vegetation variables such as low shrub and herbaceous vegetation indicate open transitional sites, inhabited by all three species, but favored by S. dekayi over forested areas. The secondary function is much weaker, accounting for 27% of the between species differences. Disturbance, elevation, and low shrubbery remain important. Bedrock geology appears in this function, possibly accounting for the rarity of Diadophis in limestone valleys and the scarcity of S. occipitomaculata on basalt ridges.

12.3 Comparison between Opheodrys, S. dekayi, occipitomaculata

The resulting model is weakened because the sample sizes are small and therefore should be cautiously interpreted. It accounts for 65% of the between species variance classifying both Storeria well but Opheodrys no better than chance. Bedrock geology is the most important discriminating variable, which I cannot reconcile with my field observations. Topography, disturbance, and vegetational cover variables are important. This is supported by my field data which found that Opheodrys occurs primarily in post-agricultural fields and pastures, S. dekayi in open canopy, disturbed areas, and S. occipitomaculata in rugged, forested, less disturbed terrain. This model adds no new information since I previously constructed a model to discriminate between Storeria. I had hoped to classify Opheodrys with this model but it has no classification ability for this species.

13. Striped Snakes (Thamnophis)

Two species of Thamnophis occur in Connecticut. T. sirtalis is Connecticut's most common reptile, occurring in virtually all habitats statewide. T. sauritus is localized, occurring in shallow water meadows and shrub swamps. However, T. sauritus is found over a widely ranging elevations and disturbance levels, as well as on all types of bedrock.

This model produced was weak with a moderately strong eigenvalue and Wilk's lambda accounting for only 16% of the species differences. The classification rate for T. sauritus was lower than for T. sirtalis. The variables topography, high shrub, and low shrub may point to the shrubby, low relief wetlands favored by T. sauritus. Since I collected T. sauritus most frequently in the spring and autumn, month was selected as a discriminating variable. T. sauritus is rarely found in limestone areas, therefore bedrock geology may have some discrimination value too. In summary, this model is not effective and did not provide an adequate explanation for the rarity of T. sauritus.

14. Wetland Snakes

(Nerodia sipedon and Thamnophis sauritus)

Two snakes are specifically adapted for life in and near aquatic habitats. The most widespread and ecologically tolerant species is Nerodia sipedon. Thamnophis sauritus is much rarer with a localized and cryptic distribution previously discussed.

The model produced provides strong discrimination between these species. The variable hydric indicates that the type of waterbody is important. Nerodia has a much wider range of aquatic habitats than T. sauritus. The vegetational variables may indicate a more specialized plant community in the shrubby wetlands favored by T. sauritus. Topography may result from T. sauritus favoring lowland swamps and meadows which have little topographic relief, in contrast to Nerodia which occurs over a wide range of terrain including steeply graded mountain streams.

Although I have a few high elevation records for T. sauritus, of the two species, Nerodia is more frequently encountered at high elevation wetlands. This may account for the inclusion of elevation in the function.

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CHAPTER NINE: CLUSTER ANALYSIS

INTRODUCTION:

Cluster analysis is a multivariate statistical technique that allocates sets of cases to mutually exclusive groups known as clusters. Cases within a cluster are similar, whereas those in different clusters are dissimilar. Cluster analysis seeks natural groupings, however this technique is notorious for creating spurious clusters. This is primarily the result of agglomerative cluster analysis techniques that combine or divide clusters until all cases are grouped. By default, some very dissimilar cases may be grouped using these techniques. My data set consisted of 43 cases, each a single species. To determine if the groupings produced by cluster analysis were "real", I ran my data set through a variety of clustering techniques. If the clusters produced were fairly consistent, they were considered to be groupings of similar species. A good discussion of cluster analysis and its pitfalls is contained in Chatfield and Collins (1980).

Cluster analysis measures the similarity or dissimilarity of each pair of cases using a variety of distance measures. The most commonly used measure is the squared Euclidian distance which calculates the distance between two cases as the sum of the squared differences between values for each variable. Large differences are weighted more heavily using squared Euclidian distance than with other measures. In city-block (=Manhattan) measure, the distance between two cases is the sum of the absolute differences in values for each variable. Therefore, large differences are not as heavily weighted using this measurement.

Cluster analysis uses various methods for combining (=agglomerating) clusters. Single linkage, also known as "nearest neighbor", combines the first two cases based on the smallest distance, i.e. the greatest similarity, between them. The distance between the newly formed cluster and all the other cases is computed as the minimum distance between an individual case and a case in the cluster. The distances between cases that have not been joined does not change. At every step the distance between two clusters is taken as the distance between their two closest points. A drawback of single linkage is the "chaining" effect which may occur when distinct clusters are united too early in the analysis by a few intermediate points. The problems of "chaining" and its interpretation are illustrated in Gibson and Phillipson (1983) and discussed in Goodall (1978).

Complete linkage, also known as "furthest neighbor", calculates the distance between two clusters to be the dissimilarity between their most remote pair of cases. This technique can be considered the opposite of single linkage. Average linkage between groups is an unweighted pair-group method using arithmetic averages. It defines the distance between two clusters as the average of the distances between all pairs of cases in which one member of the pair is from each of the clusters. It differs from single and complete linkage methods by using information about all pairs of distances, not just the nearest of the furthest. Therefore, it is often preferred to single and complete linkage methods. Average linkage within groups combines clusters so that the average distance between all cases in the resultant cluster is as small as possible. Therefore the distance between two clusters is the average of the distances between all possible pairs of cases within the resultant cluster.

Cluster analysis available on SPSSx (Statistical Package for the Social Sciences) was implemented on the VAX/VMS system at the University of Kent to analyze my data. Discussions concerning the implementation and interpretation of cluster analysis utilizing SPSSx are contained in SPSS Inc. (1988) and Norusis (1988a, 1988b). I conducted several procedures upon my data set in order to run the cluster analysis program. Aggregation of variables was necessary to produce single scores for the variables of each species. This was accomplished by running the SPSSx program "Aggregate" which produced the mean score of each variable for each species. The mean score was used instead of the median as I was interested in the extremes and spread of the variable scores.

After a new data file of aggregated values was formed, these values had to be standardized. For example, time and temperature were measured in hours and degrees. Their median scores were numerically much larger than most other variables which frequently had three categories and were numbered 1-3. In cluster analysis the scores of time and temperature would be weighted out of proportion to their contribution. By running the SPSSx "Descriptives" program, standardized scores (Z scores) were produced for the aggregated values. Once these procedures were completed cluster analysis could begin.

Cluster analyses were conducted on various taxonomic groupings, beginning first within the individual orders Caudata, Anura, Testudinata, and Squamata, then within classes Amphibia and Reptilia, and lastly between classes, i.e. all species. Initially I attempted to use only a few variables in the cluster, but their aggregated, standardized variable scores showed little variance among the variables. It was necessary to conduct analyses with the entire variable set to produce clusters and dendrograms with adequate resolution.

The following variables were used in the cluster analyses: elevation, bedrock geology, month, time, weather, air temperature, hydric conditions, surficial geology, topography, ground cover, herbaceous vegetation, low shrubbery, high shrubbery, tree, canopy closure, and disturbance. A detailed description of each is found in Chapter 2 (Materials and Methods)

Forty-three species were analyzed with only the spadefoot toad (Scaphiopus holbrookii) excluded because of missing data. Several species have very small data sets which may compromise the accuracy of their variable scores. These are slimy salamander (Plethodon glutinosus), diamondback terrapin (Malaclemys terrapin), five-lined skink (Eumeces fasciatus), copperhead (Agkistrodon contortrix mokasen), and timber rattlesnake (Crotalus horridus).

Interpretation of cluster scores is somewhat arbitrary and involves the use of some a priori knowledge of the data set. Some types of statistical analyses have absolute numerical cut- off points above or below which a score is significant. Cluster analysis groups all cases, however many of the clusters formed in the later stages of the analysis contain dissimilar cases. One of the greatest abuses of cluster analysis is the uncritical acceptance of results without any attempt to interpret the strength or weakness of the clustered data. To mitigate this pitfall several different types of cluster analyses, using different types of distance measures, should be performed and the results compared. Equally important is carefully examining the agglomeration schedule calculated by the SPSSx program. This schedule calculates a similarity coefficient for each cluster. The higher the coefficient, the more dissimilar the members of the cluster, and therefore the weaker the cluster. Where to draw the line on the agglomeration schedule is difficult. A good rule of thumb is to find the point where these coefficients begin to rapidly increase. However, in some analyses a clearly defined cutoff point is not available and some "common sense" is required. For example, a terrestrial cluster is merged with an aquatic cluster, a "logical" cutoff point may be prior to this merger. Another useful method is to generate a dendrogram of the clustered data, which graphically illustrates the distance between clusters. As more dissimilar clusters are formed the length between the merging points of the dendrogram increases. Figures 1 through 16 illustrate examples of my data clustered and plotted as dendrograms.

RESULTS:

SALAMANDERS

The six comparisons all show three groupings of salamanders. The first cluster consists of dusky (Desmognathus fuscus) and two-lined (Eurycea bislineata) salamanders. These are the two stream salamanders which are widespread and abundant in southwestern New England. The second cluster is made up of two mole salamanders, the blue spotted (Ambystoma laterale) and the spotted (Ambystoma maculatum). Jefferson's salamander (Ambystoma jeffersonianum) occasionally enters this cluster, but blue spotted and spotted salamanders always are more similar to each other than either is to Jefferson's salamander. Jefferson's salamander enters the cluster later than the two other species as it has a higher coefficient of similarity, i.e. it is more dissimilar. My field observations and previous statistical analyses indicate that Ambystoma jeffersonianum has the narrowest ecological requirements of the New England Ambystomids.

Marbled (Ambystoma opacum) and red-backed (Plethodon cinereus) salamanders form the third cluster. According to cluster analysis, marbled salamanders have greater ecological convergence with the red-backed salamander than any other Ambystoma. Both these salamanders inhabit dry deciduous woodland, a habitat often shunned by other Ambystomids. Slimy, four-toed (Hemidactylium scutatum), and spring (Gyrinophilus porphyriticus) salamanders are uncommon and ecologically specialized, therefore it is to be expected that they did not "cluster".

Figure 1

Salamander Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Clusters Combined Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Stage Cluster 1st Appears Cluster 2	Next Stage
1	5	6	1.058312	0	0	4
2	2	3	4.356234	0	0	6
3	4	9	8.600861	0	0	4
4	4	5	9.114372	3	1	5
5	4	11	9.453552	4	0	6
6	2	4	11.751899	2	5	7
7	1	2	11.914455	0	6	8
8	1	8	16.161589	7	0	9
9	1	10	18.844383	8	0	10
10	1	7	22.724594	9	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * *

Dendrogram using Single Linkage

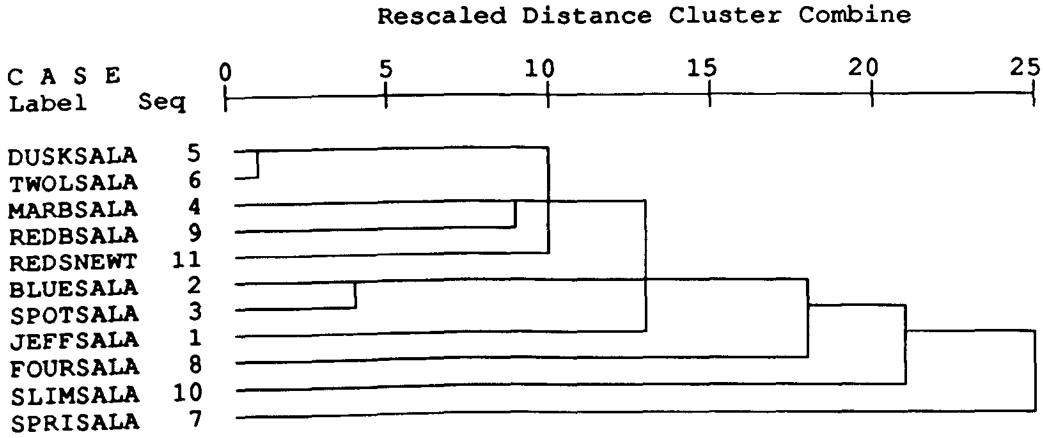


Figure 2

Salamander Dendrogram/Complete Linkage

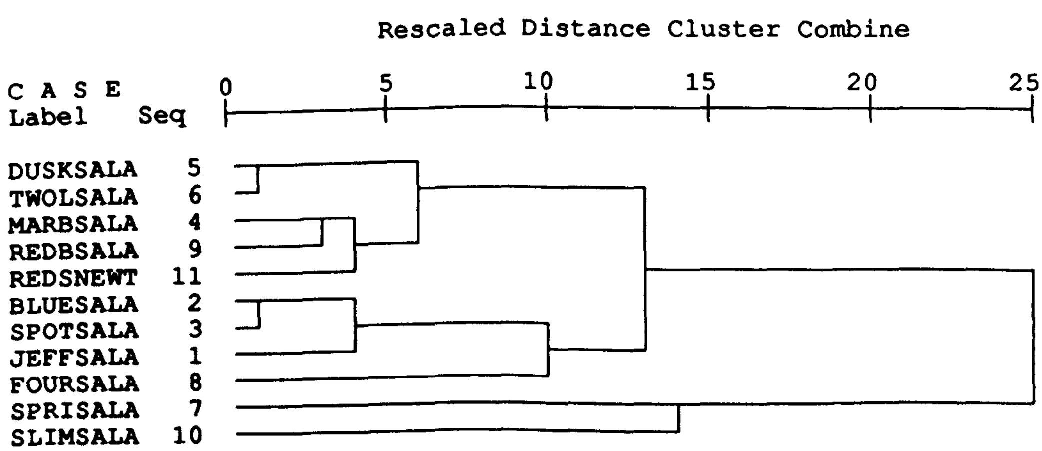
* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	5	6	1.058312	0	0	6
2	2	3	4.356234	0	0	5
3	4	9	8.600861	0	0	4
4	4	11	13.400110	3	0	6
5	1	2	14.238439	0	2	7
6	4	5	19.675194	4	1	8
7	1	8	34.504040	5	0	8
8	1	4	45.145592	7	6	10
9	7	10	46.773571	0	0	10
10	1	7	87.770546	8	9	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage



FROGS

Two clusters are formed in all these analyses. These are a three species cluster comprised of the common pond and marsh frogs, bull (Rana catesbeiana), green (Rana clamitans), and pickerel (Rana palustris) and a second cluster of early spring vernal pool breeders, the spring peeper (Hyla crucifer) and wood frog (Rana sylvatica).

The american toad (Bufo americanus) and gray tree frog (Hyla versicolor) are treated as a separate cluster in some comparisons or as part of the pond and marsh frog cluster in others. In either case, the relationships are not strong. It makes more "ecological sense" to treat them as a separate cluster (as the analyses using squared Euclidian distance do). The two species in this cluster inhabit deciduous forests and ecotones and breed in wooded swamps.

Three frogs which I consider ecologically specialized did not cluster. The spadefoot toad was excluded from analysis due to missing data, and the leopard frog (Rana pipiens) and Fowler's toad (Bufo woodhousii fowleri) had data sets too dissimilar to be effectively clustered with any other frogs.

Figure 3

Frog Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	6	7	1.066703	0	0	2
2	5	6	1.071743	0	1	3
3	1	5	8.107523	0	2	5
4	3	9	8.261852	0	0	6
5	1	4	10.022916	3	0	6
6	1	3	10.163094	5	4	7
7	1	2	15.140198	6	0	8
8	1	8	28.113771	7	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

Rescaled Distance Cluster Combine

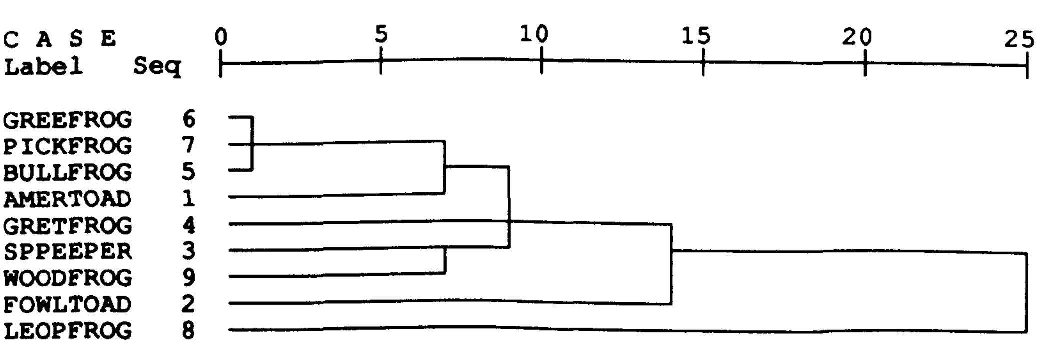


Figure 4

Frog Dendrogram/Complete Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

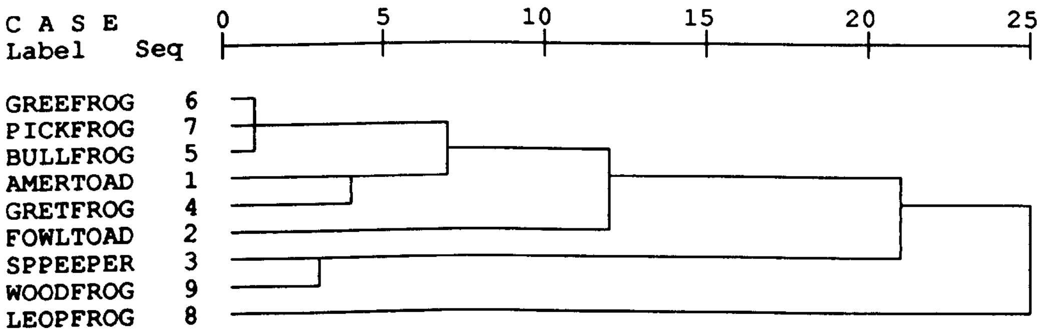
Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	6	7	1.066703	0	0	2
2	5	6	1.693882	0	1	5
3	3	9	8.261852	0	0	7
4	1	4	10.022916	0	0	5
5	1	5	18.888439	4	2	6
6	1	2	32.896679	5	0	7
7	1	3	56.733177	6	3	8
8	1	8	70.325066	7	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage

Rescaled Distance Cluster Combine



TURTLES

These analyses consistently produced a cluster of strictly aquatic species, the snapping (Chelydra serpentina), painted (Chrysemys picta), and musk (Sternotherus odoratus) turtles. The terrestrial and semi-terrestrial turtles, spotted (Clemmys guttata), wood (Clemmys insculpta), and box (Terrapene carolina) did not cluster effectively or consistently. Although these species share some similarities, they are characterized by various ecological and distributional divergences. I noted that these species are more narrowly distributed and more ecologically specialized than strictly aquatic species. Therefore, the terrestrial and semi-terrestrial turtles may be expected to cluster with less effectiveness and reliability than their aquatic counterparts.

Two ecologically specialized species, the diamondback terrapin (Malaclemys terrapin) and the bog turtle (Clemmys muhlenbergii) were consistent outliers in cluster analysis. Also noteworthy was the inability of the widespread spotted turtle to cluster with either aquatic or terrestrial groups. I observed spotted turtles inhabiting ephemeral and shallow water microhabitats rarely utilized by other turtles. Therefore, although found in a wide variety of wetlands, within these areas spotted turtles inhabit a very narrow and often exclusive zone characterized by shallow water and thick vegetation dominated by herbaceous plants and shrubs.

Figure 5

Turtle Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	1	2	2.643529	0	0	2
2	1	8	3.350909	1	0	3
3	1	4	8.984920	2	0	4
4	1	7	9.844483	3	0	5
5	1	3	14.302464	4	0	6
6	1	6	23.025820	5	0	7
7	1	5	36.813339	6	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

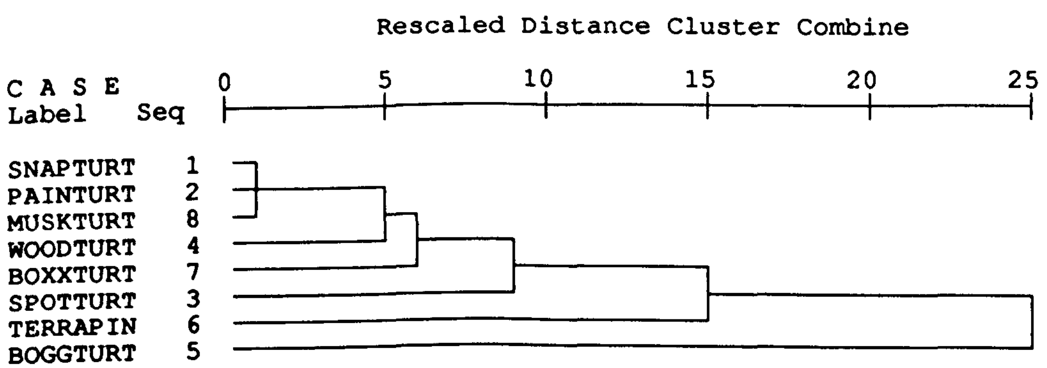


Figure 6

Turtle Dendrogram/Complete Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

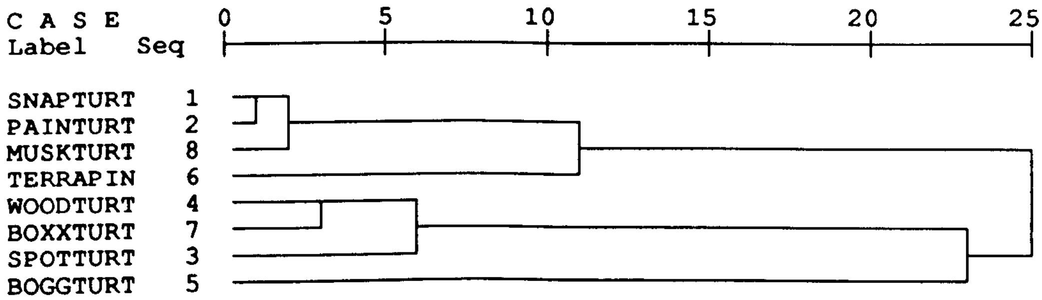
Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	1	2	2.643529	0	0	2
2	1	8	7.539812	1	0	5
3	4	7	9.844483	0	0	4
4	3	4	18.675232	0	3	6
5	1	6	35.166870	2	0	7
6	3	5	71.915047	4	0	7
7	1	3	79.258224	5	6	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage

Rescaled Distance Cluster Combine



SNAKES

Cluster analysis was not particularly useful in grouping snakes as it provided varied cluster solutions depending upon method and measure. Given these varied results one can assume that the program was calculating many spurious clusters, especially when one examines the overall high similarity coefficients, i.e. high levels of dissimilarity between species, in these snake comparisons vis a vis the salamander, frog, and turtle comparisons.

Although several species of snakes are limited by elevation, soils, and hydrology, as a group I found them to be the most widespread. I found most species microsympatrically with one another at some time during my field work. The only consistent clusters were two pairs of species. The first cluster was comprised of milk (Lampropeltis triangulum) and garter (Thamnophis sirtalis) snakes and the second cluster of ringneck (Diadophis punctatus edwardsi) and black rat (Elaphe obsoleta) snakes. Both these groups were paired in the initial stages of each analysis. I found milk and garter snakes to be widespread, ecologically tolerant species which were often found microsympatrically. Ringneck and black rat snakes frequently occur on the same wooded, rocky, talus slopes. I noted that they were the only two snakes which show a decided preference for forested habitats. Not surprisingly, the following rare and ecologically restricted species were outliers, too dissimilar to effectively cluster: copperhead, timber rattlesnake, and five-lined skink.

I was surprised by these results as I had expected at very least a cluster of snakes to be formed comprising those found in sandy soiled, open, low elevation habitats such as worm (Carphophis amoenus) and hognosed snakes (Heterodon platyrhinos), as well as additional clusters based on elevation, vegetation, and disturbance. Although certain species may show affinities for certain areas and habitats, based on these analyses these relationships are too inconsistent to effectively produce clusters of snake species.

Figure 7

Snake Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Clusters Combined Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Stage Cluster 1st Appears Cluster 2	Next Stage
1	7	13	4.465795	0	0	2
2	5	7	6.437727	0	1	3
3	4	5	6.579037	0	2	4
4	2	4	7.266183	0	3	5
5	2	9	7.682496	4	0	6
6	2	3	7.958121	5	0	7
7	2	6	9.076451	6	0	8
8	2	12	9.141778	7	0	9
9	2	10	11.063308	8	0	10
10	2	11	12.308532	9	0	11
11	2	8	12.718369	10	0	12
12	2	14	21.096506	11	0	13
13	1	2	29.861069	0	12	14
14	1	15	36.741837	13	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

Rescaled Distance Cluster Combine

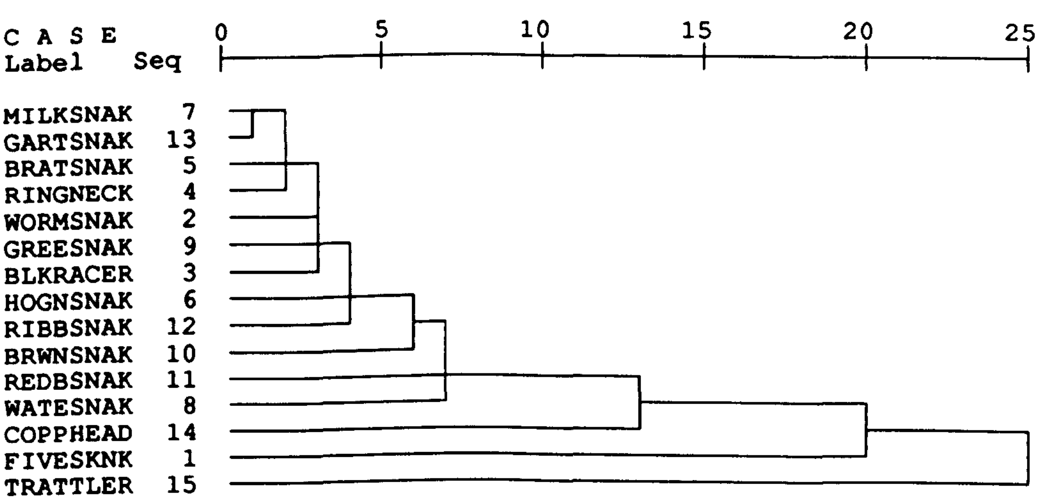


Figure 8

Snake Dendrogram/Complete Linkage

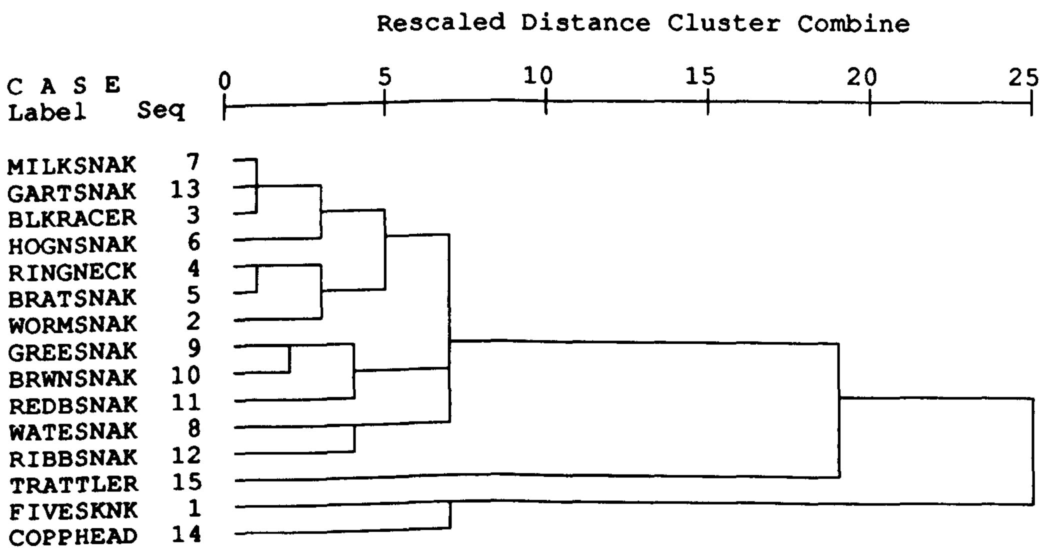
* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	7	13	4.465795	0	0	3
2	4	5	6.579037	0	0	6
3	3	7	8.310219	0	1	5
4	9	10	11.063308	0	0	8
5	3	6	14.058609	3	0	9
6	2	4	14.815051	0	2	9
7	8	12	16.778429	0	0	12
8	9	11	18.014351	4	0	10
9	2	3	22.698906	6	5	10
10	2	9	28.799557	9	8	12
11	1	14	29.861069	0	0	14
12	2	8	32.032925	10	7	13
13	2	15	77.250229	12	0	14
14	1	2	104.481628	11	13	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage



AMPHIBIANS

These analysis consistently yielded three species clusters. A cluster of pond and marsh frogs (bull, green and pickerel), a cluster of common stream salamanders (dusky and two-lined) and a cluster of early spring breeding amphibians favoring wooded, swamp habitats (spotted and blue spotted salamanders, spring peeper). A fourth cluster is formed in four of the six analyses consisting of red spotted newt (Notophthalmus viridescens), american toad, and marbled salamander representing terrestrial woodland species with a wide tolerance of xeric conditions.

Wood frog and red-backed salamander tended to form clusters with either the early spring breeding amphibians (spotted and blue spotted salamanders, spring peeper) or the terrestrial cluster (red spotted newt, american toad, and marbled salamander), although in one analysis red-backed salamander is treated as an outlier.

The following species are too dissimilar to be effectively clustered: Jefferson's, spring, four-toed, and slimy salamanders, as well as Fowler's toad, gray tree frog, and leopard frog. With the exception of gray tree frog, these species were not clustered in the comparisons (see previous discussions) of salamanders or frogs.

Figure 9

Amphibian Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	16	18	.732411	0	0	2
2	16	17	.851863	1	0	7
3	3	14	.994906	0	0	6
4	5	6	1.015317	0	0	13
5	11	12	2.673145	0	0	7
6	2	3	3.444989	0	3	10
7	11	16	3.768802	5	2	9
8	9	20	3.843945	0	0	10
9	4	11	3.888870	0	7	11
10	2	9	3.929528	6	8	11
11	2	4	6.247794	10	9	12
12	2	15	8.407375	11	0	13
13	2	5	11.061041	12	4	14
14	1	2	11.947707	0	13	15
15	1	8	11.987685	14	0	16
16	1	13	12.576624	15	0	17
17	1	7	18.349869	16	0	18
18	1	10	21.092348	17	0	19
19	1	19	27.844753	18	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

Rescaled Distance Cluster Combine

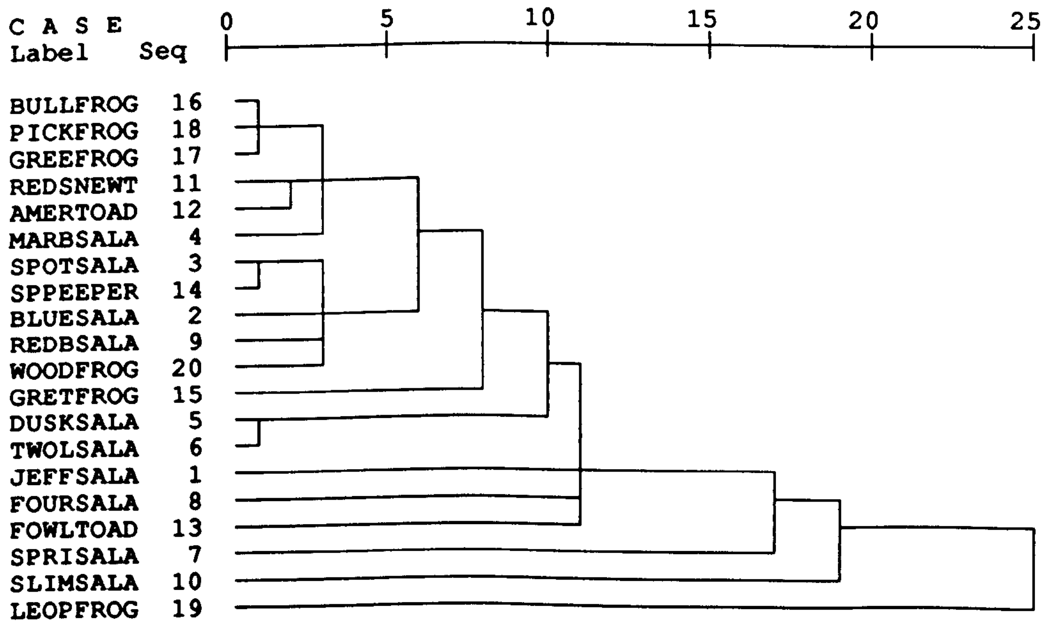


Figure 10

Amphibian Dendrogram/Complete Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

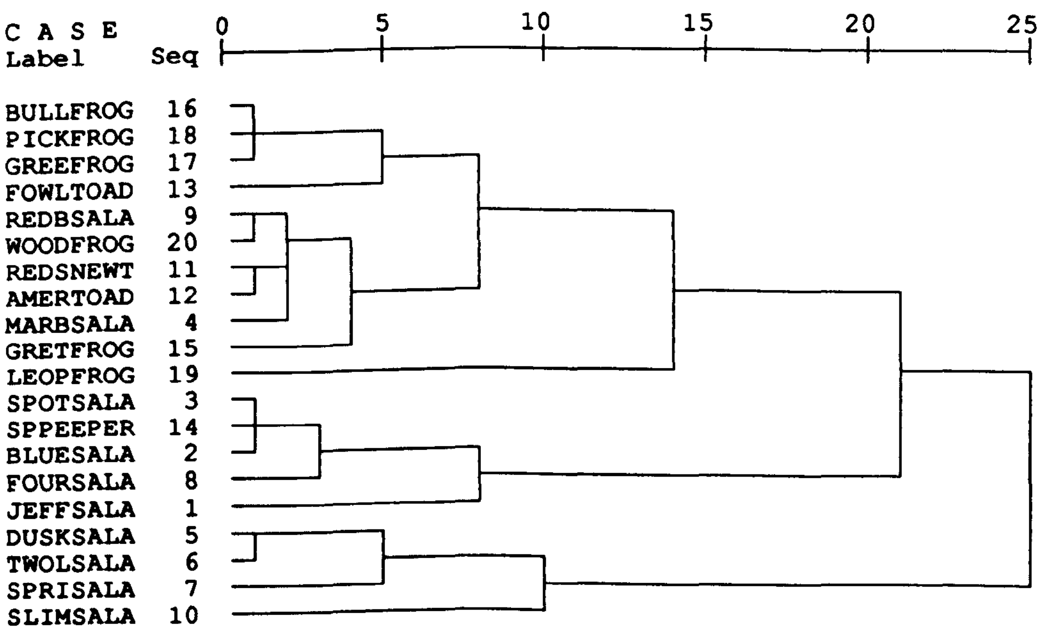
Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	16	18	.732411	0	0	4
2	3	14	.994906	0	0	7
3	5	6	1.015317	0	0	13
4	16	17	1.347978	1	0	12
5	11	12	2.673145	0	0	8
6	9	20	3.843945	0	0	9
7	2	3	4.590954	0	2	10
8	4	11	5.992302	0	5	9
9	4	9	8.222718	8	6	11
10	2	8	12.939281	7	0	14
11	4	15	14.527733	9	0	15
12	13	16	18.356354	0	4	15
13	5	7	19.303320	3	0	16
14	1	2	31.556789	0	10	18
15	4	13	35.216125	11	12	17
16	5	10	43.006176	13	0	19
17	4	19	59.220413	15	0	18
18	1	4	89.576797	14	17	19
19	1	5	108.805183	18	16	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage

Rescaled Distance Cluster Combine



REPTILES

These analyses produced two consistent clusters. The first was a grouping of generalized aquatic species including snapping, painted, and musk turtles as well as water snake (Nerodia sipedon). The second cluster was a wet meadow and shrub swamp grouping consisting of ribbon snake (Thamnophis sauritus) and spotted turtle with a later entry of box turtle into the cluster. Although preferring drier habitats, the box turtle was probably included as many of its vegetational, topographical, surficial geology, and elevational parameters are similar to the ribbon snake and spotted turtle.

Species too dissimilar to form clusters are consistent with previous analyses and include bog turtle, diamondback terrapin, timber rattlesnake, copperhead, and five-lined skink. The remaining species are all snakes (with the exception of the wood turtle) which clustered in many different combinations. This is not unexpected as snakes were the only order analyzed which did not cluster well. The two small clusters (couplets) of milk and garter snakes, as well as ringneck and black rat snakes are consistently carried over from the snake analyses into the reptile analyses.

Figure 11

Reptile Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	1	16	2.029125	0	0	2
2	1	2	2.538193	1	0	3
3	1	8	2.538435	2	0	10
4	15	21	3.795746	0	0	5
5	4	15	4.416720	0	4	7
6	3	20	4.567894	0	0	11
7	4	13	5.373751	5	0	8
8	4	12	5.991134	7	0	9
9	4	10	6.345337	8	0	10
10	1	4	6.540456	3	9	11
11	1	3	6.693404	10	6	12
12	1	11	6.816414	11	0	13
13	1	17	7.027732	12	0	14
14	1	14	7.329367	13	0	15
15	1	7	7.384372	14	0	16
16	1	19	10.139566	15	0	17
17	1	18	10.161592	16	0	18
18	1	22	18.347313	17	0	19
19	1	6	21.352583	18	0	20
20	1	9	25.902210	19	0	21
21	1	23	39.046093	20	0	22
22	1	5	39.612804	21	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

Rescaled Distance Cluster Combine

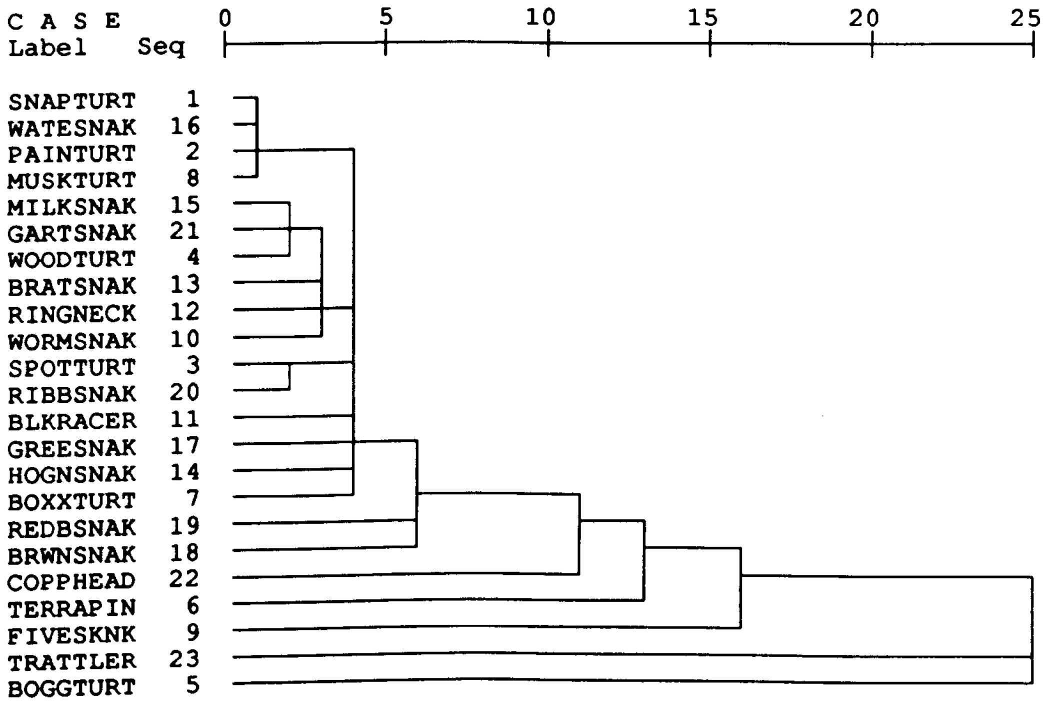


Figure 12

Reptile Dendrogram/Complete Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

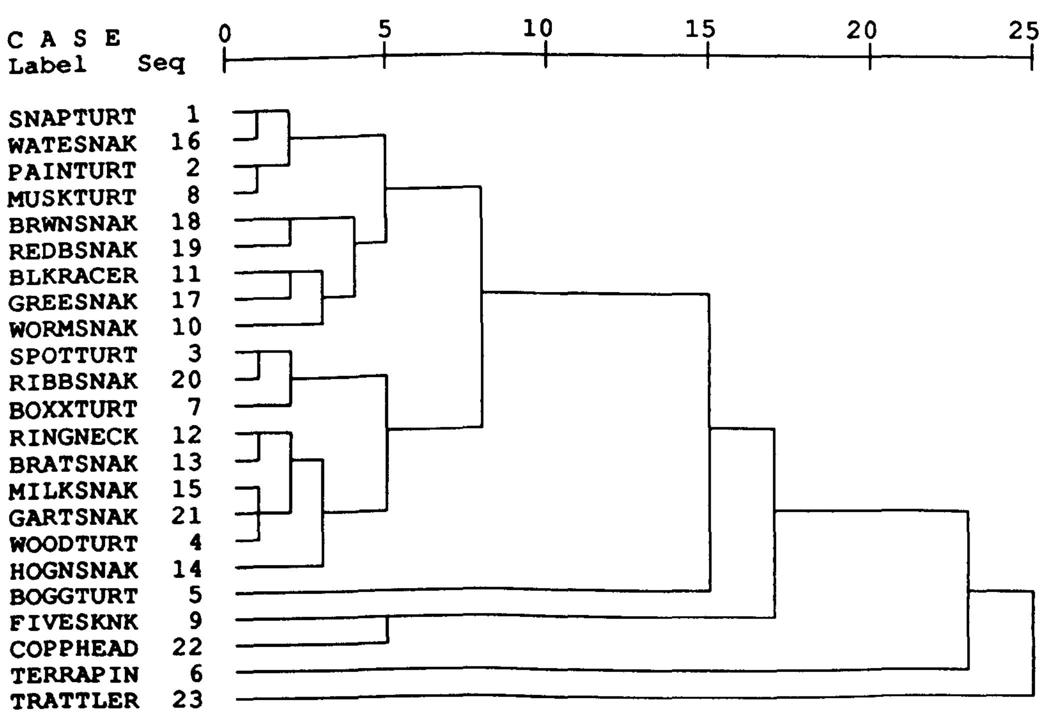
Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	1	16	2.029125	0	0	7
2	2	8	2.538435	0	0	7
3	15	21	3.795746	0	0	6
4	3	20	4.567894	0	0	10
5	12	13	5.991134	0	0	9
6	4	15	6.503624	0	3	9
7	1	2	7.677828	1	2	17
8	11	17	8.386811	0	0	12
9	4	12	8.915398	6	5	13
10	3	7	10.122519	4	0	15
11	18	19	11.475192	0	0	14
12	10	11	12.756186	0	8	14
13	4	14	16.321957	9	0	15
14	10	18	19.863592	12	11	17
15	3	4	24.406460	10	13	18
16	9	22	25.902210	0	0	20
17	1	10	27.126387	7	14	18
18	1	3	38.006702	17	15	19
19	1	5	74.422882	18	0	20
20	1	9	87.760910	19	16	21
21	1	6	117.262939	20	0	22
22	1	23	130.404068	21	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage

Rescaled Distance Cluster Combine



AMPHIBIANS AND REPTILES

In summary, the comparisons utilizing all species were unsatisfactory, providing little additional information which had not been discerned in the comparisons within class or order clusters. One cluster consistently transcends these two classes comprised of pond, river, and reservoir species including bull, green, and pickerel frogs, as well as snapping, painted, and musk turtles, and water snake. This cluster was fairly consistent, absent only from the comparisons using complete linkage.

Figure 13

All Species Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	16	18	.681523	0	0	2
2	16	17	.749524	1	0	7
3	3	14	.823346	0	0	15
4	5	6	.987793	0	0	33
5	21	22	1.748878	0	0	6
6	21	36	1.852502	5	0	7
7	16	21	1.924202	2	6	8
8	16	28	2.406458	7	0	14
9	11	12	2.531173	0	0	11
10	35	41	3.033249	0	0	13
11	11	32	3.260636	9	0	12
12	4	11	3.280066	0	11	14
13	24	35	3.398951	0	10	17
14	4	16	3.646492	12	8	18
15	2	3	3.679735	0	3	21
16	9	20	3.917527	0	0	21
17	24	30	3.990256	13	0	19
18	4	33	4.001772	14	0	19
19	4	24	4.174014	18	17	22
20	23	40	4.269786	0	0	23
21	2	9	4.402661	15	16	24
22	4	37	4.416350	19	0	23
23	4	23	5.011876	22	20	24
24	2	4	5.654227	21	23	25
25	2	31	5.853569	24	0	26
26	2	27	6.351602	25	0	27
27	2	34	6.416238	26	0	28
28	2	38	7.397750	27	0	29
29	2	15	7.923315	28	0	30
30	2	39	8.928341	29	0	31
31	2	13	10.096839	30	0	32
32	2	8	10.231067	31	0	33
33	2	5	10.966782	32	4	34
34	1	2	12.643250	0	33	36
35	19	25	15.836607	0	0	38
36	1	7	15.890798	34	0	37
37	1	26	16.295547	36	0	38
38	1	19	17.687122	37	35	39
39	1	42	18.497091	38	0	40
40	1	29	20.551048	39	0	41
41	1	10	20.928970	40	0	42
42	1	43	21.431332	41	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

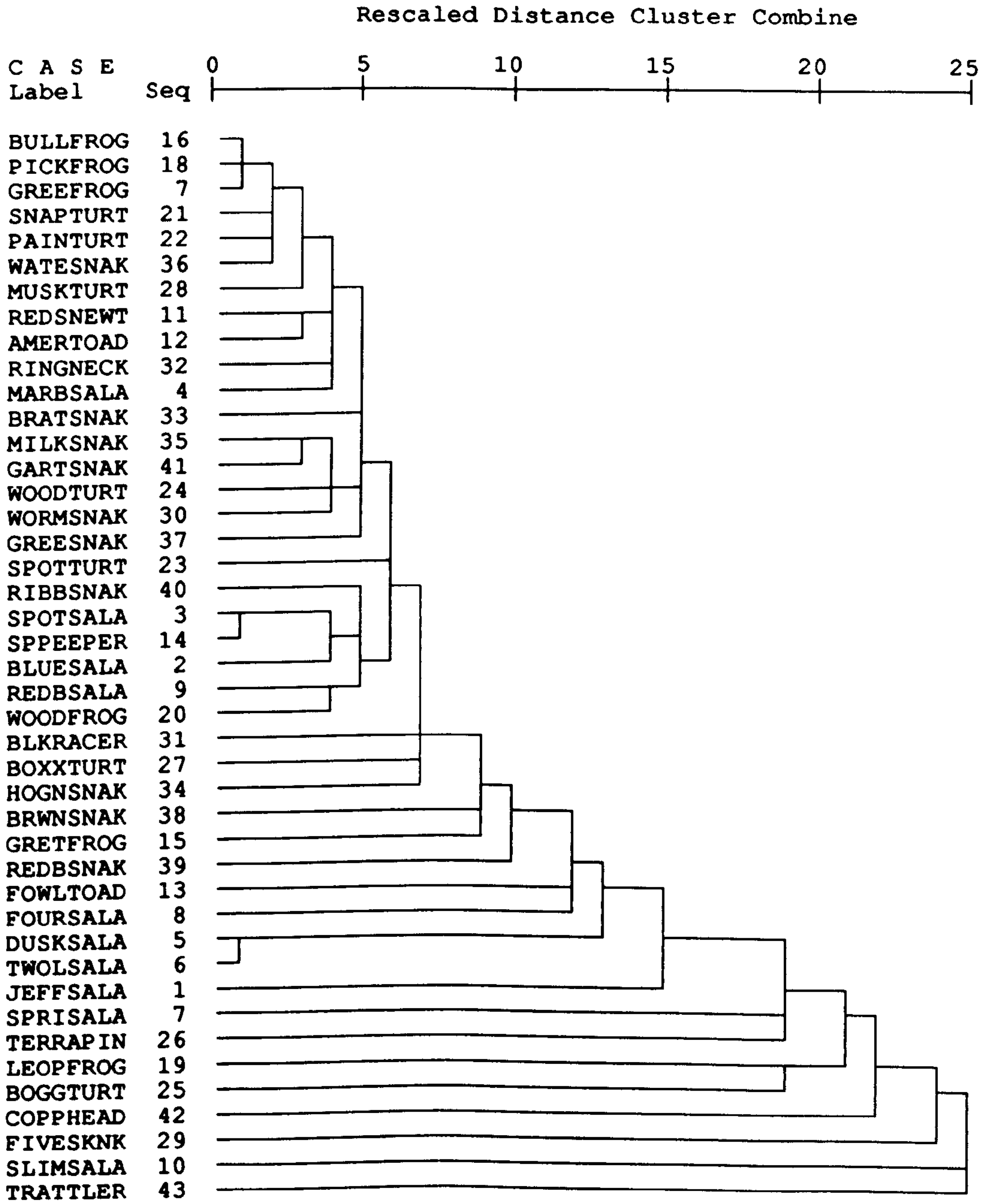


Figure 14

All Species Dendrogram/Complete Linkage

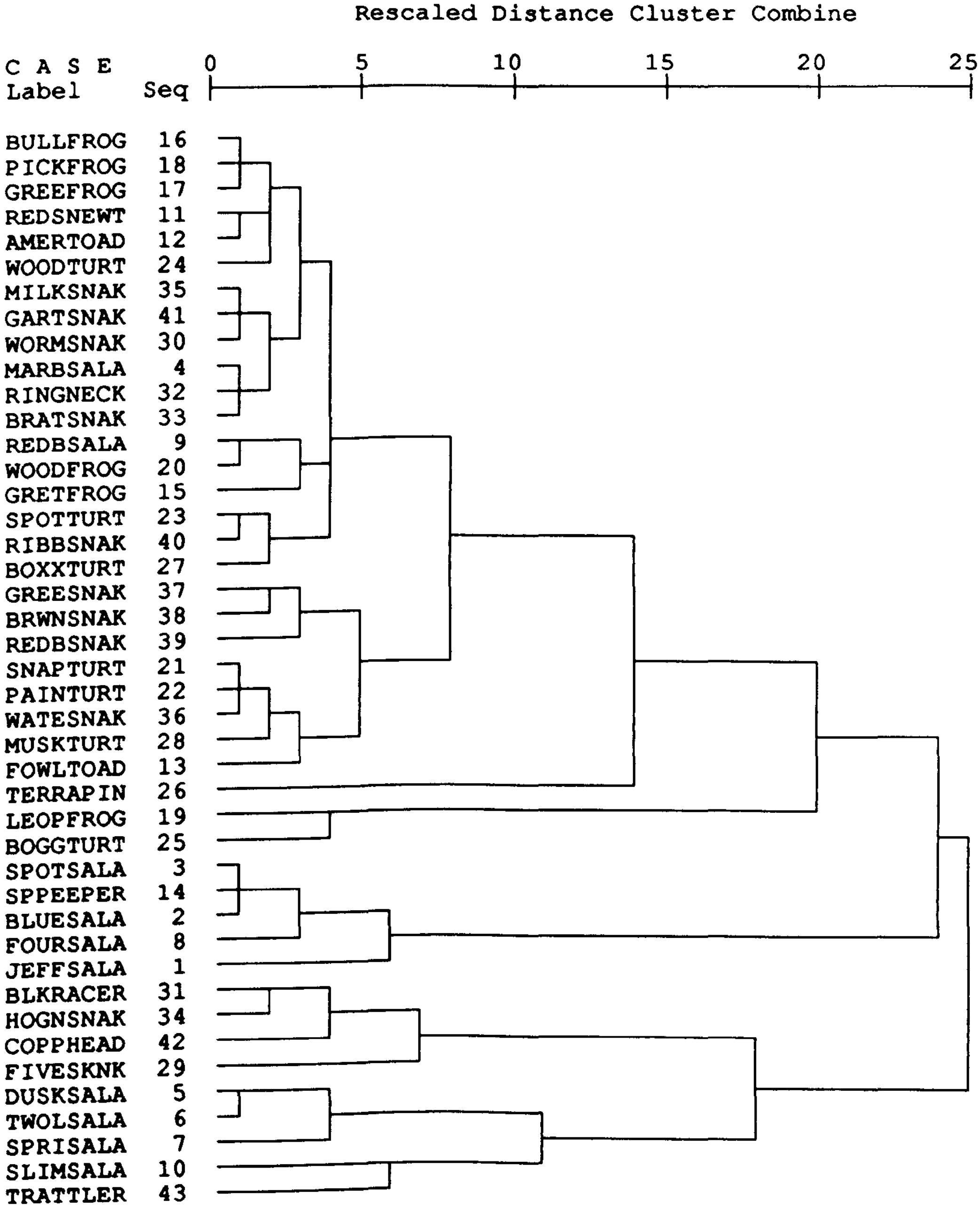
* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	16	18	.681523	0	0	4
2	3	14	.823346	0	0	12
3	5	6	.987793	0	0	28
4	16	17	1.146165	1	0	19
5	21	22	1.748878	0	0	6
6	21	36	2.082781	5	0	16
7	11	12	2.531173	0	0	15
8	35	41	3.033249	0	0	13
9	4	32	3.788424	0	0	14
10	9	20	3.917527	0	0	25
11	23	40	4.269786	0	0	21
12	2	3	4.838995	0	2	22
13	30	35	5.335020	0	8	20
14	4	33	5.484182	9	0	20
15	11	24	6.017139	7	0	19
16	21	28	6.129589	6	0	26
17	31	34	6.416238	0	0	31
18	37	38	7.397750	0	0	23
19	11	16	7.445836	15	4	24
20	4	30	8.507977	14	13	24
21	23	27	8.708261	11	0	30
22	2	8	11.413556	12	0	34
23	37	39	11.953869	18	0	32
24	4	11	12.290091	20	19	29
25	9	15	13.958139	10	0	29
26	13	21	14.485396	0	16	32
27	19	25	15.836607	0	0	40
28	5	7	16.951571	3	0	37
29	4	9	17.461899	24	25	30
30	4	23	18.126572	29	21	36
31	31	42	19.473917	17	0	35
32	13	37	22.843676	26	23	36
33	10	43	27.644228	0	0	37
34	1	2	29.093616	0	22	41
35	29	31	32.319408	0	31	39
36	4	13	39.868168	30	32	38
37	5	10	55.808319	28	33	39
38	4	26	69.678963	36	0	40
39	5	29	86.546684	37	35	42
40	4	19	96.599876	38	27	41
41	1	4	119.729782	34	40	42
42	1	5	125.975868	41	39	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage



SALAMANDERS, FROGS, AND TURTLES

In the previous analysis snakes appeared to complicate interpretation of the results by physically cluttering the dendrograms, making visual interpretation of the clusters difficult, while adding little consistent information. This is not surprising as when snakes were compared alone they failed to consistently cluster. By removing snakes from the following analyses I attempted to improve the visual resolution of the dendrograms comparing the other three orders.

These comparisons essentially show the same relationships illustrated in the comparisons utilizing all species. The interpretation of the dendrograms is greatly facilitated by the deletion of the snakes.

Figure 15

Salamander, Frog, and Turtle Dendrogram/Single Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Agglomeration Schedule using Single Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	16	18	.662998	0	0	2
2	16	17	.737460	1	0	8
3	3	14	.739024	0	0	12
4	5	6	.955530	0	0	21
5	21	22	1.635946	0	0	6
6	21	28	2.351807	5	0	8
7	11	12	2.472993	0	0	9
8	16	21	2.475245	2	6	10
9	4	11	3.068988	0	7	10
10	4	16	3.436589	9	8	14
11	9	20	3.579821	0	0	13
12	2	3	3.590135	0	3	13
13	2	9	4.012935	12	11	15
14	4	24	4.733232	10	0	15
15	2	4	5.284263	13	14	16
16	2	23	5.837906	15	0	17
17	2	15	7.240083	16	0	18
18	2	27	7.445759	17	0	19
19	2	8	9.633090	18	0	20
20	2	13	9.871824	19	0	21
21	2	5	11.053611	20	4	22
22	1	2	12.009951	0	21	23
23	1	7	14.962449	22	0	24
24	1	26	15.239968	23	0	26
25	19	25	16.401382	0	0	26
26	1	19	17.316401	24	25	27
27	1	10	20.012657	26	0	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Single Linkage

Rescaled Distance Cluster Combine

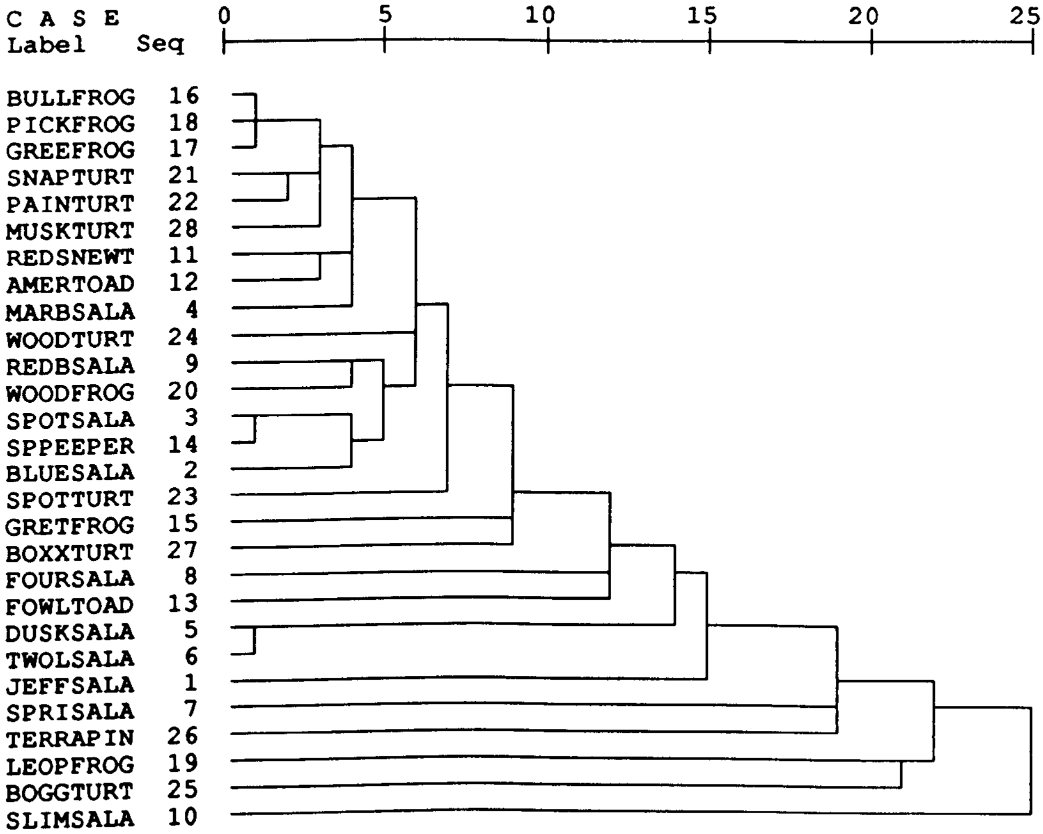


Figure 16

Salamander, Frog, and Turtle Dendrogram/Complete Linkage

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

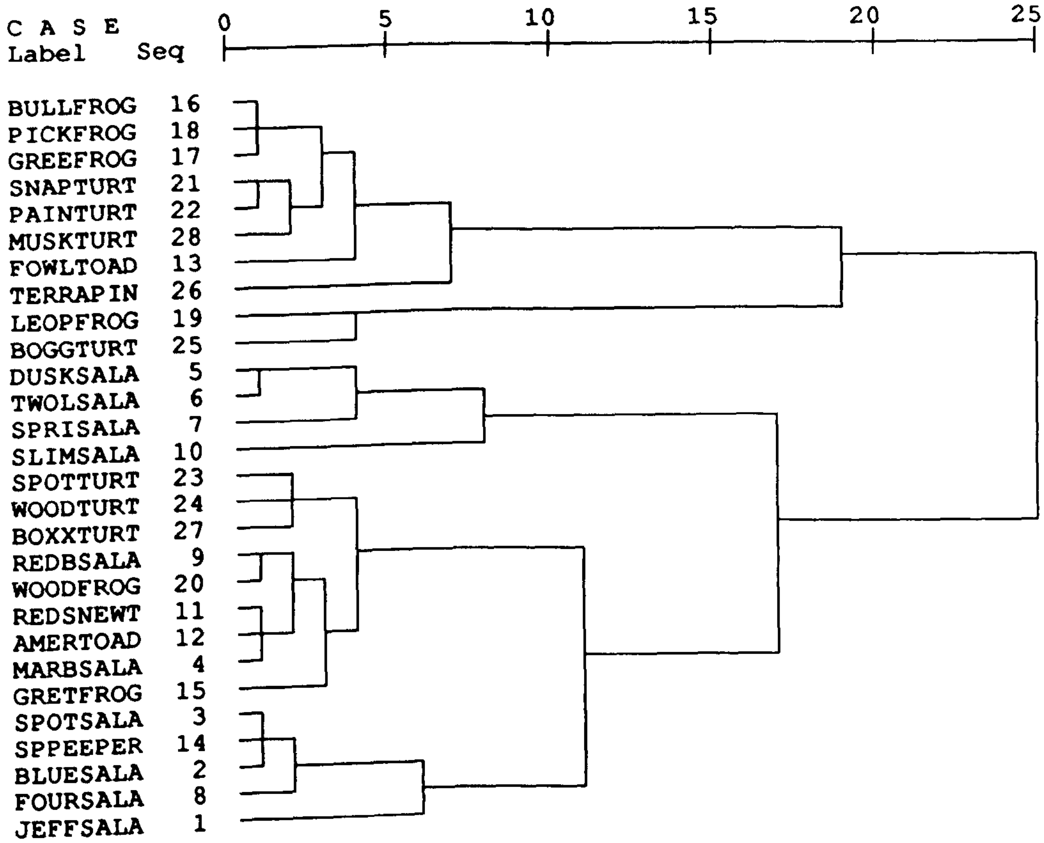
Agglomeration Schedule using Complete Linkage

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Cluster 2	Next Stage
1	16	18	.662998	0	0	4
2	3	14	.739024	0	0	8
3	5	6	.955530	0	0	17
4	16	17	1.099365	1	0	15
5	21	22	1.635946	0	0	10
6	11	12	2.472993	0	0	9
7	9	20	3.579821	0	0	12
8	2	3	4.598456	0	2	14
9	4	11	4.763571	0	6	12
10	21	28	5.795763	5	0	15
11	23	24	5.837906	0	0	13
12	4	9	6.969161	9	7	16
13	23	27	8.578882	11	0	20
14	2	8	10.509089	8	0	21
15	16	21	10.581000	4	10	18
16	4	15	12.993493	12	0	20
17	5	7	15.811814	3	0	23
18	13	16	15.884081	0	15	22
19	19	25	16.401382	0	0	26
20	4	23	16.836155	16	13	24
21	1	2	27.313667	0	14	24
22	13	26	34.281738	18	0	26
23	5	10	38.702118	17	0	25
24	1	4	51.070950	21	20	25
25	1	5	84.422127	24	23	27
26	13	19	93.468185	22	19	27
27	1	13	124.155853	25	26	0

* * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Complete Linkage

Rescaled Distance Cluster Combine



In conclusion, cluster analysis produced 13 clusters with enough consistency to be considered groupings reflecting actual ecological relationships as opposed to spurious clusters generated by the computer program. These are summarized in tables one through three. The bulk of these clusters occurred within the ordinal comparisons, comparatively few clusters transcended orders, and only one cluster transcended classes. Not surprisingly, species at the ordinal level usually have more ecological commonality with each other than with species from other orders or classes.

TABLE 1

Consistently Formed Species Clusters Within Orders

CAUDATA

1. Blue spotted salamander (Ambystoma laterale), spotted salamander (Ambystoma maculatum).

2. Marbled salamander (Ambystoma opacum), red-backed salamander (Plethodon cinereus).

3. Dusky salamander (Desmognathus fuscus), two-lined salamander (Eurycea bislineata).

ANURA

4. Bull frog (Rana catesbeiana), green frog (Rana clamitans), pickerel frog (Rana palustris).

5. Spring peeper (Hyla crucifer), wood frog (Rana sylvatica).

TESTUDINATA

6. Snapping turtle (Chelydra serpentina), painted turtle (Chrysemys picta), musk turtle (Sternotherus odoratus).

SQUAMATA

7. Milk snake (Lampropeltis triangulum), garter snake (Thamnophis sirtalis).

8. Ringneck snake (Diadophis punctatus edwardsi),black rat snake (Elaphe obsoleta).

TABLE 2

Consistently Formed Species Clusters Within Classes

AMPHIBIA

1. Blue spotted salamander (Ambystoma laterale), spotted salamander (Ambystoma maculatum), spring peeper (Hyla crucifer).

2. Marbled salamander (Ambystoma opacum), red spotted newt (Notophthalmus viridescens), american toad (Bufo americanus).

REPTILIA

3. Snapping turtle (Chelydra serpentina), painted turtle (Chrysemys picta), musk turtle (Sternotherus odoratus), water snake (Nerodia sipedon).

4. Spotted turtle (Clemmys guttata), box turtle (Terrapene carolina), ribbon snake (Thamnophis sauritus).

TABLE 3

Consistently Formed Species Clusters Between Classes

1. Bull frog (Rana catesbeiana), green frog (Rana clamitans, pickerel frog (Rana palustris), snapping turtle (Chelydra serpentina), painted turtle (Chrysemys picta), musk turtle (Sternotherus odoratus), water snake (Nerodia sipedon).

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EPILOGUE

I have demonstrated that the distributions, variations, and abundances of the amphibians and reptiles of southwestern New England are governed by a wide variety of factors. The morphological, life history, and ecological parameters of many species differ when compared to published reports from other sections of North America. A number of species generally considered to be rare, are in reality widespread, albeit secretive. Conversely, several species regarded as widespread have drastically declined or have more restricted ranges than previously thought. A few species are in need of immediate conservation attention if they are to remain part of the region's biota.

Unfortunately, many of the reproductive data samples are too small to be statistically significant. Although some of these may indicate noteworthy trends, a considerable amount of field work is needed to further develop these data. Two frailties of this study are directly attributable to its evolution. Although originally intended as a descriptive herpetology of a single state (Connecticut), in 1984 the geographic scope of my study area was doubled to include an entire zoogeographical region (southwestern New England). Because I had been studying Connecticut since 1975, this area was more extensively sampled than any other part of southwestern New England. Although the species accounts were generally not affected by this sampling bias, I was unable to resolve the peripheral range limits of several species due to insufficient data.

In 1986, my study was altered once again, from a narrative discussion to an analytical treatment of the herpetofauna of southwestern New England. The conversion of a large body of descriptive data into a numerical data matrix created some problems. Although I strove for consistency in the conversion of these data, I was limited both by the variables I could extract from my notes, and by having to construct categorical values for most of the variables. Large amounts of missing data created additional problems which are discussed in the various statistical analyses. If I had collected measurement data in the field, I would have been able to include additional parameters such as water pH, humidity, and barometric pressure. I may also have been able to address vegetational differences more precisely. However, if I had collected in depth measurement data at each of my several thousand collecting stations, I would have been unable to cover the entire southwestern New England region during the fifteen year study period.

In summary, this study has accumulated the first large regionally-specific data set on the distributions, ecology, and life histories of New England's amphibians and reptiles. The northeastern states, which include New England, have lagged behind the rest of the United States in the production of contemporary, comprehensive studies on the distribution and ecology of their local herpetofaunas. The information contained in such studies is urgently needed to augment conservation and land preservation efforts. Decisions regarding habitat acquisition and species management should be made on a scientific basis, which can be provided by long term, detailed studies. Hopefully, this monograph is only the first in a series of detailed studies concerning the distribution and ecology of the herpetofauna of the northeastern United States.

APPENDIX I

PRINCIPAL COMPONENTS ANALYSIS

JEFFERSON'S SALAMANDER (Ambystoma jeffersonianum)

Jefferson's salamander PCA produced negative eigenvalues when all 16 variables were analyzed. By removing the tree/canopy pair with a correlation of .96, negative eigenvalues were eliminated. The remaining 14 variables produced three low variance components.

Factor 14 (0.0 variance): -.04 hishrub, .04 lowshrub

Factor 13 (0.2): .10 hydric, -.06 hishrub, -.05 topogr,
-.05 surfgeo, .05 grndcov, .04 disturb

Factor 12 (0.9): .15 lowshrub, -.15 time, .14 grndcov

Elimination of the next most highly correlated variable pair, low/hishrub (.76), yielded one low variance component.

Factor 12 (0.3): .11 hydric, -.08 surfgeo, .08 grndcov

Elimination of the next most highly correlated variable pair, hydric/disturb (-.69), yielded no additional low variance components.

BLUE SPOTTED SALAMANDER (Ambystoma laterale)

Blue spotted salamander PCA produced negative eigenvalues when all 16 variables were analyzed. By removing the two most highly correlated variable pairs, tree/canopy (.91) and airtemp/month (.678), negative eigenvalues were eliminated. The resulting 12 variable PCA comparison produced a single low variance last component.

Factor 12 (0.2): produced a continuous list of 10 variables from -.07 to .01 without any break in numbers to subdivide this component into subgroups. Elev and surfgeo formed a low scoring pair of -.002 and .006 respectively.

Elimination of the next most highly correlated variable pair, weather/time (.677), yielded one additional factor.

Factor 10 (0.4): -.10 herb, .10 bedgeo

Additional variable elimination of herb/bedgeo (.65) produced components in excess of 1.0 variance.

SPOTTED SALAMANDER (Ambystoma maculatum)

A PCA comparison of 16 variables produced a single low variance component.

Factor 16 (0.4): -.17 tree, .17 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.90), yielded components in excess of 1.0.

MARBLED SALAMANDER (Ambystoma opacum)

The initial PCA of 16 variables produced three low variance last component scores.

Factor 16 (0.2): .13 tree, -.10 canopy

Factor 15 (0.4): -.12 herb, .09 canopy, .08 grndcov,
.076 topogr, -.074 elev

Factor 16 (0.9): .15 hydric, .14 herb

Elimination of the most highly correlated variable pair, tree/canopy (.91), yielded one low variance component.

Factor 14 (0.6): -.116 hydric, -.113 topogr, .110 herb,
-.10 grndcov, .09 elev, -.08 month, .07 bedgeo

Elimination of the next mostly highly correlated variable herb, tree/HERB (.81) and canopy/HERB (.78), yielded one additional low variance component.

Factor 13 (0.9): .146 hydric, .142 month, .140 topogr,

-.13 bedgeo, -.12 elev

Elimination of the next highly correlated variable hydric, herb/HYDRIC (.77) and canopy/HYDRIC (.67), yielded no additional low variance components.

DUSKY SALAMANDER (Desmognathus f. fuscus)

TWO LINED SALAMANDER (Eurycea b. bislineata)

These two widespread stream salamanders have identical PCA results. This was disappointing as I was hoping to find interspecific variable differences between these species. Although microsympatric in many streams I found many sites where only one of these species was found.

Desmognathus f. fuscus

Factor 16 (0.2): .13 canopy, -.12 tree

Elimination of the most highly correlated variable pair, tree/canopy (.89), yielded no additional low variance components.

Eurycea b. bislineata

Factor 16 (0.5): -.20 tree, .18 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.85), yielded no additional low variance components.

FOUR TOED SALAMANDER (Hemidactylium scutatum)

I was unable to eliminate negative eigenvalues from this data set. These negative eigenvalues resulted from an inability to calculate Spearman correlation coefficients for several variable pairs.

RED SPOTTED NEWT (Notophthalmus v. viridescens)

Adult (aquatic stage)

A 16 variable PCA comparison of the newt's aquatic stages yielded two low variance components.

Factor 16 (0.3): -.14 tree, .13 canopy

Factor 15 (0.5): .15 grndcov, .12 airtemp

Elimination of the most highly correlated variable pair, tree/canopy (.91), yielded one low variance component.

Factor 14 (0.8): .17 grndcov, .14 airtemp, -.14 herb

Elimination of the next most highly correlated variable pair, herb/grndcov (.67), yielded no additional low variance components.

Eft (terrestrial stage)

The presence of the newt's terrestrial stage is influenced by a last component equation of tree minus canopy. No other low variance components were extracted utilizing PCA.

Factor 16 (0.2): .128 tree, -.121 canopy

RED BACKED SALAMANDER (Plethodon c. cinereus)

This salamander produced only one low variance PCA component.

Factor 16 (0.4): -.18 tree, .16 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.89), yielded no additional low variance components.

AMERICAN TOAD (<u>Bufo</u> <u>a</u>. <u>americanus</u>)

PCA analysis of all 16 variables produced one low variance component.

Factor 16 (0.3): .16 tree, -.15 canopy

Deletion of the most highly correlated variable pair, tree/canopy (.94), yielded no additional low variance components.

FOWLER'S TOAD (<u>Bufo</u> <u>woodhousii</u> <u>fowleri</u>)

PCA analysis of all 16 variables produced four low variance components.

Factor 16 (0.2): .089 airtemp, .080 month, .06 weather

Factor 15 (0.3): .15 tree, -.11 canopy

Factor 14 (0.4): -.17 grndcov, .15 herb

Factor 13 (0.9): .21 canopy, .16 surfgeo

Deletion of the most highly correlated variable pair, tree/canopy (.90), produced two low variance components.

Factor 14 (0.2): .10 month, .09 weather, .08 airtemp

Factor 13 (0.4): -.169 grndcov, .164 herb

Deletion of the next most highly correlated variable pair, herb/grndcov (.88), yielded one low variance component.

Factor 12 (0.3): .10 month, .09 weather, .08 airtemp

Deletion of the next most highly correlated variable pair, low/hishrub (.74), yielded one low variance component.

Factor 10 (0.4): .108 month, .104 weather, .09 airtemp

Deletion of the next most highly correlated variable pair, disturb/topogr (-.61), yielded one low variance component.

Factor 8 (0.6): .13 weather, .12 month, .09 airtemp

Deletion of the next most highly correlated variable airtemp, canopy/AIRTEMP (.53), yielded no additional low variance

components.

Upon examination of the components, I noted the last three extractions added little new information, always producing equations of month, weather, and air temperature. In the last extraction, air temperature's score declined in contrast to month and weather. To explore the effects of other variables in this formula, month, weather, and airtemp were removed in the first deletion, negating their effects on subsequent components.

Factor 13 (0.4): -.13 tree, .11 canopy

Factor 14 (0.5): -.16 grndcov, .14 herb

Deletion of tree/canopy yielded one low variance component.

Factor 11 (0.6): -.17 grndcov, .16 herb

No additional low variance components could be extracted by the subsequent deletion of herb/grndcov.

SPRING PEEPER (Hyla c. crucifer)

PCA analysis of all 16 variables produced one low variance component score.

Factor 16 (0.5): .19 canopy, -.18 tree

Subsequent elimination of the most highly correlated variable pair, tree/canopy (.89), produced no additional low variance components.

GRAY TREE FROG (Hyla versicolor)

PCA analysis of all 16 variables produced negative eigenvalues. After examining the Spearman correlation coefficient matrix, air temperature was deleted eliminating negative eigenvalues. Four low variance components were produced.

Factor 15 (0.0): .05 tree, -.04 canopy

Factor 14 (0.2): .12 lowshrub, -.08 hishrub, .07 grndcov

Factor 13 (0.5): .12 bedgeo, .10 herb, -.095 tree
.090 grndcov, .08 time, .077 elev, .075 canopy

Factor 12 (0.7): .18 hydric, -.11 herb

Elimination of the most highly correlated variable pair, tree/canopy (.89), yielded three low variance components.

Factor 13 (0.3): -.13 lowshrub, .08 hishrub

Factor 12 (0.5): .12 bedgeo, .10 elev, .09 grndcov,
.08 time, .07 herb

Factor 11 (0.9): .16 grndcov, .14 hydric, .13 weather,
.124 disturb, .120 topogr

Elimination of the next most highly correlated variable pair, low/hishrub (.64), yielded one low variance component.

Factor 11 (0.6): .11 bedgeo, .10 grndcov, .096 elev,
.091 time, .085 herb

Elimination of the next most highly correlated variable pair, herb/time (-.61), did not yield any additional low variance components.

BULL FROG (Rana catesbeiana)

GREEN FROG (Rana clamitans melanota)

PICKEREL FROG (Rana palustris)

WOOD FROG (Rana sylvatica)

All four species show a single low variance relationship of tree/canopy in a 16 variable comparison. Removal of the most highly correlated variable pair, tree/canopy, produced no additional low variance components.

Rana catesbeiana

Factor 16 (0.2): .114 canopy, -.112 tree

Rana clamitans melanota

Factor 16 (0.4): .17 canopy, -.16 tree

Rana palustris

Factor 16 (0.4): -.176 canopy, .171 tree

Rana sylvatica

Factor 16 (0.4): -.18 tree .17 canopy

NORTHERN LEOPARD FROG (Rana pipiens)

PCA comparison of all 16 variables yielded negative eigenvalues. After examining the Spearman correlation coefficient matrix, air temperature was deleted eliminating negative eigenvalues. Three low variance components were produced.

Factor 15 (0.1): .07 elev, .06 bedgeo

Factor 14 (0.5): -.15 tree, .12 grndcov, .11 canopy,
.09 disturb

Factor 13 (0.8): .20 grndcov, .17 tree

Deletion of the most highly correlated variable pair, bedgeo/elev (-.94), yielded one low variance component.

Factor 13 (0.7): .16 grndcov, -.14 tree

Deletion of the next most highly correlated variable pair, tree/canopy (.81), yielded one low variance component.

Factor 11 (0.9): .23 grndcov, .15 disturb

Deletion of the next most highly correlated variable pair, grndcov/surfgeo, yielded no additional low variance components.

SNAPPING TURTLE (Chelydra s. serpentina)

PAINTED TURTLE (Chrysemys picta)

These two widely distributed aquatic turtles have identical PCA results.

Chelydra s. serpentina

Factor 16 (0.3): .148 canopy, -.141 tree

Elimination of tree/canopy (.92), yielded no additional low variance components.

Chrysemys picta

Factor 16 (0.4): .19 canopy, -.18 tree

Elimination of tree/canopy (.92), yielded no additional low variance components.

SPOTTED TURTLE (Clemmys guttata)

A PCA examination of 16 variables yielded two low variance components.

Factor 16 (0.2): .10 tree, -.08 canopy

Factor 15 (0.7): -.17 airtemp, -.12 tree

Elimination of the most highly correlated variable pair, tree/canopy (.92), yielded one low variance component.

Factor 14 (0.6): -.19 airtemp, .12 month

Elimination of the next most highly correlated variable pair, month/airtemp (.62), yielded no additional low variance

components.

WOOD TURTLE (Clemmys insculpta)

PCA analysis of 16 variables produced three low variance components.

Factor 16 (0.2): -.07 airtemp, .06 time, .0576 month,
-.0570 weather, -.051 disturb, -.050 canopy

Factor 15 (0.7): -.18 hishrub, .17 lowshrub

Factor 14 (0.9): .16 surfgeo, -.149 weather, -.145 topogr

Elimination of the most highly correlated variable pair, low/hishrub (.85), yielded one low variance component.

Factor 14 (0.4): .11 airtemp, -.085 time, .083 weather,
.077 disturb, -.074 month, .068 canopy, -.067 grndcov

Elimination of the next most highly correlated variable pair, tree/canopy (.72), yielded one low variance component.

Factor 12 (0.7): .15 airtemp, -.13 time, .12 disturb

Elimination of the next most highly correlated variable herb, tree/HERB (.61), yielded one low variance component.

Factor 11 (0.8): .15 airtemp, -.14 time

Elimination of the next most highly correlated variable grndcov, canopy/GRNDCOV (.50), yielded no additional low variance components.

BOG TURTLE (Clemmys muhlenbergii)

Unfortunately, the bog turtle Spearman correlation coefficient matrix contained numerous uncalculated coefficients as well as several perfect correlations (1.0). Eliminating all variables involved in these problems would leave a set of variables too incomplete for PCA comparison.

MUSK TURTLE (Sternotherus odoratus)

PCA analysis of all 16 variables produced two low variance components.

Factor 16 (0.2): .11 tree, -.10 canopy

Factor 15 (0.9): .27 grndcov, -.24 herb

Elimination of the most highly correlated variable pair, tree/canopy (.91), yielded no additional low variance components.

BOX TURTLE (Terrapene c. carolina)

PCA analysis of all 16 variables produced a single low variance component.

Factor 16 (0.6): .21 tree, -.18 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.88), yielded no additional low variance components.

NORTHERN COPPERHEAD (Agkistrodon contortrix mokasen)

Some preliminary PCA analysis was run on this species but the small sample size precluded additional analysis.

WORM SNAKE (Carphophis a. amoenus)

PCA analysis of all 16 variables produced negative eigenvalues. Negative eigenvalues were eliminated after deleting variables bedgeo, grndcov, time, weather, and airtemp, as well as the most highly correlated variable pair, tree/canopy (.98). The first five variables were deleted due to their small sample sizes or inability to compute Spearman correlation coefficients. A reduced data set of nine variables remained. A comparison of elev, month, hydric, surfgeo, topogr, herb, lowshrub, hishrub, and disturb produced one low variance component.

Factor 9 (0.1): 0.6 surfgeo, + all other variables (which had values from 0.3 to 0.0)

Elimination of surfgeo/hydric resulted in no additional low variance components.

BLACK RACER (Coluber c. constrictor)

PCA analysis of all 16 variables produced two low variance components.

Factor 16 (0.5): .17 canopy, -.15 tree

Factor 15 (0.9): .19 grndcov, -.14 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.88), produced no additional low variance components.

RING NECKED SNAKE (Diadophis punctatus edwardsi)

PCA analysis of all 16 variables produced one low variance component.

Factor 16 (0.7): .23 tree, -.22 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.87), did not produce additional low variance components.

BLACK RAT SNAKE (Elaphe o. obsoleta)

PCA analysis of all 16 variables produced negative eigenvalues. After examination of the Spearman correlation coefficient matrix, variables time and airtemp were eliminated due to their small sample sizes. The most highly correlated variable pair, tree/canopy (.90), was also deleted eliminating negative eigenvalues. Ten variables were left for comparison, producing one low variance component.

Factor 10 (0.7): .125 lowshrub, .123 topogr

Elimination of the next most highly correlated variable pair, low/hishrub (.75), yielded no additional low variance components.

HOG NOSED SNAKE (Heterodon platyrhinos)

PCA analysis of 16 variables produced negative eigenvalues. After examination of the Spearman correlation coefficient matrix the variables airtemp, weather, and time were eliminated due to small sample sizes. The PCA still produced negative eigenvalues. Elimination of the most highly correlated variable pair, tree/canopy (.84), corrected the negative eigenvalues. Analysis of the remaining eleven variables produced one complicated low variance component.

Factor 11 (0.4): .10 month, .08 grndcov, .07 disturb,

.06 lowshrub, -.0578 herb, .0577 surfgeo, -.056 bedgeo

Elimination of the next most highly correlated variable pair, grndcov/surfgeo (.749), clarified the previous component.

Factor 9 (0.9): .148 month, .147 lowshrub, .141 disturb

Elimination of the next most highly correlated variable hydric, HYDRIC/surfgeo (.742), yielded no additional low variance components.

MILK SNAKE (Lampropeltis t. triangulum)

PCA analysis of all 16 variables produced three low variance components.

Factor 16 (0.3): -.09 topogr, .08 surfgeo, .078 weather

.070 time, -.067 grndcov, .066 canopy

Factor 15 (0.4): .12 hishrub, -.09 lowshrub, -.088 time,

-.080 month

Factor 14 (0.6): .21 tree, -.19 canopy

Eliminating the most highly correlated variable pair, tree/canopy (.85), produced two low variance components.

Factor 14 (0.4): .098 surfgeo, -.097 grndcov, -.08 lowshrub,

-.077 topogr, .076 hydric, .0639 disturb, .0635 hishrub

Factor 13 (0.5): .14 time, -.13 hishrub

Eliminating the next most highly correlated variable pair, grndcov/hydric (.67), yielded one low variance component.

Factor 12 (0.7): .15 time, -.12 hishrub

Eliminating the next most highly correlated variable surfgeo, SURFGEO/hydric (-.66), yielded one low variance component.

Factor 11 (0.9): -.17 hishrub, .15 time

Eliminating the next most highly correlated variable lowshrub, LOWSHRUB/grndcov (-.63), yielded no additional low variance components.

NORTHERN WATER SNAKE (Nerodia s. sipedon)

PCA analysis of 16 variables produced on low variance component.

Factor 16 (0.6): -.21 tree, .20 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.93), yielded no additional low variance components.

SMOOTH GREEN SNAKE (Opheodrys v. vernalis)

PCA analysis of all 16 variables produced negative eigenvalues. Elimination of airtemp due to very small sample size still produced negative eigenvalues. Four sets of correlated variables were deleted in stepwise subtractive fashion until negative eigenvalues were eliminated. These were, in order of deletion, canopy/hishrub (.76), canopy/TREE (.73), grndcov/disturb (-.68), and surfgeo/elev (-.66). The following eight variables remained for analysis: bedgeo, month, time, weather, hydric, topogr, herb, and lowshrub. This PCA produced a single low variance component.

Factor 8 (0.6): -.1107 bedgeo, .1106 weather

Elimination of the next highly correlated variable hydric, surfgeo/HYDRIC (-.63), did not produce any additional low variance components.

BROWN SNAKE (Storeria d. dekayi)

PCA analysis of all 16 variables produced negative eigenvalues. By removing the most highly correlated variable pair, tree/canopy (.84), negative eigenvalues were eliminated. Two low variance component equations were produced.

Factor 14 (0.0): -.014 airtemp, .009 disturb, .008 grndcov

Factor 13 (0.8): -.145 hydric, .140 hishrub, .137 elev

Elimination of the next most highly correlated variable pair, elev/airtemp (.70), did not produce any additional low variance components.

RED BELLIED SNAKE (Storeria o. occipitomaculata)

PCA analysis of all 16 variables produced negative eigenvalues. These were eliminated by removing airtemp, which had a very small sample size, and the most highly correlated variable pair, tree/canopy (.93). Two low variance components were produced.

Factor 13 (0.5) included 11 of the remaining variables arranged in a continuous sequence from .10 to .04 which were not separable into subgroups. Disturb and bedgeo formed a low scoring subgroup of .01 each.

Factor 12 (0.6): .17 disturb, .13 lowshrub

Elimination of the next most highly correlated variable pair, bedgeo/topogr (.81), yielded a single low variance component.

Factor 11 (0.6): -.12 hishrub, .11 weather

Elimination of the next most highly correlated variable pair, herb/weather (-.69), yielded no additional low variance components.

EASTERN RIBBON SNAKE (Thamnophis s. sauritus)

PCA analysis of all 16 variables produced a computer program warning message that abnormally large data values negated the validity of the analysis. Examination of the Spearman correlation coefficient matrix revealed a correlation of 1.0 between tree and canopy. Deletion of this absolutely correlated variable pair removed the warning message and produced two low variance components.

Factor 14 (0.3): .10 weather, -.09 hishrub

Factor 13 (0.5): -.16 airtemp, .12 month. .11 herb

Elimination of the next most highly correlated variable pair, herb/airtemp (.62), produced one low variance component.

Factor 12 (0.3): -.10 hishrub, .10 weather

Elimination of the next most highly correlated variable lowshrub, tree/LOWSHRUB (.60), produced one low variance component.

Factor 11 (0.5): .12 weather, -.11 hishrub

Elimination of the next most highly correlated variable month, airtemp/MONTH (.568), produced one low variance component.

Factor 10 (0.5): .12 weather, -.11 hishrub

Elimination of the next most highly correlated variable pair, elev/topogr (.561), produced one low variance component.

Factor 8 (0.9): .15 hishrub, -.14 weather

Elimination of the next most highly correlated variable hydric, lowshrub/HYDRIC (.536), did not produce any additional low variance components.

EASTERN GARTER SNAKE (Thamnophis s. sirtalis)

PCA analysis of all 16 variables produced one low variance component.

Factor 16 (0.5): .20 tree, -.19 canopy

Elimination of the most highly correlated variable pair, tree/canopy (.91), yielded no additional low variance components.

APPENDIX II

DISCRIMINANT ANALYSIS

NOTE: The variable "canopy" was deleted from all these analyses due its high correlation with the variable "tree". Some comparisons have additional variable deletions which are indicated as follows.

1. Mole Salamanders (Ambystoma)

1.1 Comparison of A. jeffersonianum, laterale, maculatum, opacum:

FUNCTION 1: (Eigenvalue [E]: .4197 Wilk's Lambda [WL]: .5483
Significance [S]: .0000)

Airtemp .58; Weather .49; Bedgeo .47; Time .31; Herb .26;
Topogr .22; Hydric .15; Elev .06; Lowshrub .05

FUNCTION 2: (E: .1965 WL: .7785 S: .0000)

Topogr .82; Elev .53; Bedgeo/Airtemp .24; Lowshrub .23;
Time .16; Herb .15; Weather .07;
Hydric .03

Cases correctly classified: 45%
Expected classification: 25%

Ambystoma jeffersonianum correctly classified 94% of 18 cases
(17 correct, 1 misclassified)

Ambystoma laterale correctly classified 60% of 20 cases
(12 correct, 8 misclassified)

Ambystoma maculatum correctly classified 29% of 129 cases
(37 correct, 92 misclassified)

Ambystoma opacum correctly classified 73% of 33 cases
(24 correct, 9 misclassified)

1.2 Comparison of A. jeffersonianum, laterale:

FUNCTION 1: (E: 2.6819 WL: .2716 S: .0000)

Bedgeo 1.08; Topogr .73; Elev .59; Disturb .54; Herb .37;
Time .34; Lowshrub .31; Hydric .27

Cases correctly classified: 95%
Expected classification: 50%

Ambystoma jeffersonianum correctly classified 93% of 28 cases
(26 correct, 2 misclassified)

Ambystoma laterale correctly classified 96% of 28 cases
(27 correct, 1 misclassified)

1.3 Comparison of A. jeffersonianum, laterale, opacum:

FUNCTION 1: (E: 1.5830 WL: .2098 S: .0000)

Bedgeo .75; Airtemp .47; Hydric .43; Weather .42; Elev .38;
Month .27; Surfgeo .06; Topogr .05

FUNCTION 2: (E: .8451 WL: .5420 S: .0000)

Topogr 1.10; Hydric .69; Airtemp .60; Bedgeo .55;
Surfgeo .46; Elev/Month .38; Weather .19

Cases correctly classified: 84%
Expected classification: 33%

Ambystoma jeffersonianum correctly classified: 100% of 18 cases

Ambystoma laterale correctly classified: 82% of 22 cases
(18 correctly classified, 4 misclassified)

Ambystoma opacum correctly classified: 77% of 34 cases
(26 correctly classified, 8 misclassified)

1.4 Comparison of A. maculatum, opacum:

FUNCTION 1: (E: .3698 WL: .73 S: .0000)

Bedgeo .48; Airtemp .43; Weather/Lowshrub .39; Hishrub .34; Hydric/Topogr .30; Elev .27; Herb .20

Cases correctly classified: 73%
Expected classified: 50%

Ambystoma maculatum correctly classified: 74% of 133
(99 correctly classified, 34 misclassified)

Ambystoma opacum correctly classified: 70% of 33
(23 correctly classified, 10 misclassified)

2. Stream and Brook Salamanders (Desmognathus fuscus, Eurycea bislineata, and Gyrinophilus porphyriticus)

2.1 Comparison of Desmognathus, Eurycea, Gyrinophilus:

FUNCTION 1: (E: .1170 WL .8244 S .0135)

Lowshrub .74; Hydric .58; Herb .56; Tree .52; Topogr/Hishrub .46; Disturb .45; Elev .39

Cases correctly classified: 48%

Expected classification: 33%

Desmognathus correctly classified: 48% of 86 cases
(41 correctly classified, 45 misclassified)

Eurycea correctly classified: 44% of 135 cases
(59 correctly classified, 76 misclassified)

Gyrinophilus correctly classified: 78% of 18 cases
(14 correctly classified, 4 misclassified)

2.2 Comparison of Desmognathus, Eurycea:

FUNCTION 1: (E: .0962 WL: .9123 S: .0156)

Cases correctly classified: 59%
Expected classification: 50%

Desmognathus correctly classified: 69% of 86 cases
(59 cases correctly classified, 27 misclassified)

Eurycea correctly classified: 54% of 138 cases
(74 cases correctly classified, 64 misclassified)

2.3 Comparison of Desmognathus, Gyrinophilus:

FUNCTION 1: (E: .2288 WL .8138 S: 0.0066)

Herb .82; Elev .76; Tree .65; Disturb .38

Cases correctly classified: 74%
Expected classification: 50%

Desmognathus correctly classified: 73% of 88 cases
(64 correctly classified, 24 misclassified)

Gyrinophilus correctly classified: 78% of 18 cases
(14 correctly classified, 4 misclassified)

2.4 Comparison of Eurycea, Gyrinophilus:

FUNCTION 1: (E: .1372 WL: .8793 S: .0048)

Elev .77; Herb .59; Tree .41

Cases correctly classified: 73%
Expected classification: 50%

Eurycea correctly classified: 71% of 136 cases
(96 cases correctly classified, 40 misclassified)

Gyrinophilus correctly classified: 89% of 18 cases
(16 correctly classified, 2 misclassified)

3. Small Terrestrial Lungless Salamanders
(Hemidactylium scutatum and Plethodon cinereus)

The variable "herb" was deleted from this analysis due to its high correlation with the variables "tree" and "canopy".

FUNCTION 1: (E: .2001 WL: .8332 S: .0000)

Hishrub .55; Time .53; Elev .37; Topogr .35; Tree .33;
Lowshrub .26

Cases correctly classified: 86%
Expected classification: 50%

Hemidactylium correctly classified: 67% of 15 cases
(10 correctly classified, 5 misclassified)

Plethodon correctly classified: 88% of 218 cases
(191 correctly classified, 27 misclassified)

4. Toads (Bufo)

The variable "grndcov" was deleted from this analysis due to its high correlation with the variable "herb".

FUNCTION 1: (E: .0657 WL: .9383 S: .0102)

Herb .81; Month .60

Cases correctly classified: 65%
Expected classification: 50%

Bufo americanus correctly classified: 67% of 180 cases
(120 correctly classified, 60 misclassified)

Bufo woodhousii fowleri correctly classified: 55% of 29
(16 correctly classified, 13 misclassified)

5. Tree Frogs (Hyla)

FUNCTION 1: (E: .3412 WL .7456 S: .0020)

Airtemp .97; Time .64; Disturb .63; Lowshrub .54; Month .51

Cases correctly classified: 82%
Expected classification: 50%

Hyla crucifer correctly classified: 82% of 66 cases
(54 correctly classified, 12 misclassified)

Hyla versicolor correctly classified: 80% of 10 cases
(8 correctly classified, 2 misclassified)

This analysis was rerun deleting the variable "airtemp" which doubled the sample size of H. versicolor by reducing the amount of missing data:

FUNCTION 1: (E: .2096 WL: .8267 S: .0149)

Disturb .73; Month .70; Hydric .45; Weather/Lowshrub .39;
Bedgeo .31; Surfgeo .29

Cases correctly classified: 75%
Expected classification: 50%

Hyla crucifer correctly classified: 76% of 82
(62 cases classified, 20 misclassified)

Hyla versicolor correctly classified: 74% of 19
(14 correctly classified, 5 misclassified)

6. True Frogs (Rana)

6.1 Comparison of R. catesbeiana, clamitans, palustris, pipiens, sylvatica:

FUNCTION 1: (E: .4596 WL: .5270 S: .0000)

Hydric .76; Tree .46; Month/Surfgeo .24; Grndcov .16;
Disturb .14; Time .13; Lowshrub .12; Elev .10;
Bedgeo/Topogr .07; Herb .06; Hishrub .02

FUNCTION 2: (E: .2461 WL: .7692 S: .0000)

Grndcov .69; Herb .62; Bedgeo .47; Topogr .45; Hishrub .42;

Lowshrub/Disturb .38; Surfgeo .24; Elev .22; Month .09; Tree/Hydric .07; Time .05

Cases correctly classified: 45%

Expected classification: 20%

Rana catesbeiana correctly classified: 50% of 144 cases

(72 correctly classified, 72 misclassified)

Rana clamitans melanota correctly classified: 33% of 181 cases

(59 correctly classified, 122 misclassified)

Rana palustris correctly classified: 25% of 170 cases

(43 correctly classified, 127 misclassified)

Rana pipiens correctly classified: 73% of 30

(22 correctly classified, 8 misclassified)

Rana sylvatica correctly classified: 74% of 140

(104 correctly classified, 36 misclassified)

6.2 Comparison of R. catesbeiana, clamitans, palustris:

FUNCTION 1: (E: .0618 WL: .9268 S: .0165)

6.3 Comparison of R. catesbeiana, clamitans:

FUNCTION 1: (E: .0798 WL: .9261 S: .0054)

6.4 Comparison of R. palustris, pipiens:

FUNCTION 1: (E: .5771 WL: .6341 S. .0000)

Grndcov/Hishrub .56; Topogr .50; Lowshrub .48; Herb .45;

Bedgeo .43; Disturb .38; Elev .30; Surfgeo .17; Time .15

Cases correctly classified: 88%

Expected classification: 50%

Rana palustris correctly classified: 91% of 174

(158 cases correctly classified, 16 misclassified)

Rana pipiens correctly classified: 70% of 30

(21 cases correctly classified, 9 misclassified)

7. Aquatic Turtles

(Chelydra serpentina, Chrysemys picta, Sternotherus odoratus)

The variable "grndcov" was deleted from the following four analyses due to its high correlation with the variable "herb".

7.1 Comparison of Chelydra, Chrysemys, Sternotherus:

FUNCTION 1: (E: .1267 WL: .8534 S: .0003)

Herb .61; Hydric .44; Bedgeo .36; Lowshrub/Tree .33;
Surfgeo .28; Weather .27; Disturb .24; Topogr .05

Cases correctly classified: 48%

Expected classification: 33%

Chelydra correctly classified: 60% of 79 cases

(47 correctly classified, 32 misclassified)

Chrysemys correctly classified: 46% of 275 cases

(125 correctly classified, 150 misclassified)

Sternotherus correctly classified: 45% of 51 cases
(23 correctly classified, 28 misclassified)

7.2 Comparison of Chelydra, Chrysemys:

FUNCTION 1: (E: .1160 WL: .8961 S: .0004)

Bedgeo .53; Herb .49; Hydric .40; Surfgeo .39; Lowshrub .35;
Tree .29; Topogr .26; Weather .23

Cases correctly classified: 65%
Expected classification: 50%

Chelydra correctly classified: 65% of 79 cases
(51 correctly classified, 28 misclassified)

Chrysemys correctly classified: 65% of 275 cases
(179 correctly classified, 96 misclassified)

7.3 Comparison of Chelydra, Sternotherus:

FUNCTION 1: (E: .4144 WL: .7070 S: .0002)

Herb .73; Hydric .49; Disturb .45; Elev .39; Tree .35;
Lowshrub .29; Weather .22

Cases correctly classified: 72%
Expected classification: 50%

Chelydra correctly classified: 75% of 79 cases
(59 correctly classified, 20 misclassified)

Sternotherus correctly classified: 69% of 51 cases
(35 correctly classified, 16 misclassified)

7.4 Comparison of Chrysemys, Sternotherus:

FUNCTION 1: (E: .0757 WL: .9296 S: .0437)

8. Shallow wetland and semi-terrestrial turtles (Clemmys)

8.1 Comparison of C. guttata, insculpta, muhlenbergii:

FUNCTION 1: (E: 3.0345 WL: .1357 S: .0000)

Topogr .71; Disturb .59; Herb .44; Grndcov .43; Airtemp .38;
Elev .30; Bedgeo .25; Tree .23; Time .22; Lowshrub .16;
Month/Hydric .05

FUNCTION 2: (E: .8266 WL: .5475 S: .0000)

Bedgeo .82; Hydric .72; Elev .59; Grndcov .55;
Time/Lowshrub .45; Disturb .43; Tree .41; Airtemp .39;
Month .33; Topogr .25;Herb .12

Cases correctly classified: 83%
Expected classification: 33%

Clemmys guttata correctly classified: 76% of 37 cases
(28 correctly classified, 9 misclassified)

Clemmys insculpta correctly classified: 74% of 19 cases
(14 correctly classified, 5 misclassified)

Clemmys muhlenbergii correctly classified: 100% of 26 cases

8.2 Comparison of C. guttata, insculpta:

FUNCTION 1: (E: .8319 WL: .5459 S: .0018)

Hydric .96; Airtemp .69; Bedgeo/Month .63; Time .54;
Disturb .49; Grndcov .43; Elev .42; Hishrub .28

Cases correctly classified: 79%
Expected classification: 50%

Clemmys guttata correctly classified: 84% of 38 cases
(32 correctly classified, 6 misclassified)

Clemmys insculpta correctly classified: 68% of 19 cases
(13 correctly classified, 6 misclassified)

8.3 Comparison of C. guttata, muhlenbergii:

FUNCTION 1: (E: 3.4969 WL: .2224 S: .0000)

Disturb .66; Airtemp .63; Bedgeo .58; Topogr .52; Herb .30;
Month .26; Surfgeo .19

Cases correctly classified: 94%
Expected classification: 50%

Clemmys guttata correctly classified: 90% of 38 cases
(34 correctly classified, 4 misclassified)

Clemmys muhlenbergii correctly classified: 100% of 26 cases

8.4 Comparison of C. insculpta, muhlenbergii:

FUNCTION 1: (E: 55.5562 WL: .0177 S: .0000)

Bedgeo 3.42; Grndcov 3.39; Disturb 2.70; Hydric 2.14;
Herb 1.78; Surfgeo 1.49; Lowshrub 1.14; Weather .46;
Hishrub .45; Time .35

Cases correctly classified: 98%

Expected classification: 50%

Clemmys insculpta correctly classified: 95% of 20 cases

(19 correctly classified, 1 misclassified)

Clemmys muhlenbergii correctly classified: 100% of 29 cases

9. Terrestrial Turtles

(Clemmys insculpta, Terrapene carolina)

FUNCTION 1: (E: .7822 WL: .5611 S: .0000)

Grndcov .72; Bedgeo .68; Hydric/Disturb .36

Cases correctly classified: 72%

Expected classification: 50%

Clemmys insculpta correctly classified: 50% of 44

(22 correctly classified, 22 misclassified)

Terrapene correctly classified: 85% of 75 cases

(64 correctly classified, 11 misclassified)

10. Fossorial Snakes of Sandy Areas

(Carphophis amoenus and Heterodon platyrhinos)

The variables "time", "weather", and "airtemp" were deleted from this analysis to increase sample sizes by reducing the amount of missing data.

FUNCTION 1: (E: 1.5104 WL: .3984 S: .0024)

Tree 1.36; Lowshrub 1.27; Herb .92; Grndcov .89;

Disturb .62; Surfgeo .41; Month .37; Elev .32

Cases correctly classified: 91%

Expected classification: 50%

Carphophis correctly classified: 85% of 13

(11 correctly classified, 2 misclassified)

Heterodon correctly classified: 95% of 19

(18 correctly classified, 1 misclassified)

11. Large Black Snakes

(Coluber constrictor and Elaphe obsoleta)

FUNCTION 1: (E: .9369 WL .5163 S: .0013)

Topogr .98; Tree .82; Surfgeo .71; Elev .50; Month .42;
Hishrub .27

Cases correctly classified: 65%

Expected classification: 50%

Coluber correctly classified: 62% of 50 cases

(31 correctly classified, 19 misclassified)

Elaphe correctly classified: 74% of 19 cases

(14 correctly classified, 5 misclassified)

12. Small Snakes of Forest, Ecotone, and Field (Storeria dekayi, Storeria occipitomaculata, Diadophis punctatus edwardsi, and Opheodrys vernalis)

12.1 Comparison of S. dekayi, occipitomaculata:

The variable "airtemp" was deleted from the following analysis to increase the sample sizes by eliminating missing data.

FUNCTION 1: (E: 1.3892 WL: .4186 S: .0000)

Bedgeo 1.30; Topogr .64; Tree .41; Herb .39; Elev: .35

Cases correctly classified: 84%

Expected classification: 50%

Storeria dekayi correctly classified: 86% of 29 cases

(25 correctly classified, 4 misclassified)

Storeria occipitomaculata correctly classified: 82% of 22 cases (18 correctly classified, 4 misclassified)

12.2 Comparison of Diadophis punctatus edwardsi, Storeria dekayi, occipitomaculata:

FUNCTION 1: (E: 1.1696 WL: .3364 S: .0000)

Disturb .67; Lowshrub .60; Topogr .55; Elev .39; Herb .29;

Weather/Surfgeo .26; Month .24; Bedgeo .14

FUNCTION 2: (E: .3702 WL: .7298 S: .0077)

Bedgeo .77; Lowshrub/Disturb .41; Elev .33; Surfgeo .31;

Herb .26; Month .15; Weather .05; Topogr .00

Cases correctly classified: 79%

Expected classification: 33%

Diadophis correctly classified: 85% of 72 cases

(61 correctly classified, 11 misclassified)

Storeria dekayi correctly classified: 64% of 22 cases

(14 correctly classified, 8 misclassified)

Storeria occipitomaculata correctly classified: 76% of 21 cases

(16 correctly classified, 5 misclassified)

12.3 Comparison of Opheodrys, S. dekayi, occipitomaculata:

The variable "airtemp" was deleted from the following analysis to increase the sample sizes by reducing the amount of missing data.

FUNCTION 1: (E: 1.1560 WL: .3470 S: .0001)

Bedgeo 1.43; Topogr/Lowshrub .63; Tree .49; Disturb .48;

Surfgeo .31; Time .25; Elev .06

Cases correctly classified: 69%

Expected classification: 33%

Opheodrys correctly classified: 50% of 14 cases

(7 correctly classified, 7 misclassified)

Storeria dekayi correctly classified: 71% of 24 cases

(17 correctly classified, 7 misclassified)

Storeria occipitomaculata correctly classified: 82% of 17 cases (14 correctly classified, 3 misclassified)

13. Striped Snakes (Thamnophis)

FUNCTION 1: (E: .1931 WL: .8382 S: .0005)

Topogr .68; Bedgeo .67; Hishrub .53; Lowshrub .48;
Month .40; Disturb .25; Surfgeo .23

Cases correctly classified: 78%
Expected classification: 50%

Thamnophis sauritus correctly classified: 65% of 26 cases
(17 correctly classified, 9 misclassified)

Thamnophis sirtalis correctly classified: 80% of 197 cases
(158 correctly classified, 39 misclassified)

14. Wetland Snakes
(Nerodia sipedon and Thamnophis sauritus)

FUNCTION 1: (E: .9212 WL: .5205 S: .0000)

Hydric .84; Lowshrub .68; Topogr .34; Tree .32; Elev .25;
Hishrub .21

Cases correctly classified: 84%
Expected classification: 50%

Nerodia correctly classified: 83% of 114 cases
(94 correctly classified, 20 misclassified)

Thamnophis sauritus correctly classified: 93% or 27 cases
(25 correctly classified, 2 misclassified)

APPENDIX III

CLUSTER ANALYSIS

Forty-eight cluster analyses were conducted as follows:

Salamanders (Order Caudata)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

Frogs (Order Anura)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

Turtles (Order Testudinata)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

Lizards and Snakes (Order Squamata)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

Amphibians (Class Amphibia)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

Reptiles (Class Reptilia)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

All Species (Class Amphibia + Class Reptilia)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

Salamanders, Frogs, Turtles (Class Amphibia + Order Testudinata)

Single/complete linkage/squared Euclidian distance.

Single/complete linkage/Manhattan Block distance.

Average linkage between/within groups/squared Euclidian distance.

SALAMANDERS

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using squared Euclidian distance as a measure produced identical results. Three clusters were formed as follows:

A. Dusky and two-lined salamanders.

B. Marbled and red-backed salamanders.

C. Blue-spotted and spotted salamanders.

Jefferson's, spring, four-toed, and slimy salamanders as well as the red-spotted newt have high coefficients of similarity, therefore are too dissimilar to effectively cluster. They can be considered outliers in these clustering procedures.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance as a measure produced similar results. Single linkage produced two clusters as follows:

A. Dusky and two-lined salamanders.

B. Blue-spotted and spotted salamanders.

Complete linkage produced either two or three clusters as follows:

A. Dusky and two-lined salamanders.

B. Blue-spotted and spotted salamanders.

Or the following solution:

A. Dusky and two-lined salamanders.

B. Blue-spotted and spotted salamanders.

C. Marbled and red-backed salamanders and red-spotted newt.

The outlying species are identical to those of single and complete linkage using squared Euclidian distance, except that the red-spotted newt may enter one of the two possible complete linkage solutions.

Average linkage between/within groups/squared Euclidian distance.

A comparison between average linkage between groups versus average linkage within groups using squared Euclidian distance the measure produced identical three cluster solutions as follow:

A. Dusky and two-lined salamanders.

B. Marbled and red-backed salamanders with a later entry of red-spotted newt into the cluster.

C. Blue-spotted and spotted salamanders with a later entry of Jefferson's salamander into the cluster.

Spring, four-toed, and slimy salamanders are outliers in these comparisons.

FROGS

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using squared Euclidian distance as a measure produced the following solutions. Single linkage produced the following two clusters:

A. Bull, green, and pickerel frogs with a later entry of american toad into the cluster.

B. Spring peeper and wood frog.

Complete linkage produced three clusters, two similar to the single linkage clusters plus a third:

A. Bull, green, and pickerel frogs.

B. Spring peeper and wood frog.

C. American toad and gray tree frog.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance as a measure *produced identical results:*

A. One strong cluster of bull, green, and pickerel frogs.

OR

A. One strong cluster of bull, green, and pickerel frogs with a weak later entry of american toad.

B. One weak cluster of spring peeper and wood frog.

Average linkage between/within groups/squared Euclidian distance.

A comparison between average linkage between groups versus average linkage within groups using squared Euclidian distance as a measure produced identical two cluster solutions:

A. Bull, green, and pickerel frogs, with later entries of american toad and gray tree frog.

B. Spring peeper and wood frog.

TURTLES

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using squared Euclidian distance as a measure produced different results.

Single linkage produced one cluster:

A. Snapping, painted, and musk turtles with later entry of wood and box turtles.

Complete linkage produced two clusters:

A. Snapping, painted, and musk turtles.

B. Wood and box turtles.

In both these comparisons diamondback terrapin, spotted and bog turtles are too dissimilar to be clustered.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance measure produced varied results.

Single linkage produced one cluster:

A. Snapping, painted, and musk turtles.

Diamondback terrapin, spotted, wood, bog, and box turtles are outliers being too dissimilar to be clustered.

Complete linkage produced two clusters:

A. Snapping and painted turtles with later entry of musk turtle.

B. Wood and box turtles.

Diamondback terrapin, spotted and bog turtles are too dissimilar to be clustered.

Average linkage between/within groups/squared Euclidian distance.

A comparison between average linkage between groups versus average linkage within groups using squared Euclidian distance as the measure produced the varied results.

Between groups formed two clusters:

A. Snapping and painted turtles with later entry of musk turtle

B. Box and wood turtles.

Within groups formed one cluster:

A. Snapping and painted turtles with musk turtle added, then wood turtle.

Diamondback terrapin, spotted, bog, and in one case box turtles were too dissimilar to cluster.

SNAKES

Of the four orders of amphibians and reptiles clustered, only the Squamata (snakes and lizards) produced widely divergent results dependent upon method and measure used.

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using squared Euclidian distance as a measure produced the following results.

Single linkage produced one hierarchial cluster but four subclusters can be identified:

A. Milk, garter, black rat, and ringneck snakes.

B. Black racer, worm, and green snakes.

C. Hognose and ribbon snakes.

D. Brown, red-bellied, and water snakes.

Complete linkage produced three clusters:

A. Black racer, milk, garter, and hognose snakes.

B. Black rat, ringneck, and worm snakes.

C. Green, brown, red-bellied, water, and ribbon snakes.

In both comparisons copperhead, timber rattlesnake, and five- lined skink are too dissimilar to be effectively clustered.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance as a measure produced the following results.

Single linkage produced one hierarchial cluster divisible into three subclusters:

A. Milk, garter, worm, black rat, and ringneck snakes.

B. Black racer, hognose, brown, and green snakes.

C. Ribbon, red-bellied, and water snakes.

Complete linkage produced three clusters as follows:

A. Black racer, milk, garter, hognose, ringneck, and black rat snakes.

B. Worm, water, and ribbon snakes.

C. Green, brown, and red-bellied snakes.

In both comparisons copperhead, timber rattlesnake, and five-lined skink are too dissimilar to be effectively clustered.

Average linkage between/within groups/squared Euclidian distance.

A comparison between average linkage between groups versus average linkage within groups using squared Euclidian distance as the measure produced the following results.

Average linkage between groups produced a three cluster solution:

A. Black racer, milk, garter, green, worm, ringneck, black rat, and hognose snakes.

B. Water and ribbon snakes.

C. Brown and red-bellied snakes.

Average linkage within groups produced two clusters:

A. One large cluster of black racer, milk, garter, black rat, ringneck, worm, green, hognose, ribbon, and water snakes.

B. Brown and red-bellied snakes.

In both comparisons copperhead, timber rattlesnake, and five-lined skink are too dissimilar to cluster.

AMPHIBIANS

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using the squared Euclidian distance as a measure produced similar results.

Single linkage produced four clusters:

A. Bull, green, and pickerel frogs.

B. Red-spotted newt, marbled salamander, and american toad.

C. Blue-spotted, spotted, and red-backed salamanders, spring peeper, and wood frog.

D. Dusky and two-lined salamanders.

Complete linkage produced the same results except that red-backed salamander and wood frog were clustered with Group B (american toad, red-spotted newt, and marbled salamander).

Jefferson's, four-toed, spring, and slimy salamanders as well as Fowler's toad, gray tree and leopard frogs were too dissimilar to effectively cluster in both comparisons.

<u>Single/complete linkage/Manhattan Block distance.</u>

The comparison between single and complete linkage using Manhattan Block distance as a measure produced similar results.

Single linkage formed four clusters:

A. Bull, green, and pickerel frogs.

B. Red-spotted newt, marbled salamander, and american toad.

C. Spotted, blue-spotted, and red-backed salamanders, spring peeper and wood frog.

D. Dusky and two-lined salamanders.

Complete linkage formed four clusters:

A. Bull, green, and pickerel frogs with a later entry of red-spotted newt and american toad.

B. Red-backed and marbled salamanders, wood frog.

C. Spotted and blue-spotted salamanders and spring peeper.

D. Dusky and two-lined salamanders.

Jefferson's, spring, four-toed, and slimy salamanders, Fowler's toad, gray tree and leopard frog were too dissimilar to be clustered in either comparison.

<u>Average linkage between/within groups/squared Euclidian distance.</u>

The comparison between average linkage between groups versus average linkage within groups using squared Euclidian distance measure produced the following results.

Average linkage between groups produced four clusters:

A. Bull, green, and pickerel frogs.

B. Marbled salamander, red-spotted newt, american toad, and wood frog.

C. Spotted and blue-spotted salamanders and spring peeper.

D. Dusky and two-lined salamanders.

Average linkage within groups produced four clusters:

A. Bull, green, and pickerel frogs with later entry of red spotted newt, american toad, and marbled salamander.

B. Red-backed salamander and wood frog.

C. Spotted and blue-spotted salamanders and spring peeper.

D. Dusky and two-lined salamanders.

Jefferson's, spring, four-toed, and slimy salamanders, as well as Fowler's toad, gray tree and leopard frogs were too dissimilar to cluster in both comparisons. Red-backed salamander was too dissimilar to cluster in the between groups comparison only.

REPTILES

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using squared Euclidian distance as a measure produced the following results.

Single linkage produced three clusters:

A. Snapping, painted, and musk turtles and water snake.

B. Milk and garter snakes and wood turtle, with later entry of a subcluster of black rat and ringneck snakes, and entry of worm snake.

C. Spotted turtle and ribbon snake.

These three clusters then combined into one, followed by the addition of black racer, green snake, hognose snake, and box turtle. Species too dissimilar to cluster are red-bellied and brown snakes, copperhead, diamondback terrapin, five-lined skink, timber rattlesnake, and bog turtle.

Complete linkage produced five clusters:

A. Snapping, painted, and musk turtles, water snake.

B. Brown and red-bellied snakes.

C. Black racer, green and worm snakes.

D. Spotted and box turtles, ribbon snake.

E. Ringneck, black rat, milk, and garter snakes, wood turtle.

Species too dissimilar to cluster are bog turtle, five-lined skink, copperhead, diamondback terrapin, and timber rattlesnake.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance measure produced the following results.

Single linkage produced five clusters:

A. Snapping, painted, and musk turtles and water snake with a later of entry of cluster B.

B. Green and brown snakes.

C. Spotted turtle and ribbon snake with subsequent entries of clusters D and E.

D. Black rat and ringneck snakes.

E. Milk, garter, and worm snakes.

To the amalgamated cluster of C+D+E, wood turtle, hognose snake, black racer, and box turtle are added leaving the following species as outliers: red-bellied snake, copperhead, diamondback terrapin, five-lined skink, timber rattlesnake, bog turtle which are too dissimilar to cluster.

Complete linkage produced four clusters:

A. Snapper, painted, musk, and wood turtles, water snake.

B. Green, brown, worm, and red-bellied snakes.

C. Spotted and box turtles, ribbon snake.

D. Ringneck and black rat snake with later entry of milk, garter, black racer, and hognose snakes.

Species too dissimilar to cluster are timber rattlesnake, five-lined skink, copperhead, bog turtle, and diamondback terrapin.

Average linkage between/within groups/squared Euclidian distance.

A comparison between average linkage between groups versus average linkage within groups using squared Euclidian distance as the measure produced the following solutions.

The between groups comparison formed two clusters:

A. Snapping, painted, musk, and spotted turtles, water and ribbon snakes.

B. Wood turtle, milk, garter, ringneck, and black rat snakes.

Species too dissimilar to cluster are bog and box turtles, diamondback terrapin, worm, hognose, brown, red-bellied, green snakes, black racer, timber rattlesnake, copperhead, and five-lined skink.

The within groups comparison produced four clusters as follows:

A. Snapping, painted, musk turtles, water snake.

B. Spotted and box turtles, ribbon snake.

C. Ringneck and black rat snakes.

D. Wood turtle, black racer, milk and garter snakes.

Later entry of worm and hognose snakes. Species too dissimilar to cluster are bog turtle, diamondback terrapin, red-bellied snake, copperhead, timber rattlesnake, five-lined skink.

AMPHIBIANS AND REPTILES

Single/complete linkage/squared Euclidian distance.

The comparison of between single and complete linkage using squared Euclidian distance as a measure produced the following results.

Single linkage produced five clusters:

A. Bull, green, and pickerel frogs, snapping, painted, and musk turtles, water snake.

B. Red-spotted newt, marbled salamander, american toad, ringneck snake.

C. Wood turtle, worm, milk, and garter snakes.

D. Blue-spotted, spotted, red-backed salamanders, spring peeper, wood frog.

E. Dusky and two-lined salamanders.

Later entries into the clusters are gray tree frog, spotted and box turtles, black racer, black rat, green, ribbon, hognose, brown and red-bellied snakes.

Species too dissimilar to cluster are Jefferson's, spring, four-toed, and slimy salamanders, Fowler's toad, leopard frog, bog turtle, five-lined skink, copperhead, timber rattlesnake.

Complete linkage produced eight clusters:

A. Red-spotted newt, bull, green, and pickerel frogs, american toad, wood turtle.

B. Red-backed and marbled salamanders, gray tree and wood frogs, worm, ring neck, black rat, milk, and garter snakes.

C. Spotted and box turtles, ribbon snake.

D. Green, brown and red-bellied snakes.

E. Fowler's toad, snapping, painted, and musk turtles, water snake.

F. Blue-spotted and spotted salamanders, spring peeper.

G. Black racer and hognose snake.

H. Dusky and two-lined salamanders.

Species too dissimilar to cluster are Jefferson's, spring, four-toed, and slimy salamanders, leopard frog, bog turtle, diamondback terrapin, copperhead, timber rattlesnake, five-lined skink.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance measure produced the following results.

The single linkage comparison was essentially the same as single linkage/squared Euclidian distance.

Complete linkage produced nine clusters:

A. Red-spotted newt, bull, green, and pickerel frogs, american toad, wood turtle.

B. Spotted and box turtles, ribbon snake,

C. Red-backed salamander and wood frog.

D. Snapping, painted, and musk turtles, water snake.

E. Green, brown, and red-bellied snakes.

F. Marbled salamander, worm, ring neck, black rat, milk, and garter snakes.

G. Black racer and hognose snake.

H. Blue-spotted and spotted salamanders, spring peeper.

I. Dusky and two-lined salamanders.

Species too dissimilar to cluster are Jefferson's, spring, four-toed, and slimy salamanders, Fowler's toad, gray tree and leopard frogs, bog turtle, diamondback terrapin, five-lined skink, copperhead, timber rattlesnake.

Average linkage between/within groups/squared Euclidian distance.

The comparison between versus within groups using average linkage and squared Euclidian distance produced the following results.

Average linkage between groups produced seven clusters:

A. Bull, green, and pickerel frogs, snapping, painted, and musk turtles, water snake.

B. Red-spotted newt, marbled salamander, american toad, wood turtle, worm, ringneck, black rat, milk, and garter snakes.

C. Spotted and box turtle, ribbon snake.

D. Fowler's toad, black racer, hognose, green, brown, and red-bellied snakes.

E. Blue-spotted, spotted, four-toed, and red-backed salamanders, spring peeper, gray tree and wood frogs.

F. Dusky, two-lined, and spring salamanders.

G. Leopard frog and bog turtle.

Species too dissimilar to cluster are Jefferson's and slimy salamanders, diamondback terrapin, five-lined skink, copperhead, timber rattlesnake.

Average linkage within groups clustering produced five clusters:

A. Bull, green, pickerel frogs, snapping and painted turtles, water snake with later entry of wood, musk, and spotted turtles, as well as ribbon snake.

B. Red-spotted newt, marbled and red-backed salamanders, american toad, wood frog, ringneck and black rat snakes.

C. Box turtle, black racer, worm, green, milk, garter, hognose, and brown snakes.

D. Dusky and two-lined salamanders.

E. Blue-spotted, spotted, and four-toed salamanders, spring peeper.

Species too dissimilar to cluster are Jefferson's, spring, and slimy salamanders, Fowler's toad and gray tree and leopard frogs, bog turtle and diamondback terrapin, five-lined skink, red-bellied snake, copperhead, and timber rattlesnake.

SALAMANDERS, FROGS, AND TURTLES

In the previous analysis snakes appeared to complicate interpretation of the results by physically cluttering the dendrograms, making visual interpretation of the clusters difficult, while adding little consistent information. This is not surprising as when snakes were compared alone they failed to consistently cluster. By removing snakes from the following analyses I attempted to improve the visual resolution of the dendrograms comparing the other three orders.

Single/complete linkage/squared Euclidian distance.

The comparison between single and complete linkage using squared Euclidian distance as the measure produced the following results.

Single linkage produced four clusters:

A. Bull, green, and pickerel frogs, snapping, painted, and musk turtles.

B. Marbled salamander, red-spotted newt, american toad.

C. Blue spotted, spotted, and red-backed salamanders, spring peeper, and wood frog.

D. Dusky and two-lined salamanders.

Late entry of spotted and wood turtles. Species too dissimilar to cluster are Jefferson's, spring, four-toed, and slimy salamanders, Fowler's toad, gray tree and leopard frogs, bog and box turtles, and diamondback terrapin.

Complete linkage produced five clusters:

A. Bull, green, and pickerel frogs, snapping, painted, and musk turtles.

B. Dusky and two-lined salamanders.

C. Spotted, wood, and box turtles.

D. Red-spotted newt, marbled and red-backed salamanders, american toad and wood frog.

E. Blue-spotted, spotted, and four-toed salamanders, spring peeper.

Species too dissimilar to cluster are Jefferson's, spring, and slimy salamanders, Fowler's toad, gray tree and leopard frogs, bog turtle, and diamondback terrapin.

Single/complete linkage/Manhattan Block distance.

The comparison between single and complete linkage using Manhattan Block distance as the measure produced the following results.

Single linkage results were essentially the same as those produced by single linkage using squared Euclidian distance.

Complete linkage produced six clusters:

A. Bull, green, and pickerel frogs.

B. Red-spotted newt, american toad, wood turtle.

C. Red-backed salamander, wood frog.

D. Blue spotted and spotted salamanders, spring peeper.

E. Dusky and two-lined salamanders.

F. Snapping, painted, and musk turtles.

Species too dissimilar to cluster are Jefferson's, marbled, spring, four-toed, and slimy salamanders, Fowler's toad, gray tree and leopard frogs, spotted, bog, and box turtles, diamondback terrapin.

Average linkage between/within groups/squared Euclidian distance.

The comparison between average linkage between groups versus within groups using squared Euclidian distance produced the following results.

Average linkage between groups produced four clusters:

A. Bull, green, and pickerel frogs, snapping, painted, musk, spotted, wood, and box turtles.

B. Red-spotted newt, red-backed and marbled salamanders, gray tree and wood frogs.

C. Blue-spotted, spotted, and four-toed salamanders, spring peeper.

D. Dusky and two-lined salamanders.

Species too dissimilar to cluster are Jefferson's, spring, and slimy salamanders, Fowler's toad, leopard frog, bog turtle, and diamondback terrapin.

Average linkage within groups produced four clusters:

A. Bull, green, and pickerel frogs, snapping, painted, musk, spotted, and wood turtles.

B. Red-spotted newt, marbled and red-backed salamanders, american toad, gray tree and wood frog.

C. Blue-spotted, spotted, and four-toed salamander, spring peeper.

D. Dusky and two-lined salamanders.

Species too dissimilar to cluster are Jefferson's, spring, and slimy salamanders, Fowler's toad, leopard frog, bog and box turtles, diamondback terrapin.

APPENDIX IV

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