Supplying the Exotic Pet Trade:

Conservation and Livelihood Implications

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Abstract

The wildlife trade represents a significant threat to biodiversity, but may also provide opportunities for societal and economic benefits. To supply the trade, wildlife is often sourced from biodiverse developing countries where poverty rates are high. Ensuring a legal and sustainable trade is therefore critical not only for conservation and implementation of the Convention on International Trade in Endangered Species (CITES), but can contribute to UN Sustainable Development Goals to reduce poverty in developing regions. This thesis investigates trade in live animals, with emphasis on socio-economic implications of wildlife trade chains, and how these interact with conservation and sustainable use in supply countries. An interdisciplinary approach utilises global analysis of wildlife trade data; social research methods to examine the trade in Madagascar; and a specialised questioning technique to explore sustainability of the trade at the end-user level. The findings demonstrate an increasing component of the reptile pet trade comprises animals from ranching operations, or captive-bred in consumer countries. Although this may take pressure off wild populations, it may have implications for biodiversity and benefit sharing in supply countries. In Madagascar, a small proportion of the export value of reptiles and amphibians reaches local collectors. Whilst being potentially profitable and providing additional cash income to some households, wildlife trapping is also unreliable, part-time and financially risky. Consequently, it appears to bring limited opportunities for poverty alleviation or incentives for conservation at the local scale. Value chain analysis reveals the informal and complex nature of the supply chain, making design and implementation of interventions to enhance the trade challenging. Findings suggest that initiatives may be most effective working at the local level to improve organisation and cooperative management of the trade. At the consumer end, mortality of pet reptiles varies between taxa but appears to be relatively low. This directly informs debate concerning exotic pet keeping in consumer countries, for which there are limited data concerning sustainability of wildlife supply chains. Together, these studies enhance knowledge regarding implications of the wildlife trade for livelihoods and conservation, and inform dialogue concerning wildlife trade policy and practice more generally.

Table of Contents

List of Figures

List of Tables

CHAPTER 1

Introduction

1.1. Background - Global Exploitation of Biodiversity

Biodiversity provides humans with substantial direct economic benefits, a wide range of indirect essential services through natural ecosystems, and plays an important role in modulating ecosystem function and stability (Singh 2002). However, over the last 50 years, human-induced pressures on biodiversity have changed ecosystems more rapidly than in any other comparable time period in human history (Millennium Ecosystem Assessment 2005), leading to the sixth mass global extinction event (Barnosky et al. 2011; Ceballos et al. 2015; McKee et al. 2004). Habitat loss and degradation creates the single largest pervasive threat to biodiversity, with other primary threats including over-exploitation, climate change, environmental pollution, and invasive alien species (Secretariat of the Convention on Biological Diversity 2010). Despite decades of conservation interventions, and some local successes, the rate of biodiversity loss does not appear to be slowing (Butchart et al. 2010). With the human population predicted to reach 9.7 billion in 2050 (United Nations 2015) effective conservation measures are paramount if the rate of species extinctions is to be reduced and ecosystem services maintained.

Overexploitation and unsustainable use is recognised as a major cause of biodiversity loss (Rosser and Mainka 2002). In the case of global fisheries, overfishing precedes all other forms of human disturbance (Jackson et al. 2001). According to the International

Union for Conservation of Nature (IUCN) Red List of Threatened Species, unsustainable wildlife utilisation is the second most important threat to mammals (following habitat loss), with almost 1000 (18%) of the world's 5488 species affected; is recognised as a major threat to birds affecting over 400 of 9990 species; and is a key threat to cycads, as well as freshwater and marine biodiversity among others (Vié et al. 2009). Of 4669 reptiles currently assessed for the IUCN Red List (45% of the world's reptiles), at least 1390 (29.8%) are reported to be threatened by 'biological resource use' either as a primary or contributing threat (Auliya et al. 2016a). The Global Amphibian Assessment (GAA), which assessed threat status of all known amphibian species in the world (5915 species), listed utilisation as a major threat to 250 species. However, it was considered responsible for over a third of declines amongst 'rapidly declining' species in the Indomalayan and Palaearctic realms (Stuart et al. 2008). When overexploitation is combined with other threats such as habitat loss, species loss is accelerated, and if also combined with environmental warming, declines in population size can be up to 50 times faster (Mora et al. 2007).

Species are harvested all over the world for a variety of purposes, including fish, wild meat and plant products for consumption, medicinal ingredients, tourist curios, skins, trophies, pets, and materials for production (e.g. timber, leaves for handicrafts etc.). Whilst much of this harvest is for subsistence use, or to supply local markets, a significant proportion is also traded internationally. For example, between 1998 and 2007, 35 million animals (17.4 million reptiles; 16.0 million seahorses; 0.1 million other fish; 1.0 million birds; 0.3 million butterflies; 0.4 million mammals), as well as 18 million coral pieces and 2 million kilograms of live corals were exported from Southeast Asia alone (Nijman 2010). In 2009, the legal trade in wildlife products imported globally was estimated to be worth over 323 billion USD per annum

(TRAFFIC 2009), with the vast majority of this value (~90%) accounted for by timber and fisheries (Engler and Parry-Jones 2007). Wildlife is also traded in illegal markets where sales frequently go unrecorded making valuation difficult. However, current estimates suggest that the illicit wildlife trade could be worth 19 to 26.5 billion USD per annum (including illegal timber and fisheries), representing the fourth largest global criminal market, after narcotics, counterfeiting, and human trafficking (Haken 2011). Nearly 7000 species have been reported in global seizure data, with no single one representing more than six percent of the total, thus highlighting the diverse nature of the illegal wildlife trade (UNODC 2016).

Wildlife trade, particularly illegal and unsustainable trade, is a major global conservation concern, which may threaten species conservation (Brashares et al. 2004; Cinner et al. 2013; Grogan et al. 2010; Kenney et al. 1995; Lenzen et al. 2012; O'Brien et al. 2003; van Balen et al. 2000), facilitate disease transmission (Karesh et al. 2005; Marano et al. 2007; Schloegel et al. 2009), contribute to the spread of invasive species (Carrete and Tella 2008; Garcia-Diaz et al. 2015; Kopecky et al. 2013; Masin et al. 2014; Su et al. 2015) and in some cases has become highly militarised, threatening national and international security (Duffy et al. 2015; Roe et al. 2014; UNODC 2010). The high value of some wildlife products, low risk of detection (often due to limited resources) and relatively low penalties, provides incentives for criminal groups to engage in illicit wildlife trade (Broad et al. 2003). Equally, globalisation and online trading contributes to the ease with which transactions take place (Ehrenfeld 2005; Lavorgna 2014). Due to rising levels of poaching (Biggs et al. 2013, Wittemyer et al. 2014), illegal wildlife trade has received increasing political and public attention in recent years, with much of the focus on charismatic and endangered species such as tigers, elephants and rhinos (Anderson 2014; BBC 2015; Roe et al. 2014). This has

included a number of high-level conferences, funds and declarations such as the *London Declaration on the Illegal Wildlife Trade* in 2014, a £15 million fund from the UK Department for Environment, Food and Rural Affairs (Defra) and the Department for International Development (DFID) to combat poaching and trafficking (Duffy 2016) and a UN General Assembly resolution on 'Tackling Illicit Trafficking in Wildlife' in 2015 (UNODC 2016).

Whilst illegal wildlife trade can have devastating consequences, a significant proportion of wildlife in international trade is conducted legally, which draws far less public attention. Legal wildlife trade includes large numbers of less charismatic and less well-known taxa such as timber, fish, ornamental and medicinal plants, caviar, reptile skins, invertebrates including coral, and live reptiles and birds (Engler and Parry-Jones 2007; Nijman 2010; TRAFFIC 2009). Much of the wildlife entering international trade is sourced from biodiversity-rich developing countries, where people are frequently heavily dependent on natural resources for their survival (Robinson and Redford 1991; Roe 2002). Wildlife trade can support livelihoods and bring a range of benefits to those involved, from local communities to national and international economies (Moyle 2013; Roe 2002, 2008). For example, Uganda's lake fisheries support 135,000 fishers and 700,000 small scale operators in processing, with a value of over 200 million USD a year; and fishers of seahorses (mainly dried for use in traditional Chinese medicine) in the Philippines report that the trade contributes 30 to 40% of their annual income (Roe 2008). Indeed, The Convention on Biological Diversity (CBD) promotes the sustainable use of biological diversity as one of its key aims, and recognises the rights of people to benefit from their use (CBD 2014). Further, benefits from wildlife use may extend beyond socio-economic factors and promote incentives to protect the resource for future use, therefore potentially leading

to environmental stewardship (Gordon and Ayiemba 2003; Hutton and Leader-Williams 2003; Hutton and Webb 2003; Salafsky and Wollenberg 2000).

Ideally, sustainable and well-managed extractive use of resources may deliver positive livelihood outcomes allowing people from low income communities to benefit; which may in-turn stimulate incentives for conservation. However, wildlife trade is diverse and multifaceted, and the situations under which such win-wins are achieved are complex, situation dependent and generally under-studied. Much remains to be learned about the biological and socio-economic implications of various forms of wildlife trade in order to improve the legal trade, diminish illegal trade, and inform appropriate policy and management interventions.

1.2. International Wildlife Trade - Regulation and Management

1.2.1. Overview of legislation concerning international wildlife trade

The international trade in wildlife is regulated and influenced by a number of institutions, as well as governments and supra-national bodies, concerning animal health, animal welfare, and international movement of endangered species (Cooper and Rosser 2002). These institutions instigate laws and measures which operate at various levels including the international, regional and national level, with local and customary laws also having an influence. The key international framework concerned with exploitation of biodiversity and trade is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Section 1.2.2). In addition, the CBD encourages countries to manage and gain benefits from their genetic resources, and may therefore lead to national laws regulating international trade in certain products such as genetic material (Cooper and Rosser 2002). In terms of animal health, the World Trade Organisation (WTO) provides rules of world trade including non-

tariff barriers such as animal health controls and import licencing, while the World Organisation for Animal Health (formerly the Office International des Epizooties: OIE) sets international health standards, which are enforced under the WTO Sanitary and Phytosanitary Agreement. Animal welfare legislation varies considerably throughout the world, and is generally governed by national or regional legislation. For example, the EU has acceded to the Council of Europe directives on transport, conditions of breeding of some species, and on animals used in research (Cooper and Rosser 2002). CITES also provides overarching guidelines for non-air transport of live wild animals and plants (CITES 2013), and promotes the use of the International Air Transport Association (IATA) *Live Animals Regulations* and the IATA *Perishable Cargo Regulations* (for plants) concerning air transport. In general, these international agreements and codes provide a framework, which must be implemented into the national legislation of signatory countries.

Table 1.2.1. Laws and other measures relevant to the trade in wildlife (After Cooper and Rosser 2002).

Level	Animal and aquatic animal health	Endangered species	Welfare
International	World Trade Organization and Sanitary and Phytosanitary Agreement (SPS Agreement) International Animal Health Code and International Aquatic Animal Health Code (World Organisation for Animal Health: OIE)	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Convention on Biological Diversity (CBD) Guidelines of the International Union for Conservation of Nature (IUCN)	International Air Transport Association Regulations CITES Guidelines International Animal Health Code (OIE)
Regional European Union Council of Europe	European Union directives (numerous)	European Union and CITES Regulation	European Union Regulation (transport of animals) Council of Europe Convention (transport of animals)
National	Laws on control of disease and movement	Laws implementing CITES and CBD Species protection	Anti-cruelty laws: - general - transport Welfare codes (e.g. Great Britain, New Zealand and others)

1.2.2. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is a global agreement, currently with 183 signatory countries ('Parties'), which aims 'to ensure that international trade in specimens of wild animals and plants does not threaten their survival' (CITES 2016). Species are listed on one of three appendices, depending on their level of threat from international trade and the degree of protection they need. Appendix I includes species threatened with extinction with trade only permitted in exceptional circumstances; Appendix II includes species not necessarily threatened with extinction but may become so unless trade is controlled; and Appendix III includes species subject to regulation within the jurisdiction of a Party and for which co-operation of other Parties is needed to help control the trade. Of the ~35,600 species currently listed on CITES, the majority (97%) are listed on Appendix II (CITES 2016), allowing regulated international trade. CITES regulates trade on the basis of a system of permits, and therefore each Party is required to designate one or more Management Authorities, responsible for administration of the licensing system, and one or more Scientific Authorities to advise them on the effects of trade on the status of species. In order to issue a permit for listed-species, countries must be satisfied that such export will not be detrimental to the survival of that species ('non-detriment finding'). This essentially allows exporting countries to set trade at levels which they believe to be sustainable. Whilst only export permits are required for Appendix II species (with the exception of some Parties such as the EU which have stricter measures), both import and export permits are required for trade in Appendix I species. This means that both trading countries are required to make a non-detriment finding for Appendix I specimens. Every two to three years, CITES Parties come together at the Conference of the Parties, which is the main decision-making arena to

consider proposals to amend the Appendices, and adopt decisions and resolutions to improve effectiveness of the Convention. A two-thirds majority vote is required for decisions or amendments to be adopted. CITES deals specifically with international trade, and therefore domestic trade conducted within a nation's borders and trade in non-CITES species is usually down to country-specific regulation.

1.2.3. Strategies to manage wildlife trade on the ground

Alongside regulation, there are a variety of strategies to manage and reduce illegal and unsustainable wildlife trade on the ground, which tend to fall into three broad groups: increasing law enforcement and strengthening criminal justice systems; reducing demand and consumption; and supporting sustainable livelihoods and local economic development (Roe et al. 2014). In response to high levels of poaching (Biggs et al. 2013, Wittemyer et al. 2014), over the last 15 years there has been an increase in militarised approaches to conservation (which may involve the employment of private military personnel to guard protected areas), and record levels of funding are currently being invested in enforcement and anti-poaching measures (Challender and MacMillan 2014, Duffy 2014). However, such approaches are accused of not considering the underlying reasons why people poach, or tackling the role of global trading networks and consumer demand, resulting in socially unjust outcomes (Duffy 2014) and often end up dis-incentivising communities to conserve wildlife (Roe et al. 2015). Whilst recognising that law enforcement is an important part of successful conservation, Challender and MacMillan (2014) argue that interventions need to go beyond regulation and focus on incentivising and building capacity within local communities; re-examing sustainable off-take mechanisms such as regulated trade, ranching and wildlife farming; and reducing demand. There have been calls for renewed emphasis to be given to community-based or 'bottom-up' approaches to managing wildlife trade

(Roe 2015; Roe et al. 2015). This includes various approaches such as awareness-raising, community-based rapid response teams, conservation incentive schemes such as land leases, sustainable use, and reinvigorated cultural institutions and social status, which can, under the right situations, be highly effective (Roe 2015), and engage, rather than alienate the people that live alongside wildlife. The role of sustainable use and trade as a tool for both conservation and local development has been particularly overlooked (Roe et al. 2014).

1.2.4. Sustainable off-take mechanisms and legal wildlife trade

A legal sustainable trade, be it through managed wild-offtake, ranching (usually involving the removal of young or eggs from the wild and rearing in a captive environment) or wildlife farming, can bring income to national governments and wildlife agencies in order to manage their natural resources (Biggs et al. 2013; Thorbjarnarson and Velasco 1999), displace illegal trade (Hutton and Webb 2003; Moyle 2013), and bring benefits to local communities, promoting incentives for conservation (Gordon and Ayiemba 2003; Hutton and Leader-Williams 2003). This approach has been instrumental in countries such as South Africa, where protected area authorities have sold animals such as rhinos to private ranches for tourism and trophy hunting, obtaining significant financial gains in order to finance wildlife protection and conservation activities. Due to incentives received from managing wildlife, more land is held as private sector game ranches, than is currently held in protected areas (Roe et al. 2014) and South Africa has seen large recoveries of its wildlife (Hart 2015). However, consumptive use of wildlife creates polarised views amongst conservationists, practitioners, non-governmental organisations and other stakeholders, particularly when considering charismatic endangered species, such as legal trade in rhino horn and trophy hunting of lions (Hart 2015; Nuwer 2016). Even when including

less well-known species, the same arguments hold, and researchers argue that that the stigma associated with illegality of a product may be removed by introducing legal trade (Fischer 2004), demand increased through the creation of parallel markets (Drury 2009), loopholes created for illegal trade (Brooks et al. 2010; Lyons and Natusch 2011) and the reaction of illegal trade networks will be unpredictable potentially resulting in increased poaching effort (Bulte and Damania 2005; Collins et al. 2013). Corruption and the ability of countries to regulate legal trade is also called into question, and therefore some researchers argue that trade bans are the only plausible solution for controlling illegal trade in certain products such as ivory (Bennett 2015). However, corruption is not unique to a legalised trade, affecting all areas of conservation including trade bans, and information from other sectors suggest it can be tackled (Smith et al. 2014). While clearly effective in some instances (Cahill et al. 2006; Uscamaita and Bodmer 2010), trade bans have been shown to stimulate trade and increase the value of wildlife in illegal markets (Conrad 2012; Rivalan et al. 2007), reduce incentives and participation in conservation management (Weber et al. 2015) and counter broader values of equity and sustainable development (Cooney and Jepson 2006; Roe 2006). The outcomes of trade bans are therefore not necessarily straightforward or predictable.

Given the diversity of different forms of wildlife trade, there is no single approach to its regulation, and a combination of approaches, specific to the situation, will often be required. However, in light of the increasing political attention focussing on a few iconic species and organised crime, it is important not to cast all wildlife use in a bad light, but to recognise and differentiate legal sustainable trade efforts, which can contribute to both conservation and development (Roe et al. 2014).

1.3. Commercial Trade in Live Animals

1.3.1. The exotic pet trade

A large component of the global wildlife trade is comprised of live animals sold to meet human demand for exotic pets. The global legal trade in live animals (including primates, cage birds, birds of prey, reptiles and ornamental fish) was estimated to be worth 508 million USD in 2005, comparable in value to animal products for clothing/ornamental purposes (furs, reptile skins, corals, shells and natural pearls), estimated at 501 million USD, and animal products for food (game meat, frogs legs, edible snails, excl. fish) estimated at 586 million USD (Engler and Parry-Jones 2007). The exotic pet trade involves an increasing range of wild animal species from mammals to invertebrates (Pérez 2009), and is thought to be driven by changing consumer trends, novelty and facilitated through new media. For example, the release of mainstream television shows and films featuring animals such as *Teenage Mutant Ninja Turtles*, *Finding Nemo* and *Harry Potter* have been linked to increased demand for such animals as pets (Yong et al. 2011). Slow lorises and squirrel monkeys are particularly popular amongst women in Japan (Sakamoto 2007) and videos showing slow lorises being 'tickled' have introduced these animals to new sectors of society and possibly promoted their illegal trade (Nekaris and Campbell 2012). Rarity alone has been proposed to make a species more desirable, fuelling disproportionate exploitation of rare species and ultimately driving them into an extinction vortex (Courchamp et al. 2006). The demand for exotic pets may also be increasing with higher incomes, urbanisation, and globalisation (Ding et al. 2008). Like all wildlife trade, trade in live animals is also influenced by legislation. For example, bans on bird imports in response to the avian influenza outbreak have resulted in a decrease in wild

bird trade (Nijman 2010). In some countries such as the UAE, this has resulted in shifts in the pet trade from birds to reptiles and marine aquaria (Soorae et al. 2008).

Animals supplying the pet trade may be sourced from the wild in their country of origin, or may be captive-bred, and therefore trade chains can vary considerably in structure and length (Figure 1.3.1). Given that much of the wildlife traded is sourced from biodiversity-rich developing countries, capacity and resources to breed animals can be limited (Lyons and Natusch 2011) and much of the captive breeding tends to occur in developed consumer countries. Other modes of production include ranching, which is more often associated with the country of origin, and is mostly used for reptiles, which can have high natural mortality rates during earlier life stages (Hutton et al. 2001).

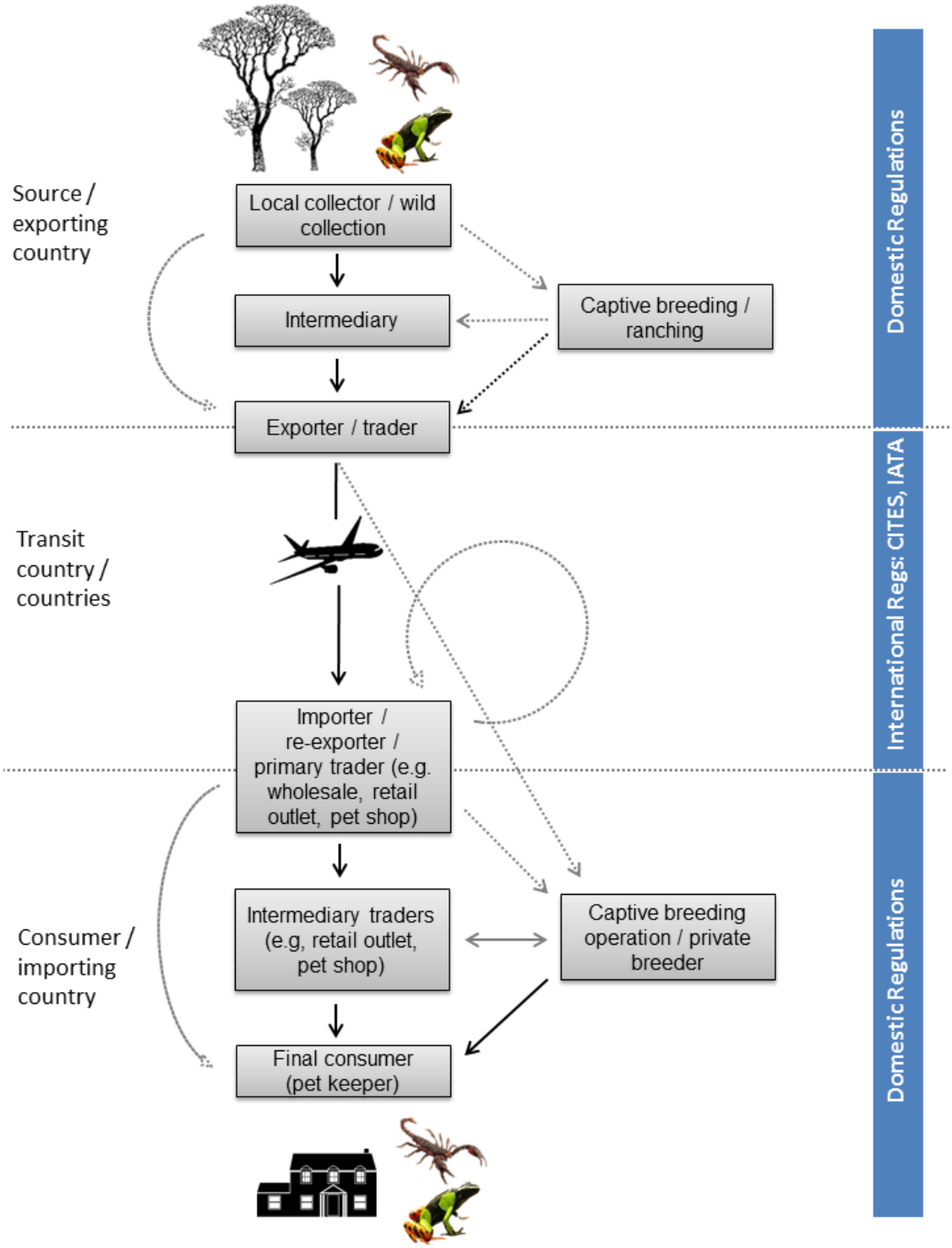

Figure 1.3.1. Typical trade chain for the exotic pet trade, illustrating potential flow of wildlife from source to consumer.

1.3.2. Reptiles and amphibians in trade

Some of the most commonly traded taxa are reptiles and amphibians. Reptiles are frequently traded in international markets for their skins (e.g. pythons, crocodilians) or as pets (e.g. chameleons, snakes, geckoes etc.) (Auliya 2003; Caldwell 2012; Jenkins and Broad 1994). Indeed, the global international trade in reptile skins and live reptiles was estimated to be worth ~319 million USD and ~39 million USD, respectively, in 2005 (Engler and Parry-Jones 2007). In the EU, the trade in reptiles accounted for 84% of the total value of all CITES animals and their products in 2010 (excluding caviar extract), mostly comprising leather products and skins (UNEP-WCMC 2012). However, a substantial national, and sometimes international trade also exists in reptiles for consumption (e.g. turtles) (Haitao et al. 2008) and medicine (e.g. Tokay geckoes) (Nijman et al. 2012). Popularity of reptiles as pets has increased over the last two decades, with increasing numbers of people drawn to commercial and amateur keeping and breeding. In addition, high prices are being attributed to newly described species, highly protected species, mutants and attractive colour morphs (Auliya 2003). The live trade in CITES reptiles into the EU is valued at 4.3 million USD per annum, accounting for 22% of all live animal imports by value, and superseded only by mammals (which is made up predominantly of monkeys imported for medicinal research) (UNEP-WCMC 2012). However, only 7.7% of the world's reptile species are listed in the CITES appendices and therefore the vast majority of those traded are not monitored or regulated at the international level (Auliya et al. 2016a). Using data from the European Commission (Eurostat), Auliya et al. (2016a) calculated that ~20.8 million live reptiles (CITES and non-CITES) were imported into the EU between 2004 and 2014.

A review of global trade in CITES-listed amphibians concluded that the majority were traded for meat, followed by live animals, and a smaller proportion traded for skins and eggs (Carpenter et al. 2014). Indeed, the global trade in frog's legs was estimated to be worth ~50 million USD in 2005 (Engler and Parry-Jones 2007). Amphibians are also known to enter trade for biomedical and educational research (O'Rourke 2007). At least 278 species of amphibians have been recorded in the pet trade (Stuart et al. 2008), with many being harvested from the wild, attracting much conservation attention (Carpenter et al. 2014). However, like reptiles, only a minority (2.8%) of amphibian species are listed on the CITES Appendices (Auliya et al. 2016b). Particular concerns surrounding live amphibian trade include its potential to mediate the introduction of amphibian infectious diseases, such as ranavirus and chytridiomycosis (*Batrachochytrium dendrobatidis* (Bd)), responsible for local and global amphibian extinctions (Berger et al. 1998; Bosch et al. 2001; Bradley et al. 2002; Kolby et al. 2014; Lips et al. 2006; Schloegel et al. 2009).

1.3.3. Current debates concerning the live trade in reptiles and amphibians

Due to concerns regarding biodiversity loss (O'Brien et al. 2003; Webb et al. 2002), disease (Check 2004; Chomel et al. 2007; Masin et al. 2014), animal welfare (Baker et al. 2013) and also ethical and moral considerations (Warwick 2014), the trade in live animals, and particularly reptiles and amphibians, attracts debate between scientists, keepers, veterinarians, animal welfare and animal protection groups. In particular, arguments range from whether the trade should be banned on health or welfare grounds (Garner et al. 2009; Kriger and Hero 2009), or whether carefully managed trade should be supported in order to allow exporting countries to benefit from their natural resources and support sustainable use and incentive-based conservation (Pool 2015). However, the issue of welfare (in particular mortality of animals throughout the

trade chain), morality and ethics of the trade is frequently brought into such discussions (Warwick 2014). Accordingly the trade enters a range of different environmental policy arenas. For example, in 2012, US regulations were amended to add a number of large constrictor snakes to the Species Listed as Injurious Wildlife under the Lacey Act, on the grounds of ecosystem damage (USFWS 2012), whilst discussions in the UK concerned new EU legislation on Invasive Alien Species (FBH 2012). At one extreme the keeping of exotic animals is prohibited under the Animal Welfare Act in Norway, and a proposal to open trade in a limited number of reptile and amphibian species was rejected by the Norwegian government in 2013 amidst opposition from groups opposed to the trade (Anderson 2013; CABI 2014). Additionally, in early 2015, Scotland announced plans to review exotic pet keeping legislation, following discussions with animal welfare charities (BBC 2015b). Debates concerning the live animal trade are influenced by a range of stakeholders with conflicting agendas and little collaboration between them in order to obtain a more holistic understanding and better management of the trade.

1.4. Case Study: Reptile and Amphibian Collection in Madagascar

1.4.1. Madagascar - a biodiversity hotpot

Madagascar is described as one of the 'hottest' biodiversity hotspots with unparalleled levels of endemic biodiversity undergoing severe rates of decline (Myers et al. 2000) (Table 1.4.1). Over 90% of its ~12,000 species of vascular plants, 50% of its birds, 75% of its mammals, 90% of its reptiles and 99% of its amphibians are endemic (Langrand and Wilmé 1997; Myers et al. 2000; Schatz et al. 2000). Whilst the original proportion of Madagascar's forest cover has not been conclusively determined (Kull 2000; Quéméré et al. 2012), it is clear that much of its original forest has been lost. Analyses of aerial photographs and Landsat images indicate that forest cover decreased

by almost 40% from the late 1950s to ~2000, and deforestation was estimated to be continuing at ~1% per year between 1990 and 2000 (Harper et al. 2007). The use of fire for slash and burn agriculture, practiced for subsistence purposes and cattle raising, along with cutting of fuelwood represent the most significant threats to Madagascar's biodiversity (Harper et al. 2007), with economic activities, population growth and poverty, thought to be the main factors driving this degradation (Quéméré et al. 2012). Unstable political conditions, particularly following a coup in 2009, have exacerbated the situation, providing the opportunity for organised illegal logging of valuable hardwoods such as Malagasy rosewood to proliferate in protected areas, facilitated by insecure governments focused on short term priorities (Innes 2010; Schuurman and Lowry II 2009; Waeber and Wilmé 2013). With over 90% of the population living on less than two USD a day (Waeber and Wilmé 2013) and a Human Development Index of 0.520 (ranked 154 out of 185 countries) (UNDP 2015), poverty is a significant issue in Madagascar. In addition, over 80% of the rural population engage in agriculture (INSTAT, 2010), and therefore preventing further degradation of natural resources is challenging.

Table 1.4.1. The eight hottest biodiversity hotspots in terms of five factors (From Myers et al. 2000).

Hotspot	**Endemic plants**		**Endemic vertebrates**		**Endemic plants/area ratio (species per 100km^2)**		**Endemic vertebrates/area ratio (species per 100km^2)**		**Remaining primary vegetation as % of original extent**		**Times appearing in top 10 for each of five factors**
Madagascar	9,704	4	771	4	16.4	8	1.3	7	9.9	9	5
Philippines	5,832	8	518	9	64.7	2	5.7	2	3	1	5
Sundaland	15,000	2	701	5	12	10	0.6	10=	7.8	7	5
Brazil's Atlantic Forest	8,000	5	654	6	8.7		0.6	10=	7.5	6	4
Caribbean	7,000	6=	779	3	23.5	6	2.6	4	11.3		4
Indo-Burma	7,000	6=	528	8	7		0.5		4.9	3	3
Western Ghats/Sri Lanka	2,180		355		17.5	7	2.9	3	6.8	5	3
Eastern Arc and Coastal Forests of Tanzania/Kenya	1,500		121		75	1	6.1	1	6.7	4	3

1.4.2. Reptile and amphibian trade in Madagascar

Whilst famously known for its lemurs, considerable attention has also been paid to Madagascar's diverse and endemic herpetofauna (amphibians and reptiles). There are at least 370 reptile species (Jenkins et al. 2014) and a minimum of 300 amphibian species known, with many yet to be described (Perl et al. 2014; Vieites et al. 2009). Many of these animals are rare, brightly coloured and decorated, and display exceptional evolutionary adaptations; they are therefore highly desirable within the exotic pet trade. As with most of Madagascar's flora and fauna, these animals are under pressure with over 25% of its amphibians and 40% of its reptile species considered to be threatened with extinction (Andreone et al. 2005; Jenkins et al. 2014). Whilst habitat degradation is the most pervasive threat, direct removal for international trade is the primary threat to Malagasy tortoises, and affects some of its most endangered amphibian species (Andreone et al. 2005; Jenkins et al. 2014).

According to the CITES Trade Data Dashboards (UNEP-WCMC 2016), exports of live CITES-listed reptiles from Madagascar peaked at ~180,000 individuals in 1998 and dropped to ~16,000 in 2014; amphibians peaked at ~40,000 in 2001, falling to ~6000 in 2014. Madagascar was the dominant exporting country of the world's chameleon trade in the early 1990's, with a global market share of ~40%, before declining again by the early 2000's (Carpenter et al. 2004). Export levels were influenced by key legislative changes in Madagascar. This included the relaxation of export controls due to a national policy shift in 1998, followed by CITES interventions to regulate the trade due to concerns regarding significant trade and poor implementation of the Convention. CITES recommended that Parties suspend imports in all but four species of chameleons from Madagascar in 1994 (with the exception of *Furcifer pardalis, F. oustaleti, F. lateralis and F. verrucosus,* Figure 1.4.2), which

combined with a national initiative to establish a management structure for the trade in 1998, led to a massive reduction in exports (Carpenter et al. 2004; Carpenter et al. 2005). Export quotas for additional Malagasy chameleon species have only recently been reopened, with a number of new export quotas established by the national authority in 2014 (UNEP-WCMC 2014). The best-known examples of amphibians exported from Madagascar for the pet trade include the brightly coloured mantella frogs, of which the golden frog (*Mantella aurantiaca*) (Figure 1.4.2) was listed on CITES Appendix II in 1995, and the whole genus later listed in 2000. Thousands of *M. aurantiaca* have been recorded in trade, peaking at 31,941 individuals in 1998 and decreasing in 2002 and 2003 to 4780 and 2681, respectively. The mantella trade was estimated to be worth an export value of almost 250,000 USD over three years from 2001 to 2003 (Rabemananjara et al. 2008).

Whilst some consider it unlikely that smuggling of large quantities of low commercial value species such as mantella occurs (Rabemananjara et al. 2008), illegal trade in high value Appendix I species, including several of Madagascar's endemic tortoise species, has proliferated, having a devastating impact on their wild populations (O'Brien et al. 2003; Walker et al. 2004). Fifty-four Critically Endangered ploughshare tortoises (*Astrochelys yniphora*) were intercepted in Thailand in 2013, representing 10% of the entire species (Platt 2013). There are now fewer than 100 ploughshare tortoises left in the wild (Dasgupta 2016) and the species has been advertised for sale on the black market for 50,000 USD each (Roe 2015). Ongoing smuggling efforts are occurring despite active, long-term conservation efforts by the Durrell Wildlife Conservation Trust to protect the species (Shukman 2015). The Critically Endangered radiated tortoise (*Astrochelys radiata*, Figure 1.4.2) is also undergoing significant decline. It is used extensively as bushmeat, but also smuggled abroad, fetching 270 USD in Asia

and almost 5000 USD in Europe in 2010 (Ganzhorn et al. 2015; Todd 2011). Given the challenges of enforcing the trade ban in radiated tortoises, some have suggested alternative measures such as legalising the trade and assigning trading rights to local communities in order to provide financial incentives to reduce domestic trade and subsistence harvest (Ganzhorn et al. 2015).

Figure 1.4.2. Traded reptile and amphibian species from Madagascar with CITES and IUCN Red listing in parentheses: (a) Panther chameleon *Furcifer pardalis* (Appendix II, Least Concern), (b) Radiated tortoise *Astrochelys radiata* (Appendix I, Critically Endangered) (c) Decary's leaf chameleon *Brookesia decaryi* (Appendix II, Endangered) (d) Madagascar tree boa *Sanzinia madagascariensis* (Appendix I, Least Concern) (e) Oustalet's chameleon *Furcifer oustaleti* (Appendix II, Least Concern) (f) Tomato frog *Dyscophus* spp. (Appendix II, Least Concern)* (g) Golden frog *Mantella aurantiaca* (Appendix II, Critically Endangered) (f) Madagascar day gecko *Phelsuma* spp. (Appendix II) (all photos: J. E. Robinson).

*All species of *Dyscophus* are considered Least Concern with the exception of *D.antongilii* which is listed as Near Threatened.

1.5. Thesis Outline

Due to the diverse and complex nature of the international wildlife trade, interdisciplinary and innovative approaches are required to develop a better understanding of its implications, and inform future management. The research presented in this thesis seeks to develop a more comprehensive understanding of the conservation and livelihood costs and benefits of the commercial trade in live animals. This is achieved through targeting a number of knowledge gaps which all ultimately link back to a wider consideration of how to manage a more sustainable trade in wildlife. The thesis comprises the following data chapters, each of which is a stand-alone research paper.

Chapter 2 presents the most comprehensive global overview of the live trade in CITES-listed reptiles, through analysis of 15 years' of international trade data from the CITES trade database. This study focusses on the dynamics of the trade in terms of taxa, importing and exporting countries, and sources of species in trade (i.e. wild, ranched, captive-bred), with discussion on how reported trends may influence both conservation, livelihoods and benefit sharing in source countries.

Chapter 3 explores in detail the livelihood benefits provided to local collectors in villages supplying the live animal trade in Madagascar, with a focus on reptiles and amphibians. Using an extensive questionnaire, this study utilises systematic and snowball sampling to estimate the proportion of people involved in wildlife collection, calculate its profitability as a livelihood, compare this to other livelihood activities, and explore the potential for the trade to provide incentives for conservation at the local level.

Chapter 4 expands on the previous chapter by utilising value chain analysis to understand how the costs and benefits of the trade in reptiles and amphibians extend all along the supply chain in Madagascar, from village to export. This work seeks to document the structure and operation of the supply chain, report on the type and number of actors engaged, the flow of profit and proportion of final sales price received by different actors in the chain. This chapter concludes with discussion on how to enhance the wildlife trade for both conservation and livelihoods.

Chapter 5 explores the consumer side of the wildlife trade supply chain by investigating a topic representing a severe knowledge gap, and important aspect concerning sustainability of the trade - mortality of traded species. This study uses the additive Randomised Response Technique (Gupta and Thornton 2002) amongst pet owners to investigate reptile mortality rates in the home. The insights into the consumer market, consideration of captive-bred versus wild animals, and different taxa, in relation to their mortality rates improves our understanding of the whole trade chain and the different policy arenas and debates in which it enters.

Chapter 6 provides a synthesis of the main findings from chapters 2 to 5, and outlines the contribution this thesis makes to conservation science, policy, and practice. Thoughts concerning the future of the live animal trade, and avenues for further research building on the work presented herein are considered, before drawing final conclusions.

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CHAPTER 2

Dynamics of the Global Trade in Live Reptiles: Shifting Trends in Production and Consequences for Sustainability

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2.1. Abstract

Biodiversity-rich countries provide wildlife for the exotic pet trade, but the implications of this for conservation, sustainable use and livelihoods remain poorly understood. CITES Appendix II import data from 1996 to 2012 were used to analyse spatial and temporal trends in live reptiles, a group comprising a substantial component of the commercial wildlife trade. Between 2001 and 2012 the trade declined by a third. The decrease was greatest in wild-caught reptiles (70%), but imports in captive-bred reptiles also decreased (40%), due to reduced trade in green iguanas. Imports originating from captive sources comprised about half of the total trade over the period. In contrast, there was a nearly 50-fold increase in imports of ranched reptiles, dominated by royal pythons from sub-Saharan Africa, but including a recent upsurge of ranched turtles from South America and Asia. Additionally, the proportion of reptiles sourced from 'range countries' (where species naturally occur in the wild) declined. Numbers of reptiles captive-bred within consumer countries to supply domestic markets are difficult to obtain, but may be impacting international trade. Captive breeding may ease collection pressure on wild populations, but might also divert benefit flows, impacting local livelihoods. Ranching may benefit livelihoods and have low impacts on natural populations, but along with captive breeding, could be detrimental if loopholes allow wild animals to be exported as ranched. Given the shift from wild to ranched reptiles, more information is required on the benefits and impacts of commercial ranching operations for traded reptile species.

2.2. Introduction

Overexploitation contributes significantly to the extinction risk of threatened species (Rosser and Mainka 2002). If sustainability is an ultimate conservation goal, it is crucial to understand supply, demand and the temporal and spatial dynamics of resource use. Millions of live animals and plants, as well as their parts and derivatives, are traded each year to supply consumer demand around the world (Broad et al. 2003; Nijman 2010; Smith et al. 2009). The legal international trade in wildlife, excluding fisheries and timber, was estimated to be worth ~24 billion USD in 2005 (Engler and Parry-Jones 2007) but domestic and illegal trade is much more difficult to value. Wildlife trade can impact species conservation (O'Brien et al. 2003; Shepherd and Magnus 2004; van Balen et al. 2000) but also has important social and economic implications (McNeill and Lichtenstein 2003; Roe 2002, 2008). The Convention on International Trade in Endangered Species (CITES) was established to help regulate international trade in wild species and ensure it does not threaten their survival. Over 35,000 species are afforded varying levels of protection through CITES, according to their conservation status and risk from trade, which is regulated through an import-export permitting system.

In some cases, captive breeding may provide a suitable alternative to wild collection (Jepson et al. 2011). It can reduce pressure on wild populations, and captive-bred animals are subject to less stringent CITES controls than wild-sourced animals. Indeed, many commonly kept pets are bred in consumer nations, and this can contribute to research regarding biology, husbandry and disease (Marano et al. 2007). However, captive breeding can also reduce benefit flows to countries where species originate, counter to the Convention on Biological Diversity which recognizes sovereign rights of states over their natural resources and advocates ‘fair and equitable

sharing of benefits arising out of their use' (CBD 2014). Captive breeding may also disconnect suppliers from source habitats thus limiting opportunities for sustainable use and conservation initiatives. Additionally, captive breeding has been linked to laundering of illegally wild-caught animals (Brooks et al. 2010; Lyons and Natusch 2011), demonstrating the complex and varied nature of the benefits and impacts of alternative production strategies for supplying the trade.

'Ranching', defined within CITES as 'rearing in a controlled environment of specimens which have been taken as eggs or juveniles from the wild, where they would have a very low probability of surviving to adulthood' (CITES 2014a), is another system used for producing reptiles. Ranching relies on harvesting young life stages that regularly experience high mortality in the wild, and is therefore considered a relatively benign method of exploitation (Hutton et al. 2001). In some cases, the harvesting is compensated for by the release of some offspring back into the wild. Ranching is practiced within the country where the species occurs, and if well managed, has potential to benefit both livelihoods and conservation (Gordon and Ayiemba 2003; Moyle 2013; Thorbjarnarson 1999).

A substantial component of the international wildlife trade is made up of reptiles and their products, (Caldwell 2012; Hoover 2000; Kasterine et al. 2012). For example, excluding caviar extract, the trade in reptiles accounted for 84% of the value of CITES-listed animals and animal products imported into the EU in 2010, mostly consisting of leather products and skins (UNEP-WCMC 2012). Additionally, commercial and recreational breeding of reptiles has increased in recent years (Auliya 2003). The live reptile trade into the EU was valued at 4.3 million USD in 2010, accounting for 22% of all live imports by value, superseded only by mammals (UNEP-WCMC 2012).

Some reptile groups, particularly those associated with freshwater and marine habitats are facing disproportionately high extinction risks (Bohm et al. 2013). These risks are particularly severe amongst turtles, terrapins and tortoises, which in addition to suffering a range of threats (Bugoni et al. 2001; Lewison and Crowder 2007), are traded extensively as food, curios, pets and use in traditional medicine (Gibbons et al. 2000; Nijman and Shepherd 2007). Further, there is often limited information about the viability of wild populations (Pough 2013). Reptiles with small ranges and narrow niche requirements are particularly vulnerable to anthropogenic threats (Bohm et al. 2013). Equally, turtles, snakes and crocodilians that have life histories with prolonged adult survival are vulnerable to commercial exploitation (Pough 2013).

There is a lack of information regarding the number of live reptiles in trade, where they come from, and the production strategies used to supply them. Using CITES Appendix II trade data we review trends in the production strategies used to supply live reptiles for commercial international trade from 1996 to 2012. In particular, we address the following questions: (1) How has the relative importance of captive-bred, ranched, and wild-sourced animals changed over time? (2) How have changes in production strategies been reflected in global supply routes? (3) What are the consequences of the temporal and spatial dynamics for long term sustainability of the live reptile trade? We focus on the commercial trade in live reptiles, which are predominantly destined for pet trade, but in some cases supply production industries such as farming for meat and skins. Whilst the CITES Trade Database provides substantive data on trade in endangered species at a global scale, we acknowledge that it represents a subset of the entire global trade in reptiles as it does not take into account non-CITES species, illegal or unreported trade, and trade conducted within national borders.

2.3. Methods

The CITES Trade Database is managed by the United Nations Environment Program and World Conservation Monitoring Centre (UNEP-WCMC) on behalf of the CITES Secretariat with data collated from CITES annual reports submitted by the Parties (CITES signatories). Data on all live reptiles traded globally since 1996 were supplied by UNEP-WCMC [7 April 2014]. Data up to and including 2012 were chosen for analysis based on the completeness of the annual report submission record [dated 4 April 2014].

Ambiguous trade records, such as live specimens traded with units in 'kg' or 'shipments' (representing 0.3% of the data set), rather than as whole units, were excluded. Only data on Appendix II (representing 92.3% of all live reptile trade), commercially traded (coded purpose 'T' in the Trade Database - representing 99.2% of Appendix II reptiles) were analysed. Quantities of reptiles reported by importing countries were analysed rather than quantities reported by exporting countries because some exporting countries report the number of permits issued rather than actual numbers of reptiles exported (UNEP-WCMC 2013). Only direct trade between exporting and importing countries was analysed, re-export data were excluded. This was because the inclusion of re-export data can lead to double counting and therefore elevated trade records. Re-export data are also unrelated to the country of origin of traded specimens. Because the 27 EU members are not required to report within-EU trade (due to the free trade agreement), rarely reported within-EU trade records were removed.

Comparisons were made between captive-bred (source 'C'), ranched ('R') and wild ('W') reptiles. Remaining sources including first generation ('F'); confiscated or

seized ('I'); pre-convention ('O'); unknown ('U') and source unreported ('blank') are incorporated in the 'total trade' figures that are presented.

Genus level records were not included when reporting the number of different species imported over time. However, these records were not excluded for any other analysis. Following CITES standard nomenclature as adopted by the Conference of the Parties (CITES, 2014b), and to avoid duplication, any data reported using synonyms were combined with data reported under the accepted name. Data recorded at subspecies level were combined with species data.

Exporting countries were assigned to geographical regions following the ISO 3166 list of countries maintained by the International Organisation of Standardization and used by the IUCN Red List of Threatened Species. For the top 100 species in trade, exporting countries were categorised as 'range' and 'non-range' according to species range information on the UNEP-WCMC SPECIES+ database and the IUCN Red List. Countries where species were listed as 'introduced' were considered 'non-range'. To compare imports from range versus non-range countries, the percentage of trade coming from range countries in 1996 was compared with 2012, excluding species which were CITES listed post-1996.

Analyses were conducted using IBM SPSS Statistics 20. Pearson's correlations were used to test for relationships between the proportions of imports from different sources (captive-bred, ranched, and wild) over time. A Sign Test was used to test for differences between proportions originating from range versus non-range countries across species.

2.4. Results

2.4.1. Global reptile trade

Over 18.8 million live Appendix II reptiles were imported globally for commercial purposes between 1996 and 2012. Most (96.8%) were captive-bred, ranched or sourced from the wild, with remaining sources (D, F, O, I, U and 'blank') accounting for 3.2%.

Following peaks in 1996 and 2001, there has been an overall decline in annual Appendix II reptile imports. Imports decreased by 32.8% from 2001 to 2012 at an average rate of 3.4% per year (Figure 2.4.1.1(a)).

Green iguana (*Iguana iguana*) consistently dominated the live reptile trade, with annual imports peaking at nearly one million in 1996 (Figure 2.4.1.2). In total, 8.7 million *I. iguana* were imported, accounting for close to half (46%) of all imports between 1996 and 2012. However, *I. iguana* imports decreased by 62% from 2001-2012. If *I. iguana* is removed from the data, global imports increase to 2003 and then decrease by 12% from 2003 to 2012 (Figure 2.4.1.1(b)). The royal python (*Python regius)* was the second most highly traded reptile, with about 2.7 million imported between 1996 and 2012, accounting for 14% of total trade. No other species comprised more than 4% of total trade, and the top ten most imported species accounted for 77% of all trade (Table 2.4.1).

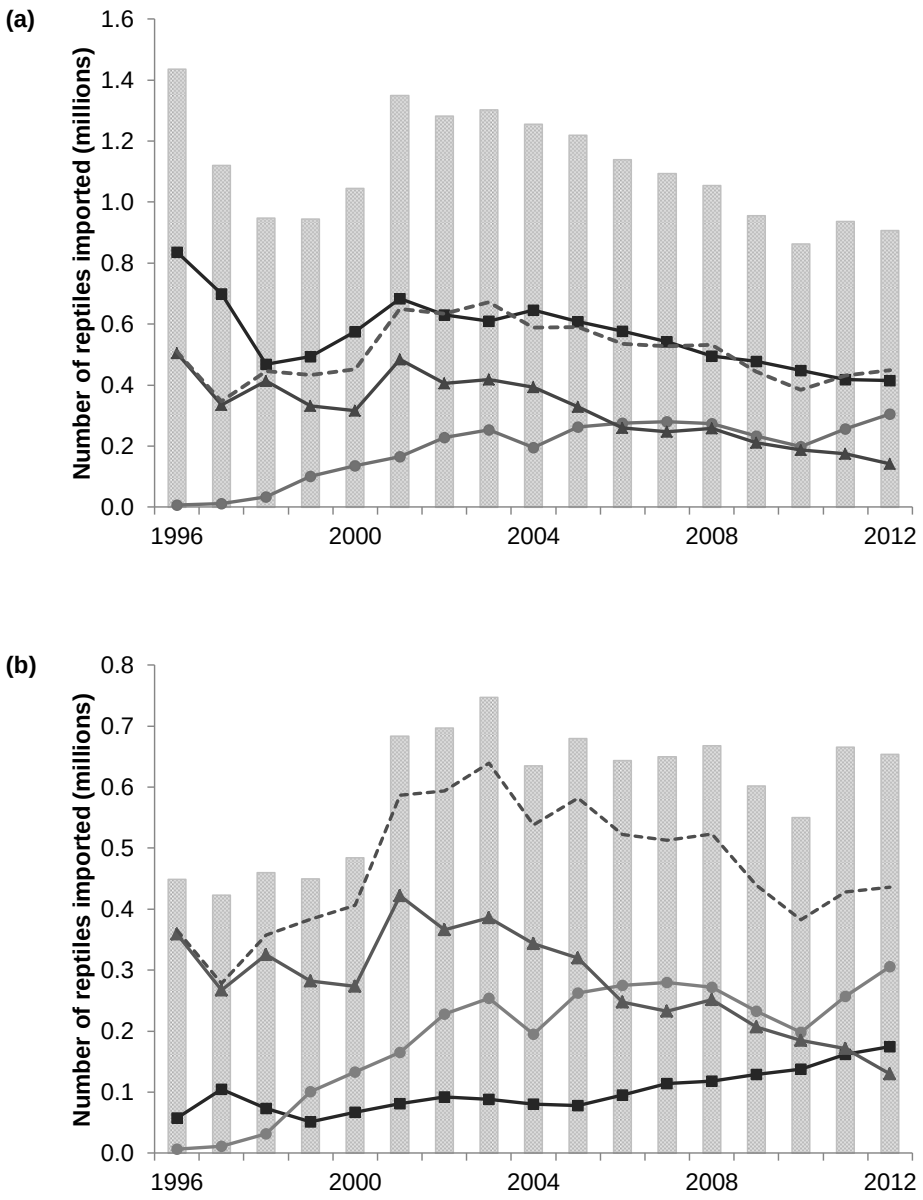

Figure 2.4.1.1 (a) Global imports in CITES Appendix II live reptiles traded for commercial purposes from 1996 to 2012 displaying totals in captive-bred (solid line with square markers), ranched (solid line with round markers), wild (solid line with triangle markers) and ranched plus wild (dashed line) against total annual imports (bars). When wild and ranched imports are combined, imports follow a similar pattern to that of total trade. (b) As above, excluding the green iguana (*Iguana iguana*), which accounts for 46.2% of all trade.

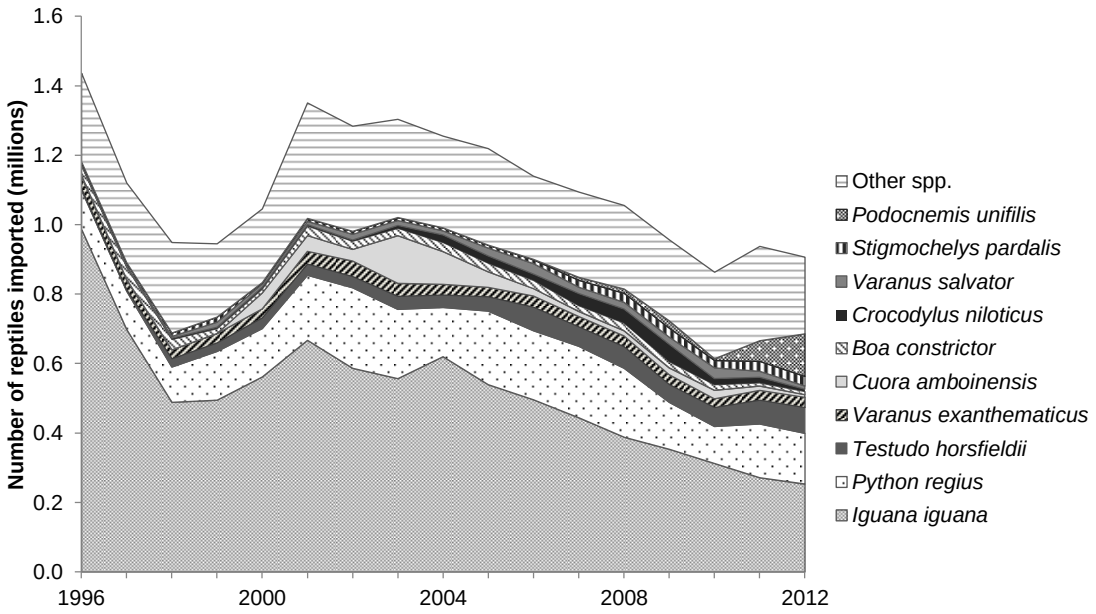

Figure 2.4.1.2. Summary of trade in ten CITES Appendix II reptile species most imported for live commercial trade between 1996 and 2012, including all sources. This graph displays stacked totals and not cumulative totals; therefore the thickness of the area indicates the quantity of trade for each species.

Table 2.4.1. Summary of trade in live CITES Appendix II reptiles most imported for commercial purposes as captive-bred, ranched and wild between 1996 and 2012, including the percentage trade each species comprised for each source over the time period, and the percentage change in the number of imports of each species from 1996 to 2012. Percentage change was calculated between 1996 and 2012 except in the following cases where trade records were incomplete: *C. amboinensis* (2000-2012), *A. cartilaginea* (2005-2012), *P. muscosus* (2000-2012), *G. elegans* (1997-2012), *C. niloticus* (1997-2012), *P. unifilis* (2005-2012), *T. horsfieldii* (2001-2012), *H. grandis* (2006-2012), *H. annandalii* (2009-2010), *P. sebae* (2006-2010), *T. graeca* (2005-2012)**,** *C. amboniensis* (2000-2012), *A. cartilaginea* (2006-2012) and *U. dispar* (1997-2012). Bold = species listed as threatened on the IUCN Red List (Endangered, Vulnerable or Critically Endangered).

Source	Total trade (mean per annum ± se)	Top 15 species in trade (% of total trade 1996-2012, % change 1996-2012)
All sources	18,858,195 (1,109,306 ± 42,113)	*Iguana iguana (46.2%, -74%), Python regius (14.4%, +29%), **Testudo horsfieldii** (3.7%, +1935%), Varanus exanthematicus (2.8%, -25%), Cuora amboinensis (2.7%, -83%), Boa constrictor (1.9%, -69%), Crocodylus niloticus (1.4%, +6091%), Varanus salvator (1.3%, +233%), Stigmochelys pardalis (1.1%, +375%), **Podocnemis unifilis** (1.2%, +90,775%), Chamaeleo senegalensis (1.1%, +21%), **Amyda cartilaginea** (1.1%, -34%), **Testudo graeca** (1.0%, +296%), Varanus niloticus (0.9%, -72%), **Python bivittatus** (0.7%, -88%)*
Captive-bred	9,622,228 (566,013 ±	*I. iguana (82.3%, -69%), B. constrictor (3.3%, -67%), S. pardalis (1.6%, +15,167%), P. regius (1.6%, -1%), **Testudo graeca** (1.3%, +730%), **P. bivittatus** (1.1%, -83%), Chamaeleo calyptratus (1.0%, +13,513%), Chelonoidis carbonaria (1.0%, +1565%), **Geochelone sulcata** (0.8%, +25,585%), **Ptyas mucosus** (0.8%, +478%), Testudo hermanni (0.7%, +478%),*

	27,482)	*Morelia viridis (0.4%, +1767%), C. niloticus (0.4%, +83,233%), Tupinambis teguixin (0.3%, +18%), Geochelone elegans (0.3%, +74,425%)*
Ranched	3,214,908 (189,112 ± 23,833)	*P. regius (63.1%, +3342%), C. niloticus (6.6%, +471%), **P. unifilis** (5.9%, +39,431%), V. exanthematicus (5.2%, +1191%), **T. horsfieldii** (4.4%, +1390%), C. senegalensis (3.9%, +12,022%), V. niloticus (2.8%, +281%), Chamaeleo gracilis (1.3%, +37742%), **Heosemys grandis** (1.3%, -100%), Kinixys belliana (0.8%, +1583%), **Kinixys homeana** (0.8%, +3164%), **Heosemys annandalii** (0.8%, +336%), V. salvator (0.7%, +133%), Python sebae (0.3%, +45%), **T. graeca** (0.3%, +517%)*
Wild	5,412,285 (318,370 ± 26,235)	*I. iguana (11.9%, -91%), C. amboinensis (9.3%, -83%), P. regius (9.2%, -97%), **T. horsfieldii** (8.2%, +1034%), V. exanthematicus (6.1%, -61%), V. salvator (4.1%, +233%), **A. cartilaginea** (3.7%, -34%), Uromastyx dispar (2.2%, -61%), Naja naja (1.9%, -97%), Phelsuma laticauda (1.7%, -91%), Cordylus tropidosternum (1.7%, -96%), Chamaeleo dilepsis (1.7%, -72%), C. senegalensis (1.4%, -81%), V. niloticus (1.4%, -99%), Phelsuma lineata (1.3%, -89%)*

From 1996 to 2012, the number of Appendix II species imported for commercial purposes increased from 142 to 234, totalling 388 different species over the entire time period, with 119 species common to both 1996 and 2012. This excludes 15 genus level records in 1996 and five in 2012, the decrease of which is likely to be a result of improved reporting. A total of 54 species in the dataset were listed post-1996, including 35 of the 234 species in trade in 2012.

2.4.2. Trends in live reptile production systems

Consistent with the decrease in total Appendix II reptile imports, there has been a decrease in the number of wild caught reptiles imported globally, decreasing by 71% from 2001 to 2012. Meanwhile, imports of ranched reptiles increased by more than 4740% from 1996 to 2012. Imports of captive-bred reptiles decreased by 39% from 2001 to 2012. However, if *I. iguana* is excluded, the trend shows a 202% increase in imports of captive-bred reptiles between 1996 and 2012 (Figure 2.4.1.1(b)) indicating that this species is responsible for the general decrease in captive-bred reptile imports.

Captive-bred reptiles represented about half of annual trade from 1998 to 2012, after peaking around 60% in 1996 and 1997. Wild reptile imports decreased from 35% in 1996 to 16% in 2012. Meanwhile, ranched reptiles increased from 0.4% to 34% of total trade. There was a significant negative relationship between the proportion of wild imports and the proportion of ranched imports between 1996 and 2012 (r=-0.85, n=17, p<0.001) and between the proportion of captive-bred and ranched imports (r=-0.76, n=17, p<0.001), demonstrating that trade in ranched reptiles increased as trade in both wild and captive-bred reptiles decreased.

If however, *I. iguana* and *P. regius*, which dominate the trade in captive-bred and ranched imports (Table 2.4.1), are removed, an alternative pattern emerges. In this case

there is a significant positive correlation between the proportion of captive-bred and ranched imports (r=0.86, n=17, p<0.001), as both increased over the time period. Conversely there is a significant negative relationship between the proportion of wild and captive-bred imports (r= 0.96, n=17, p<0.001) and the proportion of wild and ranched imports (r=-0.96, n=17, p<0.001), indicating that captive-bred and ranched imports increased as wild imports decreased.

Captive-bred reptiles

The trade in captive-bred species expanded from 77 to 152 species in 2012 (16 of which were listed post-1996). Trade of captive-bred *I. iguana* decreased from 93% to 58% of captive-bred imports, whilst trade in other species, notably Nile crocodile (*Crocodylus niloticus*), leopard tortoise (*Stigmochelys pardalis*) and Indian star tortoise (*Geochelone elegans*) increased over the time period (Table 2.4.1).

Ranched reptiles

The trade in ranched species expanded from eight in 1996, to 23 in 2012 (four of which were listed post-1996). Total trade in ranched reptiles represented by *P. regius* decreased from 60% to 42%, whilst the proportion of imports represented by various other species, particularly yellow-spotted river turtle (*Podocnemis unifilis*), graceful chameleon (*Chamaeleo gracilis*) and Senegal chameleon (*C. senegalensis*) increased (Table 2.4.1).

Wild reptiles

Imports of wild species changed from 113 in 1996, to 121 in 2012, representing an overall decrease considering that 20 of the species traded in 2012 were listed post-1996. *I. iguana* was the most heavily traded wild reptile (Table 2.4.1), but decreased

from 29% to 9% from 1996 to 2012. Imports in some wild species increased over the time period, most notably Horsfield's tortoise (*Testudo horsfieldii*), whilst imports in many others decreased (Table 2.4.1).

2.4.3. Regional trends

Main reptile exporting regions

The proportion of live reptiles exported from range countries was significantly higher in 1996 (range countries represented 98% of trade) than in 2012 (range countries represented 92% of trade) (Sign test: $Z = 2.04$, $p < 0.05$), when tested across 91 top traded species (100 most traded species excluding nine species listed post-1996).

Considering total imports from 1996 to 2012 on a regional scale, Mesoamerica was the largest exporting region, closely followed by sub-Saharan Africa. South America was the third largest exporting region, followed by South and South-East Asia, and West and Central Asia (Figure 2.4.3.1). See Supporting Information (Table S2.8.2) for a breakdown of trade levels and species exported from each region.

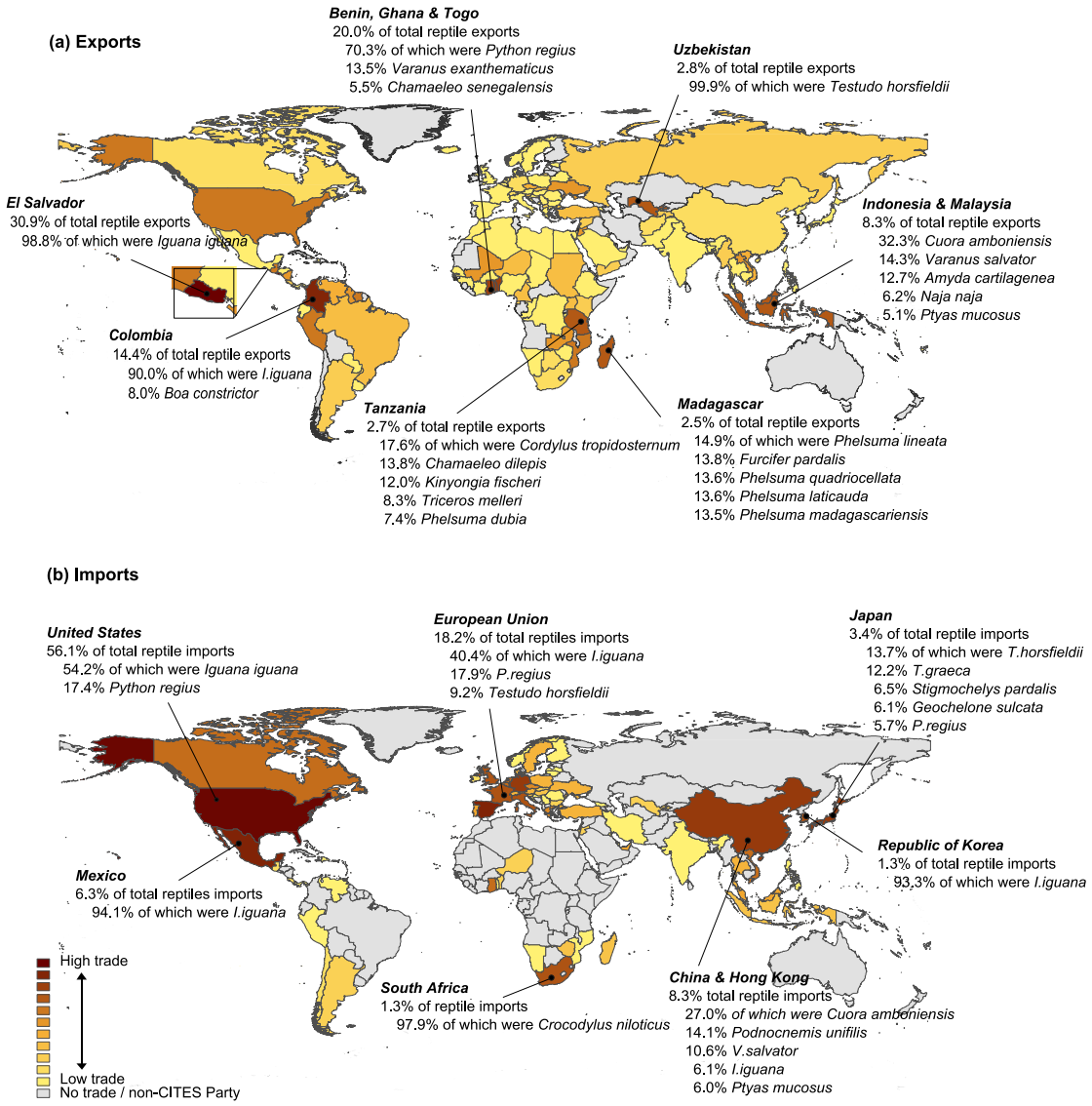

Figure 2.4.3.1. World map displaying (a) levels of exports and (b) levels of imports in live CITES Appendix II reptiles traded by individual countries for commercial purposes from 1996 to 2012. Figures based on importer-reported quantities obtained from the CITES Trade Database. Countries with text are those with the highest trade volumes. Countries from similar geographical areas have been pooled for the annotations e.g. 'Ghana, Benin and Togo', 'Malaysia and Indonesia'; however more information on exporting countries and regions is available in Supporting Information: Tables S2.8.1 and S2.8.2.

There was evidence of shifting regional patterns over time. This included a rapid drop in imports from South America in the late 1990's to an all-time low in 2010, before a rise in 2011 and 2012. Meanwhile imports from Mesoamerica increased from 1996 to a peak in 2004 and then decreased. Imports from West and Central Asia and North America steadily increased over the time period, whilst imports from sub-Saharan Africa and South and South-east Asia have fluctuated (Supporting Information: Figure S2.8(a)).

Regional trends in captive-bred reptiles

Exports in captive-bred reptiles were dominated by Mesoamerica and South America (Figure 2.4.3.2, Supporting Information: Figure S2.8(b)). This was largely due to *I. iguana*, in which trade shifted from South America (mainly Colombia) to Mesoamerica (mainly El Salvador) in the late 1990s. Imports of captive-bred reptiles from Sub-Saharan Africa have fluctuated, with a notable increase in imports of captive-bred leopard tortoises (*Stigmochelys pardalis*): 151 in 1996 to 24,656 in 2012. There has been a steady increase in imports of captive-bred reptiles from North America over the time period; notably *P. regius* which increased from zero in 1996 to 12,414 in 2012, supplying 8% of the total trade in this species in 2012.

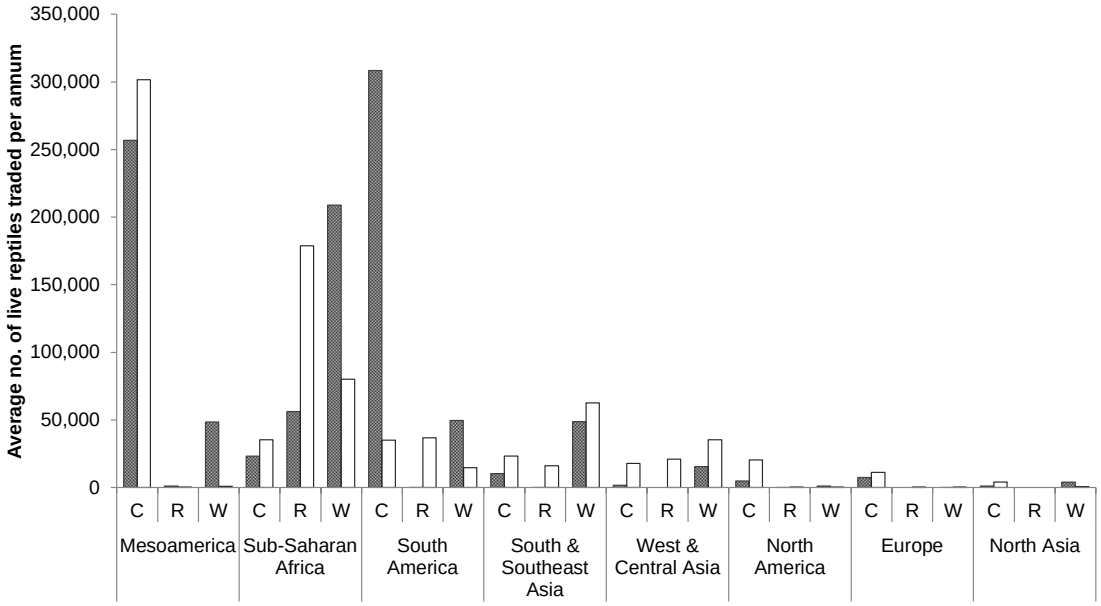

Figure 2.4.3.2. The average number of live CITES Appendix II reptiles traded for commercial purposes as captive-bred (C), ranched (R), and wild (W) for two five year periods: 1996-2000 (grey bars) and 2008-2012 (white bars). Oceania, East Asia, North Africa and the Caribbean Islands export on average less than 2000 individuals per year and are omitted from this figure.

Regional trends in ranched reptiles

Sub-Saharan Africa dominated exports in ranched reptiles, increasing rapidly from 6 323 individuals in 1996 to 265,936 in 2007, with *P. regius* accounting for 74% of this trade. However, by 2010 trade in ranched reptiles from this region had decreased by 55%. Meanwhile there was a sharp increase in ranched reptiles originating from South America, South and South-East Asia, and more gradually from West and Central Asia (Figure 2.4.3.2, Supporting Information: Figure S2.9(c)). Imports of ranched reptiles from South and South-East Asia have been sporadic, increasing suddenly in 2010. This

mainly included giant Asian pond turtle (*Heosemys grandis,* 38% of trade in ranched reptiles from this region), yellow-headed temple turtle (*H. annandalii,* 24%) and common water monitor (*V. salvator,* 22%). The more recent increase from South America was largely due to imports of ranched yellow-spotted river turtle (*Podocnemis unifilis,* 96%). The increase in imports from West and Central Asia was predominantly due to trade of ranched *T. horsfieldii* (91%).

Regional trends in wild sourced reptiles

Wild trade decreased in many regions including sub-Saharan Africa, South America and Mesoamerica (Figure 2.4.3.2, Supporting Information: Figure S2.8(d)). However, there was a slight increase from West and Central Asia consisting mainly of *T. horsfieldii* (86%). Trade in wild reptiles from South and South-East Asia has fluctuated greatly.

Main reptile importing regions

The United States was the principal importing country accounting for over half (56.1%) of all live reptile imports (Figure 2.4.3.1(b)). The EU was the second largest importer (18.2%), followed by Mexico (5.8%) and Hong Kong (5.8%) (Supporting Information: Table S2.8.1). Imports into the United States have decreased by 76.8% from 1996 to 2012, whilst imports into Europe have decreased by 44.2% from 2006 to 2012.

2.5. Discussion

According to the data, international trade in CITES Appendix II live reptiles has decreased over the last ten years, with a dramatic switch from wild sourcing to ranching. Equally, there has been a small increase in the proportion of reptiles sourced

from non-range countries. Despite this, the diversity of species represented in trade appears to have increased, reflecting the growing demand for a wide variety of species (Auliya 2003; Stuart et al. 2006).

Our analysis focussed on direct trade only to reduce double counting of re-exported specimens, allowing better representation of the true numbers and sources of individuals in live trade. However, importing countries may not represent the final destination of specimens. For example, the US plays a major role as a re-exporter of imported animals, probably due to its well-established pet market and central location (Hoover 1998; Schlaepfer et al. 2005). Additionally, import data do not always represent the final use for specimens. For example, much of the trade in live Nile crocodiles (*C. niloticus* - seventh most traded species) is likely to be supplying crocodile farming industry for skins and/or meat. Additionally, trade in South Asian box turtle (*Cuora amboinensis* - fifth most traded species), is thought to supply demand for consumption and Traditional Chinese Medicine (TCM) (Schoppe 2009). It is assumed that much of the remaining trade is indicative of trade destined for pet markets.

It is important to note that the data analysed comprise a subset of the overall global trade in reptiles as much trade goes unrecorded (e.g. illegal, domestic, and non-CITES trade). Additionally, this analysis does not include trade in products and derivatives (e.g. skins). Comparisons have been drawn between CITES data and national trade data for the US using the USFWS Law Enforcement Management Information System (LEMIS), which includes non-CITES trade. Herrel & Meijden (2014) reported a positive relationship ($r^2 = 0.71$) between the total import number of live reptiles and amphibians recorded by the USFWS and the CITES database between 2000 and 2009. They also reported a number of other similarities between datasets, including the

approximate proportion of imports comprised of captive-bred individuals and a recent decline in total imports. However, there were notable differences in the species dominating trade with *Trachemys scripta* (non-CITES) comprising 77% of reptiles traded, and for exports, the CITES data were a less reliable indicator of trade from the US. Schlaepfer et al. (2005) made similar comparisons for 1998-2002 and reported that 28-56% of the 25 most commonly traded reptile species in the US were CITES listed (including pets, skin products, food and TCM). It is difficult to determine how indicative of overall global wildlife trade CITES data are, therefore, findings drawn from data presented herein should not be taken to represent all trade in reptiles. Nonetheless, CITES data form the only comprehensive dataset of global reptile trade and therefore provide an invaluable source of information for monitoring emerging trends in an important subset of species considered threatened by international trade. For a detailed explanation of limitations and caveats associated with CITES trade data see UNEP-WCMC (2012).

There are a variety of complex factors and interactions affecting trade dynamics including CITES controls (new species listings on appendices, trade suspensions, quotas), regional measures (e.g. European import suspensions and opinions), national measures (domestic legislation, trade policies and national quotas), taxonomic changes, biological effects (species rarity), as well as market and economic forces. For these reasons, providing an in-depth explanation of causal factors for specific trade patterns, across several species and countries at the same time is not viable. A number of studies have provided region or taxon specific analyses of trade data (Arroyo-Quiroz et al. 2007; Carpenter et al. 2005; Li and Jiang 2014; Luiselli et al. 2012) but, as far as we are aware this is the most comprehensive global overview of the commercial trade in live Appendix II reptiles.

2.5.1. Decline in global reptile trade

The decline in commercial trade of Appendix II live reptiles may be due to a number of factors, specifically including increased legislative controls, reduced demand, increased captive breeding within consumer nations or external factors such as the global economic climate. The reduction in trade in *I. iguana* was a contributing factor as this species accounted for nearly half of all trade and its imports have decreased considerably, possibly due to reduced demand (Stephen et al. 2011). However, this species is not entirely responsible for the reduction in global imports. Furthermore, a total of 54 species imported over the time period have been newly listed on the appendices since 1996, including a number of turtle species from South-East Asia which feature heavily in trade. This includes *Cuora* spp. (*C. amboinensis* – fifth most traded species) at CoP11 (Kenya, 2000), *Heosemys* spp. (*H. grandis*, *H. annandalii* and *H. spinosa*) at CoP12 (Chile 2002) and *Amyda cartilaginea* (12^{th} most traded species) at CoP14 (Bangkok 2004). Therefore the trade data show an overall decreasing trend since 2001, despite additional species listings.

Increased captive breeding of reptiles outside of their source countries may be satisfying an increasingly large proportion of the demand for pet reptiles within consumer nations, thereby reducing demand for international trade. Data to this effect are lacking, but, there is a significant increase in the percentage of reptiles exported from non-range countries in 2012 compared to 1996. This reflects trade in captive-bred animals, often occurring in developed, consumer nations where adequate resources and expertise exist. Despite the proportion of global trade represented by captive-bred individuals remaining relatively constant between 1996 and 2012, trade in captive-bred *I. iguana* decreased considerably, indicating that numerous other species are increasingly being imported as captive-bred. Additionally, when *I. iguana* is removed

from the dataset, there is evidence of an increase in imports of captive-bred reptiles over the time period. Furthermore, Herrel & Meijden (2014) reported a steadily increasing proportion of captive-bred individuals in the trade when analysing USFWS export data from the US.

The benefits and impacts of captive breeding for supplying commercial trade in wildlife are subject to much debate (Abbott and van Kooten 2011; Bulte and Damania 2005; Drury 2009; Hutton et al. 2001). On one hand, captive breeding reduces pressure on wild populations and particularly for reptiles, consumers often prefer captive-bred specimens as they are easier to keep owing to lower aggression and reduced parasitic infection (Auliya 2003). However, wildlife trade can bring considerable foreign capital to countries of origin, with benefits passed to a network of hunters and collectors (Auliya 2003; Roe 2002). In certain circumstances sustainable trade may support livelihoods of collectors, which can create values for traded species, and promote their conservation, whilst also increasing political motivation to direct resources towards conservation (Hutton and Webb 2003). However, if the market is saturated by captive-bred specimens from beyond source countries, trade in wild specimens may be displaced thus reducing benefits returning to stakeholders in range countries, which may in turn threaten incentive-based conservation. Even when practiced within range countries, captive breeding may benefit few people and have limited positive impacts on conservation (Arroyo-Quiroz et al. 2007; Hutton and Webb 2003). Essentially all *I. iguana* in international trade are produced on a few large commercial farms that could produce enough iguanas to exceed world market demand - small farms do not appear to be economically viable and the conservation value of iguana farming is thought 'dubious' (Stephen et al. 2011). Captive breeding within range states can also negatively affect species conservation as it may rely on harvest of wild animals to

bolster breeding stock (Haitao et al 2007) and could create a loophole for illegal laundering of wild animals (Lyons and Natusch 2011). For this reason Madagascar currently does not allow exports of captive-bred CITES reptiles and amphibians (Madagascar Management Authority, personal communication).

2.5.2. Shifting production systems - increase in ranching

Whilst the international trade in CITES Appendix II wild and captive-bred reptiles decreased between 2001 and 2012, there has been a substantial increase in imports of ranched reptiles. A negative correlation between ranched and wild caught reptiles does not signify causation, but it may indicate that trade in ranched reptiles is replacing some trade in wild reptiles. Although the trade in ranched reptiles is dominated by *P. regius*, when this species is removed, the relationship remains, demonstrating that numerous other species are increasingly being traded as ranched. A similar switch in trade from wild to captive-bred and ranched sources is well known for crocodiles (Hutton et al. 2001) and has also been demonstrated for monitor lizards (Pernetta 2009).

The shift towards more highly managed and concentrated systems such as captive breeding, artificial propagation and ranching is often associated with increased trade controls (Jenkins and Broad 1994; Roe 2002). This is promoted within CITES through exemptions for captive-bred Appendix I and II specimens, and a resolution allowing transfer of populations from Appendix I to Appendix II specifically for ranching, provided the programme benefits conservation of the local population. Ranching was originally used for crocodilians transferred from Appendix I to Appendix II and has been instrumental in improving the conservation status of some crocodilian species (Ross and Espinosa 1998; Thorbjarnarson and Velasco 1999) whilst also displacing

illegal trade (Hutton and Webb 2003) and generating funds for surveys and management (Jenkins and Broad 1994; Thorbjarnarson 1999). Over the years, ranching has been increasingly applied to exports in Appendix II species, but there is little known about the systems employed. In the case of *P. regius* from Ghana, gravid females are collected from wild and kept in captivity until they have laid their eggs which are then artificially incubated. Following this, females plus 10% of neonates are re-released back into the wild (Gorzula et al. 1997). *P. regius* is collected from traditionally managed farmland by villagers who are said to protect the snakes as a key resource (Luiselli et al. 2012). A similar practice is used for ranching of *V. exanthematicus* (Bennett 2001) and Giant Amazon River Turtles *Podnocnemis expansa* in the Amazon (Bonach et al. 2003).

Given that captive breeding is often economically unviable in developing countries (Lyons and Natusch 2011), ranching may provide a more cost-effective means to supply trade. As well as reducing impacts on local populations relative to wild collection, ranching systems have potential to benefit livelihoods and promote incentive-based conservation if local people are involved in collection of young life stages from the wild. However, undoubtedly a switch from wild collecting to ranching would affect some beneficiaries (Roe 2002) and there are limited baseline data on the contribution that reptile trade makes to livelihoods in developing countries. Furthermore, the benefits of such systems are dependent upon complex systems of resource rights; if hunters do not own the land where animals are collected, they may not be empowered to protect it (Auliya 2003). Additionally, the impacts concerning genetics, survival and disease of re-released animals are not well understood.

Unfortunately, the use of source code ‘R’ (indicating ranched animals) in CITES has been subject to some ambiguity. Following CoP14 (Netherlands, 2007) its use was

reviewed and concluded that it had been used erroneously in several countries. Despite guidance provided by CITES on the use of source codes, there are likely to be inconsistencies amongst data which is reported by Parties. The review acknowledged that some ranching operations seemed to have some conservation benefit (CoP15, Doc 29), but there were also indications that benefits may be absent, unknown or questionable. However, very little information was received with only six out of 27 Parties involved in the review responding. Given that significantly more reptiles are apparently being sourced from ranching operations it is imperative that more research is directed towards understanding the benefits and impacts of such systems for commercially traded reptiles.

2.5.3. Conclusion

Commercial trade in live wildlife is dynamic and complicated by a variety of factors. Increased legislative control, economics or consumer demand may have driven shifting production of reptiles from wild to ranched sources. Previous research has shown that trade bans may not always be the best solution for controlling wildlife trade (Rivalan et al. 2007). Indeed, sustainable and well-managed wildlife collection has potential to support livelihoods and promote valuation and stewardship of species and habitats (Andreone et al. 2006). In this case the substantial increase in ranched reptiles in place of wild reptiles may have significant conservation and sustainability consequences, as pressure is reduced on wild populations and benefits from the trade are retained within range states. Management of the trade in order to ensure sustainability remains a challenge, but certification schemes such as the FSC Forest Certification Scheme play an important role in other traded products. It remains to be seen whether such systems could be applied to the exotic pet trade, stimulating sufficient demand from end-users.

In terms of conservation, the best mode of supplying live reptiles for trade will vary depending on the species conservation status, biology and demand. Ranching programs are based on utilising young life stages that would normally have high mortality in the wild, and are therefore applied to species with relatively large clutch sizes and high mortality between the egg and adult life stages. Additionally, whilst species with high population estimates and a broad distribution could withstand certain levels of exploitation associated with wild trade or ranching, collection of species with low population estimates could easily lead to local extinction (Andreone et al. 2006). In addition to this, due to the boom-and-bust nature of wildlife trade, programs based predominantly on the sale of wildlife products for a single market makes conservation outputs vulnerable so for programs to ensure sustainability, they should find ways to diversify outputs (Thorbjarnarson 1999).

Knowledge of consumer demand and preferences are undoubtedly important in understanding future dynamics of the live reptile trade. Although some consumers may prefer captive-bred animals, there are likely to be others who seek rare individuals not currently available in captivity, or prefer wild sourced animals in order to bolster bloodlines. Therefore, without a good understanding of the demand for traded species, it is difficult to know whether programs based on breeding commercially important species will reduce demand for their wild counterparts. A better understanding of the impacts of alternative modes of production, such as ranching, along with an improved understanding of consumer demand in the commercial live trade may help us understand not only the drivers of change, but also mitigate for negative consequences of the trade in the future.

2.6. Acknowledgements

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2.8. Supporting Information

Table S2.8.1. Summary of trade in 20 live Appendix II reptile species most exported for commercial purposes between 1996 and 2012 and main exporting and importing countries (only displaying countries exporting ≥ 1% of trade) for the species and time period concerned. European member states are listed individually as well as together (EC). The species are listed in rank order according to import volume from highest to lowest. Bold text: non-range countries.

Species	IUCN Red List	Total trade (mean per annum ± se)	% of total trade	Main exporting countries	Main importing countries
All species	-	18,858,195 (1,109,306 ± 42,113)	100	El Salvador (30.6%), Colombia (14.4%), Togo (7.7%), Ghana (6.5%), Benin (5.8%), Indonesia (4.2%), Malaysia (4.1%), Uzbekistan (2.8%), Tanzania (2.7%), Madagascar (2.5%), Mozambique (1.6%), Peru (1.3%), Guatemala (1.3%), USA (1.3%), Suriname (1.2%), Mali (1.1%), Guyana (1.0%), Ukraine (1.0%)	USA (56.1%), *EC (18.2%),* Mexico (6.3%), Hong Kong (5.8%), Spain (4.9%), Germany (3.4%), Japan (3.4%), China (2.5%), Italy (1.9%), France (1.9%), UK (1.7%), South Africa (1.3%), Rep. of Korea (1.3%), Ghana (1.2%), Netherlands (1.0%), Belgium (1.0%)
Iguana iguana	Not listed	8,715,988 (512,705 ± 43,623)	46.2	El Salvador (65.3%), Colombia (28.0%), Guatemala (2.8%), Suriname (1.9%), Nicaragua (1.0%)	USA (65.7%), *EC (15.9%),* Mexico (12.7%), Spain (7.6%), Rep. of Korea (2.6%), Italy (2.2%), Germany (1.5%), Greece (1.3%), Hong Kong (1.1%)
Python regius	LC	2,721,455 (160,086 ± 10,161)	14.4	Togo (35.0%), Ghana (32.5%), Benin (29.9%), **USA (2.0%)**	USA (67.7%), *EC (22.5%)*, Germany (6.7%), Ghana (5.0%), France (3.9%), UK (3.4%), Italy

					(2.2%), Spain (2.1%), Belgium (1.5%), Japan (1.4%), Hong Kong (1.0%)
Testudo horsfieldii	VU	700,274 (41,193 ± 5163)	3.7	Uzbekistan (74.3%), **Ukraine (19.6%),** Tajikistan (3.0%), Russian Federation (2.1%)	*EC (45.2%)*, USA (38.5%), Japan (12.6%), UK (10.0%), Italy (9.7%), Spain (7.9%), France (6.0%), Germany (4.8%), Czech Republic (3.2%), Ukraine (2.0%), Poland (1.0%), Uzbekistan (1.0%)
Varanus exanthematicus	LC	527,385 (31,023 ± 1312)	2.8	Ghana (47.9%), Togo (31.4%), Benin (19.5%)	USA (80.0%), *EC (14.0%),* UK (4.5%), Germany (3.1%), Japan (2.2%), Spain (1.7%), Canada (1.6%), Ghana (1.5%), France (1.3%), Czech Republic (1.0%)
Cuora amboinensis	VU	512,249 (39,404 ± 10,307)	2.7	Malaysia (65.8%), Indonesia (32.7%), Laos (1.6%)	Hong Kong (44.4%), China (38.1%), USA (8.6%), Malaysia (4.0%), Japan (1.8%), Viet Nam (1.6%), *EC (1.2%)*
Boa constrictor	Not listed	360,875 (21,228 ± 1845)	1.9	Colombia (60.4%), Nicaragua (21.2%), *EC (4.4%),* **Czech Republic (4.2%),** Guyana (4.1%), **USA (2.7%)**, Suriname (2.5%), El Salvador (2.5%)	USA (84.0%), *EC (11.9)*, Germany (2.8%), France (2.0%), Belgium (1.7%), Netherlands (1.6%), Spain (1.5%), Canada (1.2%), Japan (1.0%)
Crocodylus niloticus	LC	258,416 (15,201 ± 3595)	1.4	Mozambique (94.1%), Botswana (5.0%)	South Africa (94.2%), Zimbabwe (4.8%)
Varanus salvator	LC	253,465 (14,910 ± 2024)	1.3	Malaysia (65.5%), Indonesia (22.5%), Laos (9.5%), Myanmar (2.4%)	Hong Kong (61.7%), USA (15.1%), Viet Nam (11.9%), Japan (3.8%), China (3.7%), *EC (3.1%)*
Stigmochelys pardalis	Not listed	244,661 (14,392 ± 2009)	1.1	Zambia (56.9%), **El Salvador (14.4%),** Tanzania (13.7%), Mozambique (6.1%), Uganda (3.1%), **USA (1.8),** South Africa (1.4%), Kenya (1.3%)	*EC (43.7%),* Hong Kong (21.6%), Japan (17.2%), Spain (10.1%), Netherlands (9.0%), Italy (6.1%), USA (5.9%), France (4.9%), Germany (4.9%), UK (4.8%), Mexico (4.4%), Rep. of Korea (2.8%), Thailand (2.0%), Czech Republic (1.3%),

					Denmark (1.0%), Malaysia (1.0%)
Podocnemis unifilis	VU	231,978 (15,465 ± 8644)	1.2	Peru (98.0%), Venezuela (1.8%)	Hong Kong (95.5%), Mexico (1.7%), *EC (1.4%),* Japan (1.0%)
Chamaeleo senegalensis	LC	209,511 (12,324 ± 1265)	1.1	Togo (59.1%), Benin (27.5%), Ghana (11.7%)	USA (66.1%), *EC (21.6%)*, Ghana (8.4%), Spain (6.1%), Belgium (5.1%), France (5.1%), Japan (2.7%), Germany (1.3%), Italy (1.2%)
Amyda cartilaginea	VU	198,958 (24,870 ± 3824)	1.1	Indonesia (95.0%), Malaysia (5.0%)	Singapore (55.1%), Hong Kong (33.5%), China (11.3%)
Testudo graeca	VU	181,057 (10,650 ± 1653)	1	Jordan (47.6%, **Lebanon (18.2),** Turkey (16.8%), Syria (11.8%), **Ukraine (2.6%)**	Japan (43.6%), USA (22.9%), *EC (21.1%)*, Germany (9.0%), United Arab Emirates (7.0%), Hong Kong (2.6%), Slovenia (2.5%), France (2.1%), Czech Republic (1.1%)
Varanus niloticus	Not listed	178,758 (10,515 ± 1040)	0.9	Togo (52.5%), Benin (35.2%), Tanzania (8.8%), Ghana (2.3%)	USA (81.0%), *EC (8.4%),* Ghana (7.3%), Japan (2.1%), France (2.1%), Germany (1.9%), Spain (1.3%)
Python bivittatus	VU	131,446 (7732 ± 1336)	0.7	Viet Nam (80.1%), *EC (14.5%),* **Czech Republic (14.2%), USA (4.1%)**	USA (72.3%), *EC (19.3%)*, France (4.2%), Germany (3.8%), Belgium (3.5%), Spain (2.9%), Malaysia (2.4%), Mexico (1.9%), Netherlands (1.7%), Italy (1.5%), UAE (1.3%)
Geochelone sulcata	VU	129,321 (7607 ± 784)	0.7	**USA (67.5%),** Mali (9.9%), **Ghana (8.3%), El Salvador (7.8%),** Togo (2.7%), *EC (1.7%),* Slovenia (1.6%)	Hong Kong (36.4%), Japan (30.7%), *EC (19.9%),* France (5.8%), Ghana (5.0%), Italy (2.9%), Mexico (2.5%), Spain (2.5%), Germany (2.4%), Malaysia (2.4%), Rep.of Korea (2.2%), UK (1.8%), USA (1.4%), Thailand (1.2%)
Uromastyx dispar	Not listed	126,921 (7933 ± 1766)	0.7	Mali (94.3%), Chad (1.7%), **El Salvador (1.7%)**	USA (81.7%), Canada (4.5%), *EC (4.0%),* Niger (3.5%), Benin (2.6%), Ghana (1.4%), Japan (1.2%), Spain (1.0%)

Chelonoidis carbonaria	Not listed	119,562 (7033 ± 1064)	0.6	Brazil (36.1%), Venezuela (32.4%), Suriname (7.6%), Guyana (7.3%), Colombia (6.9%), **Barbados (6.2%), El Salvador (2.1%)**	USA (39.4%), *EC (26.9),* Hong Kong (19.1%), Japan (7.2%), Spain (6.7%), UK (4.9%), Mexico (4.5%), Netherlands (4.3%), Germany (3.7%), Italy (2.9%), Belgium (2.4%)
Chamaeleo calyptratus	LC	112,764 (6633 ± 1057)	0.6	***EC (56.5%),*** **Slovakia (31.6%), Czech Republic (24.1%), Ukraine (21.5%),** Yemen (6.9%), **Jordan (6.7%), USA (4.3%), El Salvador (2.5%)**	USA (36.8%), *EC (21.7%)*, Japan (17.5%), Hong Kong (9.1%), Canada (8.4%), France (6.8%), Spain (5.4%), Mexico (3.2%), Thailand (2.4%), Czech Republic (2.2%), Italy (1.9%), Germany (1.6%), Sweden (1.3%)
Naja naja	Not listed	110,842 (6520 ± 1718)	0.6	**Malaysia (83.3%), Cambodia (5.4%), Myanmar (4.5%), Indonesia (4.4%), Laos (2.2%)**	China (53.9%), Hong Kong (28.5%), Japan (10.3%), Viet Nam (6.7%)

Table S2.8.2. Summary of trade in Appendix II live reptiles imported for commercial purposes from all 12 regions between 1996 to 2010, including total number of live reptiles imported over the time period (plus mean number per year and standard error), main species exported (only reporting species comprising ≥1% of trade from that region for the time period concerned) and main importing countries (only reporting countries importing ≥1% of trade from that region). The regions are listed in rank order according to import volume from highest to lowest.

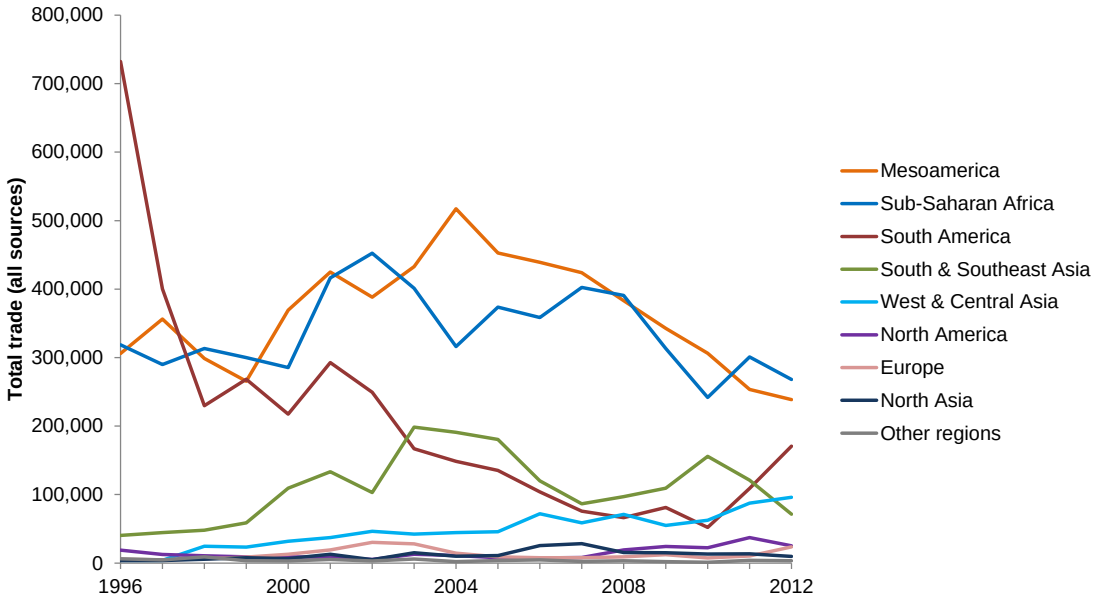
Region	**Exports**	**Total trade (mean per annum ± se)**	**Main species exported (≥1% of trade)**	**Main importing countries (≥1% of trade)**
World	Decreasing trend since 2001	18,858,195 (1,109,306 ± 42,113)	*Iguana iguana (46.2%), Python regius (14.4%), Testudo horsfieldii (3.7%), Varanus exanthematicus (2.8%), Cuora ambionensis (2.7%), Boa constrictor (1.9%), Crocodylus niloticus (1.4%), Varanus salvator (1.3%), Stigmochelys pardalis (1.1%), Podocnemis unifilis (1.2%)*	USA (56.1%), *EC (18.2%),* Mexico (6.3%), Hong Kong (5.8%), Spain (4.9%), Germany (3.4%), Japan (3.4%), China (2.5%), Italy (1.9%), France (1.9%), UK (1.7%), South Africa (1.3%), Rep. of Korea (1.3%), Ghana (1.2%), Netherlands (1.0%), Belgium (1.0%)
Mesoamerica	Increasing to 2004, decrease thereafter	6,199,438 (364,673 ± 19,085)	*I. iguana (97.5%), B. constrictor (1.4%)*	USA (52.4%), Mexico (18.1%), Spain (10.7%), Rep. of Korea (3.4%), Italy (3.1%), Germany (2.0%), Greece (1.7%), Hong Kong (1.7%), France (1.0%)

Sub-Saharan Africa	Fluctuating, peak in 2002 and 2007, decrease since 2007	5,742,729 (337,808 ± 14,349)	*P. regius (46.3%), V. exanthematicus (9.2%), C. niloticus (4.5%), Chamaeleo senegalensis (3.6%), S. pardalis (3.6%), Varanus niloticus (3.1%), Uromastyx dispar (2.2%), Phelsuma laticauda (1.6%), Cordylus tropidosternum (1.6%), Chamaeleo dilepsis (1.5%), Chamaeleo gracilis (1.4%), Phelsuma lineata (1.2%), Uromastyx geyri (1.2%), Furcifer pardalis (1.1%), Phelsuma quadriocellata (1.1%), Phelsuma madagascariensis (1.1%), Kinyongia fischeri (1.1%), Furcifer lateralis (1.0%)*	USA (60.8%), Germany (6.5%), South Africa (4.3%), Ghana (4.0%), Japan (3.9%), France (3.3%), Spain (2.7%), UK (2.5%), Netherlands (2.1%), Belgium (1.6%), Italy (1.6%), Hong Kong (1.5%), Canada (1.1%)
South America	Decreasing trend from 1996 to 2010, increase since 2010	3,500,117 (205,889 ± 40,001)	*I. iguana (75.1%), B. constrictor (7.0%), Podnocemis unifilis (6.6%), Chelonoidis carbonaria (3.1%), Caiman crocodilus crocodilus (2.3%), Tupinambis teguixin (1.8%), Corallus hortalanus (1.1%)*	USA (86.7%), Hong Kong (7.0%)
South & Southeast Asia	Fluctuating, peak in 2003 and 2010	1,868,567 (109,916 ± 12,136)	*Cuora amboinensis (27.4%), V. salvator (13.6%), Amyda cartilaginea (10.6%), Naja naja (5.9%), Python bivittatus (5.7%), Heosemys grandis (4.5%), Morelia viridis (2.5%), Naja sputatrix (2.4%), Heosemys annandalii (2.2%), Python reticulatus (2.2%), Siebenrockiella crassicollis (2.1%), Python curtus (2.1%), Ortilia borneensis (2.1%), Heosemys spinosa (1.1%), Python brongersmai (1.0%)*	Hong Kong (31.2%), China (24.9%), USA (19.1%), Viet Nam (8.4%), Singapore (6.1%), Japan (3.0%), Malaysia (1.7%), France (1.3%)
West & Central Asia	Overall steady increasing trend since 1996	806,834 (47,461 ± 6310)	*T. horsfieldii (67.5%), Testudo graeca (21.2%), Geochelone elegans (3.9%), Chamaeleo calyptratus (1.9%), Uromastyx aegyptia (1.7%)*	USA (37.0%), Japan (23.2%), UK (8.9%), Italy (6.6%), Spain (4.9%), Czech Republic (3.0%), France (2.6%), Ukraine (1.8%), Hong Kong (1.0%)

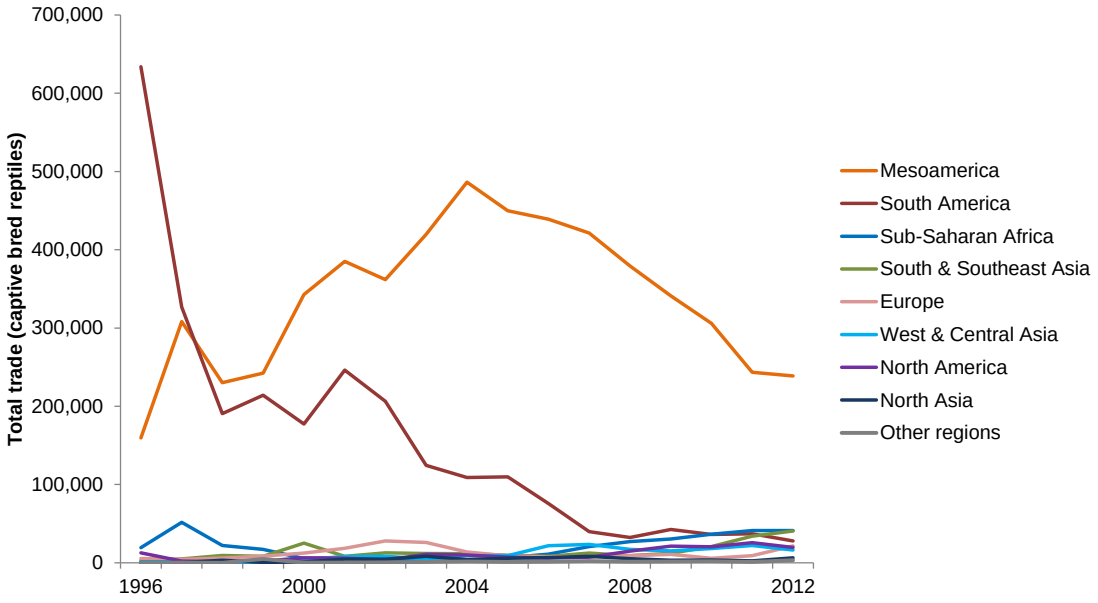
North America	Gradual increase since 2003	249,195 (14,659 ± 2082)	*Geochelone sulcata (35.0%), P. regius (23.3%), I. iguana (13.6%), B. constrictor (4.3%), Graptemys pseudogeograp*	Japan (25.5%), Hong Kong (19.2%), UK (9.8%), Rep.of Korea (8.5%), Germany (8.2%), Mexico (6.0%), UAE (4.0%), France (3.0%), Sweden (1.9%), USA (1.6%), Malaysia (1.4%), Spain (1.1%), Canada (1.1%), Thailand (1.0%), Italy (1.0%)
Europe	fluctuating/steady, peak in 2007 and 2012	217,706 (12,806 ± 1908)	*Testudo hermanni (36.2%), C. calyptratus (29.3%), P. bivittatus (8.8%), B. constrictor (7.4%), Testudo marginata (2.8%), Epicrates cenchria (2.3%), I. iguana (1.4%), Geochelone sulcata (1.3%)*	USA (19.5%), Japan (16.0%), Germany (14.6%), France (8.2%), UK (6.0%), Hong Kong (5.3%), Spain (4.7%), Canada (4.1%), Netherlands (2.7%), Italy (2.5%), Poland (2.0%), Mexico (1.8%), Czech Republic (1.8%), Thailand (1.6%), Slovenia (1.5%), Sweden (1.4%), Belgium (1.1%), Switzerland (1.1%)
North Asia	Fluctuating, peak in 2007	202,066 (11,886 ± 1672)	*T. horsfieldii (75.2%), C. calyptratus (12.2%), Testudo graeca (2.3%), Furcifer pardalis (2.2%), I. iguana (1.5%), Uromastyx ornata (1.4%), Geochelone elegans (1.4%)*	USA (27.6%), France (14.9%), Japan (12.3%), Spain (9.1%), Italy (7.5%), Germany (6.0%), UK (5.8%), Hong Kong (4.8%), Poland (3.6%), Belgium (1.4%), Czech Republic (1.0%), Ireland (1.0%)
Oceania	Low trade	32,151 (2009 ± 351)	*Corcucia zebrata (51.4%), Varanus indicus (26.3%), Candoia cainata (12.4%), Candoia bibroni (8.6%)*	USA (65.7%), Japan (8.4%), France (8.4%), Germany (6.6%), Malaysia (3.6%), Slovenia (2.6%), Thailand (1.3%), Hungary (1.1%)
East Asia	Low trade	18,181 (1069 ± 348)	*Testudinidae spp. (31.9%), Corallus spp. (25.1%), Indotestudo elongata (11.8%), Mauremys mutica (6.8%), Cuora flavomarginata (5.5%), Mauremys reevesii (3.6%), Chelonoidis denticulata (3.3%), Cuora trifasciata (2.6%), Cuora galbinifrons (2.6%), C.calyptratus (1.1%), Mauremys sinensis (1.1%)*	USA (73.4%), Japan (20.4%), Czech Republic (4.4%), Austria (1.7%)
North Africa	Low trade	8911	*T. graeca (37.2%), Uromastyx aegyptia (32.7),*	UK (35.0%), USA (18.9%), Hong Kong (7.8%),

		(891 ± 306)	*Uromastyx acanthinura (9.1%), Eunectes spp. (7.6%), Uromastyx spp. (6.6%), Chamaeleo chameleon (5.0%)*	Netherlands (6.0%), Germany (5.8%), Mexico (5.3%), Italy (3.3%), Spain (3.2%), Japan (3.1%), Slovenia (2.9%), Rep. of Korea (2.9%), France (2.3%), Malaysia (2.4%)
Caribbean Islands	Fluctuating/low trade	8749 (515 ± 89)	*C.carbonaria (87.3%), Tropidophis haetianus (5.4%), Epicrates striatus (4.1%)*	USA (57.6%), Madagascar (23.9%), Indonesia (12.4%), Jordan (3.4%), Netherland (2.1%)

(a)


800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Total trade (all sources)
1996
2000
2004
2008
2012
Mesoamerica
Sub-Saharan Africa
South America
South & Southeast Asia
West & Central Asia
North America
Europe
North Asia
Other regions

(b)


700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Total trade (captive bred reptiles)
1996
2000
2004
2008
2012
Mesoamerica
South America
Sub-Saharan Africa
South & Southeast Asia
Europe
West & Central Asia
North America
North Asia
Other regions

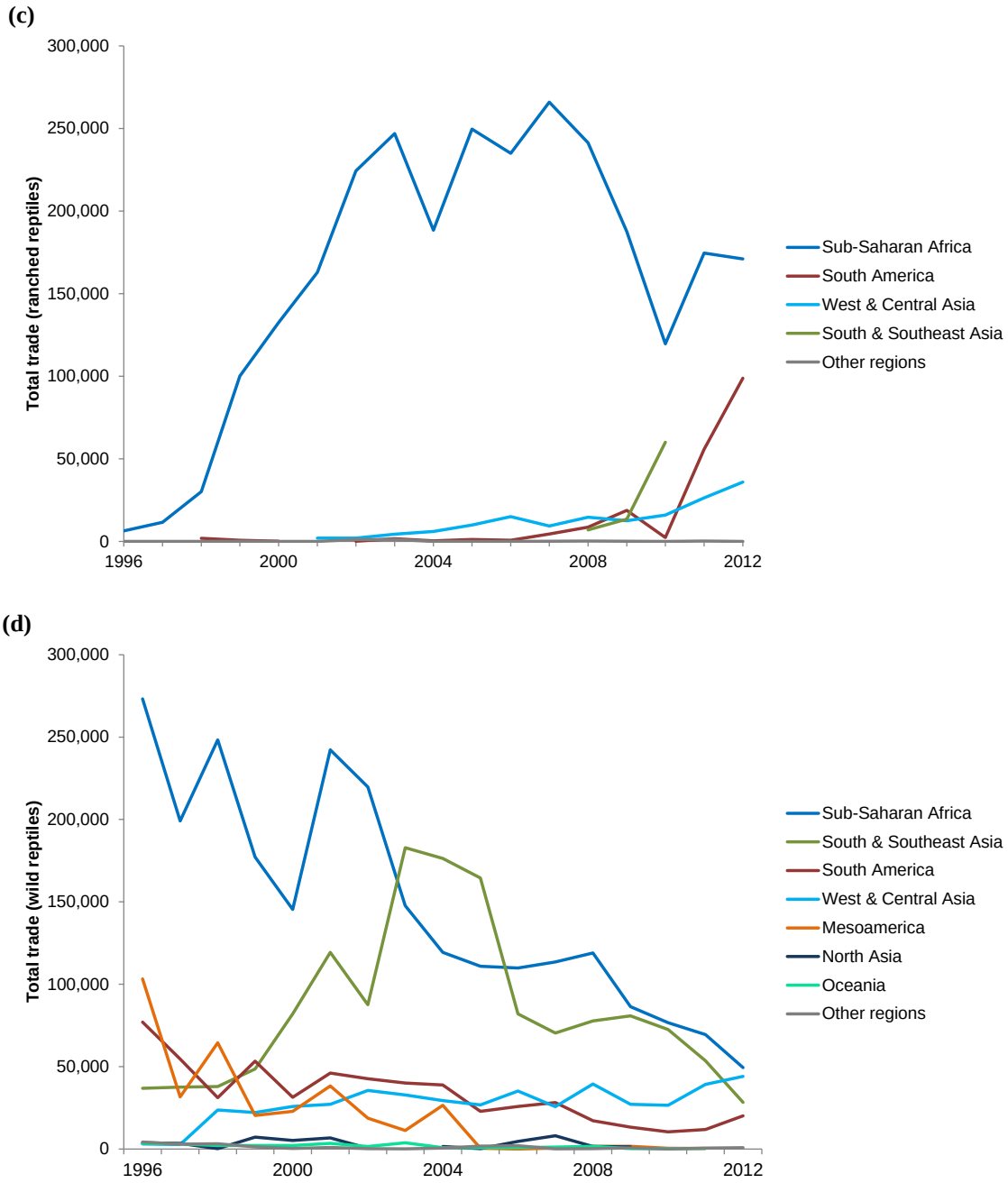


Figure S2.8. Regional trends in live Appendix II reptiles imported for commercial purposes from 1996 to 2012, displaying main exporting regions. (a) All sources: 'Other regions' (<50 000 trade records from 1996-2012) includes Oceana, East Asia, North Africa and Caribbean Islands. (b) Captive bred: 'Other regions' (<15 000 trade records from 1996-2012) includes East Asia, Caribbean Islands, Oceans and North Africa (c) Ranched: 'Other regions' (<10 000 trade records from 1996-2012) includes Mesoamerica, Europe, North America and Oceania (d) Wild (<10 000 trade records from 1996-2012) includes Europe, North Africa, North America, East Asia and Caribbean Islands.

CHAPTER 3

Supplying the Wildlife Trade as a Livelihood Strategy in a Biodiversity Hotspot

Due for submission to Biological Conservation:

Robinson, J.E., Griffiths, R.A., Fraser, I.M., Raharimalala, J., Roberts, D.L., St. John, F.A.V., Supplying the wildlife trade as a livelihood strategy in a biodiversity hotspot.

3.1. Abstract

Much of the global wildlife trade is sourced from biodiversity-rich developing countries. These often have high levels of poverty and habitat loss, particularly in rural areas where many depend on natural resources. However, wildlife collection may incentivise local people to conserve habitats that support their livelihoods. Here we examined the contribution of the commercial collection of live animals to rural livelihoods in Madagascar, one of the world's most important biodiversity hotspots. Using questionnaires, we investigated the prevalence, local value and importance of the trade, and its capacity to provide incentives for conservation. Thirteen percent of households were engaged in live animal collection, and ~5% trapped reptiles and amphibians (the remainder trapped invertebrates). This formed part of a diverse livelihood strategy, and was more profitable than other activities, with median earnings of ~100 USD per season (~25% of Gross National Income per year). However, trapping was a part-time activity, often perceived as unreliable, opportunistic and financially risky. Further, trappers and non-trappers held similar perceptions regarding conservation, suggesting wildlife trade currently does not incentivise enhanced stewardship of traded species and their habitats. Our study represents comprehensive insights into livelihoods and conservation in poor rural communities involved in the commercial collection of live animals. This improved understanding of the wider socio-economic dimensions of wildlife trade can inform policy and management interventions for both the threats and opportunities associated with global trade in biodiversity.

3.2. Introduction

Millions of animals, plants, and their products, are traded annually, both legally and illegally, to supply domestic and international markets (Broad et al., 2003). Much of this trade occurs in biodiversity-rich developing countries where people depend on natural resources (Robinson & Redford, 1991), and where sustainable and legal use of wildlife can potentially support livelihoods (Roe, 2002, 2008). Indeed, international agreements such as The Convention on Biological Diversity (CBD) promotes sustainable use of biological diversity and recognises rights of people to benefit from their use (CBD, 2014). However, unsustainable and illegal wildlife trade threatens wildlife populations (Kenney et al., 1995), has detrimental environmental and health related impacts (Karesh et al., 2005; Vitousek et al., 1996), and in some cases has become highly militarised threatening human security (Duffy et al., 2015).

A key framework regulating international wildlife trade is The Convention on International Trade in Endangered Species (CITES), a global agreement aiming to ensure that wildlife trade is sustainable (CITES, 2016). Species are listed on appendices offering varying levels of protection, with trade regulated and monitored via a permitting system. However, capacity and resources to implement and enforce CITES is often inadequate (Bennett, 2011, Rosen & Smith, 2010) and enforcement alone can be problematic (Challender & MacMillan, 2014; Cooney & Jepson, 2006). Consequently, conservationists advocate alternative strategies to regulate wildlife trade including incentivising local communities, demand mitigation, and examining sustainable off-take mechanisms (e.g. wildlife farming) (Challender & MacMillan, 2014; Roe et al., 2015). Incentive-based programs, such as Integrated Conservation and Development Programs and Payments for Ecosystem Services, originate from shared goals to reconcile conservation and development so that mutual benefits can be

realised (Spiteri & Nepalz, 2006). Where local stakeholders benefit directly from a resource, they may have an incentive to protect it, leading to environmental stewardship (Salafsky & Wollenberg, 2000). Whilst sustainable and well-managed extractive use of resources can deliver positive livelihood outcomes and promote incentives for conservation (Gordon and Ayiemba, 2003; Hutton & Leader-Williams, 2003), many projects have not realised their goals (Kusters et al., 2006; Lybbert et al., 2011).

Clearly, when addressing the incentives and motivations of different actors involved in wildlife trade supply chains, it is important to engage local communities (Duffy et al., 2016; Roe et al., 2015). A thorough understanding of the social and economic dimensions of wildlife trade supply chains allows evaluation of who will be affected (and by how much) by policy and management interventions aiming to regulate trade, and informs conservation interventions. Additionally, socio-economic characteristics of target communities have been shown to impact the success of conservation projects (Chukwuone, 2009). However, little is known about livelihoods associated with the commercial supply of wildlife in exporting countries (Roe, 2002), particularly at the harvesting stage where people arguably have the most direct impact on natural resources. This may seem far removed from retail outlets in consumer countries, particularly in the case of the exotic pet trade, where discussions frequently focus on animal-health, welfare and ecological consequences of trade (Baker et al., 2013; Carrete & Tella, 2008; Chomel et al., 2007).

Using Madagascar as a case study, we analyse the contribution of legal live animal collection to rural livelihoods in villages at the source of the trade to understand the local value and importance of this activity. We estimate the proportion of households engaged in wildlife collection; determine how it contributes to the livelihood portfolio;

compare its profitability to other livelihoods; and investigate the perceptions of trappers and non-trappers towards traded and non-traded animals to explore the potential for trade to act as an incentive for conservation. Given the global importance of Madagascar's herpetofauna and its popularity in international markets, we focus on reptiles and amphibians as a traded commodity. To our knowledge, this is the first study providing a detailed analysis of the relative importance of the collection of live animals supplying the pet trade, to the livelihoods of rural people.

3.3. Methods

3.3.1. Study area

Regions prioritised for their globally important biodiversity frequently overlap with areas of severe poverty. Madagascar is a biodiversity hotspot with high concentrations of endemic species (Myers et al., 2000), and is one of the poorest countries in the world, with a Human Development Index of 0.520 (ranked 154 of 185 countries) (UNDP, 2015). Madagascar has lost much of its original forest and whilst 80% of the rural population are engaged in agriculture (INSTAT, 2010), slash and burn agriculture, along with fuelwood cutting represent the most significant threats to Madagascar's biodiversity (Harper et al., 2007). The country has a rich wildlife trade, particularly reptiles and amphibians, which are highly desirable in international herpetofauna markets (Carpenter & Robson, 2008). For example, Madagascar is the largest global exporter of live CITES-listed amphibians (UNEP-WCMC, 2016) and exports 2.5% of the global commercial trade in live CITES reptiles (Robinson et al., 2015). Madagascar joined CITES in 1975, and has export quotas for a number of species permitted in trade.

Our research was conducted in the Moramanga district, of the Alaotra-Mangoro region (Figure 3.3.1). Moramanga is located on a plateau between the central highlands (and the capital city Antananarivo), and the east coast. The district is subdivided into several communes, each representing a collection of villages; these are mostly rural except for the Moramanga urban centre. Preliminary interviews with government authorities, non-governmental organisations, exporters and middlemen along the wildlife trade supply chain suggested Moramanga may be a hub for wildlife collection and trade. This is likely due to its proximity to Antananarivo (where most of Madagascar's wildlife exporters are situated) and its position relative to the national road and biodiverse eastern rainforests.

Ethical approval was granted by the School of Anthropology and Conservation, University of Kent. On arrival in communes, commune and village leaders were visited to discuss the research and explain that we were studying legal collection of wildlife for trade and how this fits into local livelihoods. Local guides were recruited in each village to assist the research team. We informed respondents that taking part in the survey was voluntary and they could stop at any time. Consent was recorded by means of a tick box on the questionnaire and persons under 18 were only interviewed with agreement of their parent or guardian.

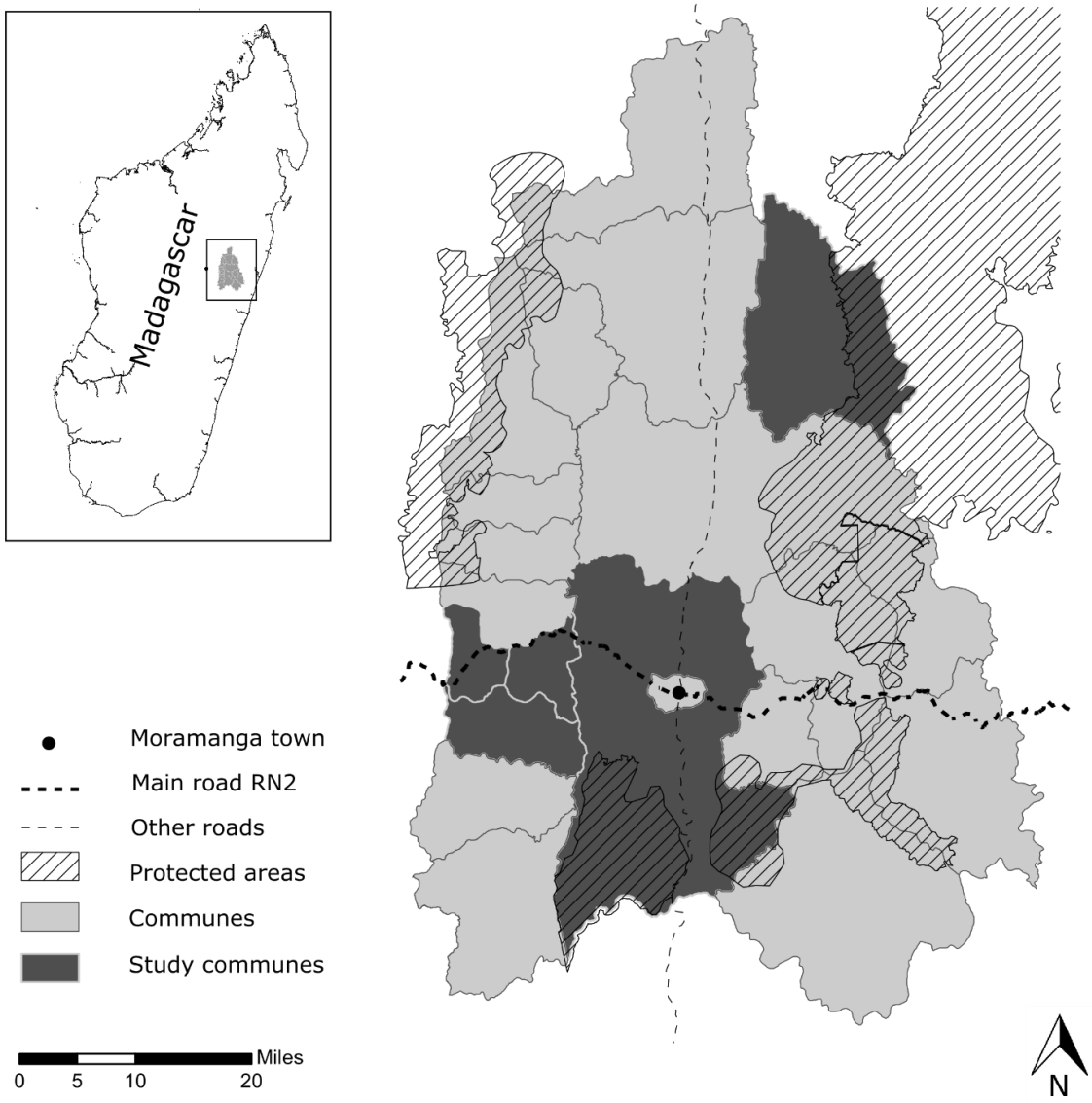


Figure 3.3.1. Moramanga district and study communes. Inset: position of Moramanga district in Madagascar.

3.3.2. Sampling strategy

We used two approaches to sampling: systematic household sampling in villages identified as having trappers; and snowball sampling of households involved in trapping reptiles and amphibians specifically, as a priori, trapping households were considered hard to identify and rare. We used the systematic household sample to

estimate the prevalence of wildlife collectors in the study area and collect detailed information on livelihood strategies. We used the snowball sample to maximise the number of reptile and amphibian trapping households encountered in order to collect detailed information on this activity. Two questionnaires were used: a household questionnaire completed by all respondents; and a detailed trapper questionnaire completed by trappers of reptiles and amphibians (in addition to the household questionnaire).

3.3.3. Systematic household sample

Trapping is prohibited within Protected Areas and our study was focussed on legal collection of wildlife for trade, therefore we constrained our research to villages outside of Protected Areas. Five rural communes (excluding Moramanga urban centre) were identified as trapping areas. For each commune, a list of villages where wildlife trappers resided was generated and refined throughout the course of the study through discussion with traders, village leaders, guides and during household questionnaires. We randomly selected between two and four villages (depending on village size) per commune from this list (aiming for ~60 households per commune) in order to distribute effort across the communes. Thirty percent of households per village were interviewed, with a maximum of 30 and minimum of 10 per village. On arrival in the village, we mapped the households with assistance from guides. Whilst walking in a zig-zag pattern, we surveyed every *n*th household according to village size. If the household head was unavailable, the interviewer returned when they were available. A household was defined as all persons who normally live together and eat from the same cooking pot/kitchen.

3.3.4. Snowball sampling of reptile and amphibian trappers

The household questionnaire asked respondents if they knew anyone who collected reptiles and amphibians for trade. If a trapper was identified within a household that had not been selected for inclusion in the systematic household survey, that individual was located and asked to complete both questionnaires. If trappers were identified in neighbouring villages (within study communes) not selected for inclusion in the study, where possible, these villages were visited to survey those trappers. We therefore attempted to interview most reptile and amphibians trappers in the five communes.

3.3.5. Questionnaires

Both questionnaires were piloted in February 2014 and refined prior to fieldwork (March to July 2014). Cost information was collected in Malagasy Ariary (MGA) and converted to US dollars (USD) based on an exchange rate of 1 USD=2335 MGA valid at the time the study was carried out (XE, 2016).

The household questionnaire (Appendix A) collected information on demographic attributes, livelihood activities, assets/wealth, perceptions and knowledge of wildlife and wildlife trade. We asked respondents to list all household livelihood activities. In order to provide a measure of the perceived importance of trapping live animals compared to other activities, respondents then ranked these in order of importance to their own household for (1) income and (2) food. The most important activity was given a score of one, the second most important given a score of two, and so on. Activities that were not considered important were given a score of zero.

To compare relative profitability of livelihood activities, Household Livelihood Return (HLR) was calculated for each activity. HLR was defined as the median amount of

profit earned (USD), per unit of time (1 hour). For agricultural activities, we asked respondents about time spent on the activity (months/days/hours), revenue (including percentage of produce sold each year) and costs (excluding fixed costs e.g. land purchase). For wildlife trade, we asked respondents about the collection period (months per year), number of orders per collection period, time taken to complete an order (days), money received per order and associated costs (for extended methodology see Supporting Information, S3.8.7). By focussing on activities that households were currently engaged in rather than historical activities, we aimed to minimise recall bias. We also verified price information by collecting market price data from village/commune leaders.

In order to measure wealth, we used a standard asset bundle of 26 items as a comparative proxy of wealth, converted into a Household Asset Index (HAI) following Morris et al., (2000) (Supporting Information, Table 3.8.7).

To investigate perceptions towards wildlife, we asked respondents a series of questions on a three or four point scale. We used several animal groupings with photographs representing traded and non-traded groups, including: chameleons, geckoes, frogs, invertebrates, birds, lemurs and tenrecs. Respondents were asked whether they perceived the different groups to be important for income (1=disagree, 2=neither agree nor disagree, 3=agree) and whether they thought the numbers of the animals in the wild, and the amount of habitat, should be eliminated, reduced, maintained at the same level, or increased. To investigate factors influencing engagement in trapping, we asked respondents whether they were afraid of different animal groups, based on the hypothesis that fear of animals may be related to trapping.

The trapper questionnaire (Appendix B) collected detailed information on reptile and amphibian trapping as a livelihood activity, the trade network and collection practices. Whilst the household questionnaire was completed by the household head, the trapper questionnaire was completed by trappers themselves in order to gain their perspective. However, in all but one case, the trapper was the same person as the household head.

3.3.6. Data analysis

Data analysis was conducted in R (R Core Team, 2015). We used non-parametric tests (χ^2, Mann Whitney) to investigate differences in household size, education, time lived in village, number of household livelihood activities and differences in perceptions regarding wildlife and habitats between live animal trapping and non-trapping households. We used a Linear Model (LM) to investigate predictors of household wealth, and a Generalized Linear Model (GLM) with binomial error structure to investigate predictors associated with trapping households. We numerically coded responses to scale questions regarding how afraid people were of different animals, and averaged for each person across different animal groups, to create a 'mean fear' score for use in the GLM. Exploratory analysis including graphical inspection, correlation matrices and bivariate tests were performed, and variance inflation factors (VIFs) were used to test for collinearity amongst explanatory variables. For model selection, we used a model averaging-approach (Burnham & Anderson, 2002; Symonds & Moussalli, 2011) using the MuMIn package (Barton, 2011). The model set included all variable combinations of the predictors listed in tables 3.4.2.1 and 3.4.2.2. Prior to model averaging, models were restricted to $\Delta AIC_c<4$ (corrected Akaike Information Criterion) to exclude potentially implausible models with low AIC weights (Burnham & Anderson, 2002). Averaged parameter estimates (β), unconditional standards errors (SE), upper and lower 95% confidence intervals (UCI,

LCI), p-values and relative variable importance factors (RI) are reported after model averaging.

We calculated HLR for all livelihood activities where >5% of households engaged in the activity, with the exception of hunter-gathering activities (data collection was not set up to value produce from hunter-gathering) and 'trading produce' (too variable due to the large range of products traded). Therefore we prioritised HLR analyses to comparing profitability for activities most commonly conducted, excluding activities that very few households engaged in and for which data would have been less reliable due to low sample sizes. We only calculated HLR for trappers of reptiles and amphibians (not all wildlife) as the trapper questionnaire was designed to collect this information. The following formula was used to calculate HLR:

$$HLR = \text{Net Revenue} / \text{Total Time}$$

where Net Revenue is the annual income, minus costs for that year and Total Time is the time in hours spent doing the activity over one year. We calculated HLR in two ways: HLR1 was calculated as if 100% of produce was sold therefore accounting for the subsistence value of this produce, whilst HLR2 incorporated percentage sold as indicated by respondents, giving a more reliable measure of the actual monetary value obtained. HLR was calculated for each household and then the median value across all households calculated for each activity. Throughout the analysis, where a range of values was given e.g. 5-10 hours, then the mid-value was used (i.e. 7.5). This was used to calculate median and IQR

Because snowball sampling is a non-probability technique, inferential univariate statistics were only conducted on data collected via systematic sampling. However, we performed the LM and GLM in both ways (primarily using data from the systematic

sample, and then with the addition of households selected via snowball sampling). Whilst this is interpreted with caution, this increases the sample size for the rare and hard-to-reach trapping households and, we believe, provides a more comprehensive understanding. For HLR calculations and specific information regarding reptile and amphibian collection (Sections 3.4.3, 3.4.4 and 3.4.5) summary data are presented using households identified via both sampling approaches in order to maximise data on trapping as an activity.

3.4. Results

3.4.1. Wildlife trapping prevalence

A total of 240 household questionnaires were completed through systematic sampling across 16 villages corresponding to an average of 33% of households per village. Non-response rate was 6% (n=12, recorded in four of five communes). The systematic sample identified 32 (13.3%) households currently involved in trapping live animals for trade. Thirteen (5.4%) trapped reptiles and amphibians and the remaining 19 trapped invertebrates only (butterflies, stick insects, crickets and scorpions).

We identified a further 21 trappers through snowball sampling incorporating an additional two villages. Of these, 17 trapped reptiles and amphibians (four trapped invertebrates only). In summary, 30 trappers of reptiles and amphibians were encountered across 18 villages in five communes, using both sampling approaches, 28 of which completed the trapper questionnaire. A total of 260 household questionnaires were completed using both sampling approaches.

3.4.2. Household livelihood profile

Households participated in a wide variety of livelihood activities (Supporting Information, Table S3.8.1). Six broad livelihood categories, each containing a number of subcategories, were identified including: cultivation; livestock keeping; wildlife trapping (for trade); hunting and gathering; farm labour; and non-farm labour**.** Farm labour involved working on other people's farms. Non-farm labour included various forms of self-employment (e.g. laundry) and a few types of formal employment (e.g. teaching). Due to the informal nature of many of these jobs it proved difficult to split this category up further.

Households engaged in a median of three of the six livelihood categories, and eight different individual activities. As expected, nearly all households engaged in cultivation (median 6 crop types per household, IQR=3) and three-quarters (77%) had livestock (median 2 types per household, IQR=2). Households cultivated a diverse array of crops, cumulatively reporting 40 fruit and vegetable types including three rice production systems (lowland, irrigated and upland). Hunting and gathering was listed by a-third of households and included: collection of animals for food (tenrecs, shrimps, edible frogs and fish); collection of forest plants/fruits for food, medicine and other uses; collecting firewood and honey; and making charcoal. A group of households (15%) engaged in daily farm labour and nearly a third (30%) in non-farm labour.

There were no significant differences between wildlife trapping and non-trapping households according to household size ($U=3410.5_{208, 32}$, p=0.819), migration into the district (χ^2=0.010, n=237, p=0.921), years lived in village ($U=3305_{199, 32}$, p=0.730) or education level (χ^2=1.424, n=240, p=0.491) (for demographic parameters see Supporting Information, S3.8.2).

The LM showed that wealth, quantified using an Asset Index, was negatively associated with hunter-gathering households and engagement in farm labour. Wealth was positively associated with the number of working members in the household, the number of cultivation activities and education (Table 3.4.2.1). Whilst not significant after model averaging (confidence intervals overlapped zero), wildlife trapping showed a negative relationship with wealth and appeared in 62% (RI=0.62) of models prior to averaging. However, when trapping households identified via snowball sampling (n=20) were combined with the systematic sample, trapping became a significant predictor negatively associated with household wealth, appearing in 85% (RI=0.85) of models prior to model averaging (Supporting Information, Table S3.8.3).

Table 3.4.2.1 Summary of averaged linear model (LM) fitted with normal errors to investigate predictors associated with household (HH) wealth in systematically sampled villages, in the Moramanga district of Madagascar.

Response	Predictor	β	SE	LCI	UCI	P	RI
Asset Index *N*=205	(Intercept)	3.05	0.04	2.98	3.12	<0.001	
	Farm labour: TRUE	-0.28	0.10	-0.48	-0.09	0.004	1.00
	Hunter-gatherer: TRUE	-0.20	0.08	-0.35	-0.05	0.010	1.00
	No. working in HH	0.27	0.07	0.13	0.41	<0.001	1.00
	Education	0.19	0.08	0.04	0.33	0.013	0.96
	No. cultivation activities	0.18	0.08	0.03	0.33	0.021	0.95
	Trapper of animals: TRUE	-0.18	0.11	-0.38	0.03	0.086	0.62
	Non-farm labour: TRUE	-0.08	0.08	-0.25	0.08	0.314	0.31
	Migrant: TRUE	0.04	0.12	-0.19	0.27	0.714	0.22

*Averaged parameter estimates (β), unconditional standards errors (SE), upper and lower confidence intervals (UCI, LCI), p-values and relative variable importance factors (RI) are reported. The Akaike Information Criterion correction (AICc) was used to rank models and model ranked ΔAIC_c<4 were averaged to obtain final estimates. Non-significant explanatory parameters, where confidence intervals cross zero, are italicized. Relative importance (RI) refers to the summed Akaike weights across all models in which the variables were present. Response variable (asset index) was log10 transformed to improve model fit. Farm labour, hunter-gatherer, non-farm labour, trapper of animals and migrant were all binary variables, whilst no. cultivation activities, no. working members in HH and education were treated as continuous variables.

Results of the binary GLM investigating factors associated with trapping households revealed that having a family member involved in the wildlife trade significantly predicted the probability of involvement in live animal collection (Table 3.4.2.2). Wealthier households, those engaged in hunter-gathering and reporting higher levels of fear for wildlife all showed a negative association with live animal trapping; these variables appeared in 60 to 90% of models prior to model averaging, but were not in the final model. However, when data from the snowball sample (n=20) were combined, the final model revealed that wealthier households, hunter-gathering households and those more afraid of animals were significantly less likely to be wildlife trappers (Supporting Information, Table S3.8.4).

Table 3.4.2.2. Summary of averaged generalized linear model (GLM) with binomial error to investigate predictors associated with live animal trapping households (HH) in systematically sampled villages, in the Moramanga district of Madagascar

Response	Predictor	β	SE	LCI	UCI	P	RI
Trapper/ non-trapper	(Intercept)	-2.45	0.32	-3.07	-1.83	<0.001	
N=210	Family involved in WT: TRUE	2.42	0.52	1.39	3.44	<0.001	1.00
	Asset index	-1.61	0.88	-3.33	0.01	0.069	0.89
	Hunter gatherer: TRUE	-1.08	0.56	-2.18	0.01	0.052	0.84
	Mean fear	-0.81	0.50	-1.79	0.17	0.106	0.63
	Age	-0.67	0.50	-1.45	0.24	0.182	0.43
	Education	-0.25	0.49	-1.22	0.72	0.608	0.20
	Migrant: TRUE	0.20	0.73	-1.25	1.65	0.785	0.16
	No. people in HH	0.08	0.45	-0.81	0.97	0.855	0.16

*Averaged parameter estimates (β), unconditional standards errors (SE), upper and lower confidence intervals (UCI, LCI), p-values and relative variable importance factors (RI) are reported. The Akaike Information Criterion correction (AICc) was used to rank models and any model that ranked ΔAIC_c<4 was averaged to obtain final estimates presented. Non-significant explanatory parameters, where confidence intervals cross zero, are italicized. Relative importance (RI) refers to the summed Akaike weights across all models in which the variables were present. 'Family involved in WT' (wildlife trade), 'hunter gatherer' and 'migrant' were all binary variables. 'Asset index', 'age', 'no. of people in household' and 'education' were all treated as continuous variables. 'Mean fear' was calculated by averaging

the responses given to the Likert scale questions across the different wildlife groups: chameleons, geckoes, snakes, frogs, insects, birds, lemurs and tenrecs, where the question 'I am afraid of this animal' was asked and responses were coded as disagree=1, neither agree nor disagree=2 and agree=3.

3.4.3. Reptile and amphibian trapping as a livelihood

Reptile and amphibian trapping was largely seasonal, usually conducted during the rains when animals were reportedly most abundant (most popular months: November to April, median no. months=8, IQR=4, n=28). The official collection season was 1st February to 30th April for herpetofauna, and all year for insects (Ministere de l'environment, 2006) but does not appear strictly adhered to. Respondents reported fulfilling between two and 24 orders in a season (median=8, IQR=11) with each order taking one hour to two weeks (median 3.3 days, IQR=3.1). Collection sites took between five minutes and three days to reach, usually by foot, with five to 450 animals collected per order (median=75, IQR=110, n=21).

All reptile and amphibian trappers interviewed were male, with a median age of 41 (IQR=14, n=28). Trappers had been engaged in the activity for a median of 19 years (IQR=14, n=28) and stated a number of reasons for becoming involved, with the largest proportion declaring monetary reasons (37%, n=10). Thirty percent (n=8) were encouraged to trap by family or friends, 19% (n=5) were engaged directly by collectors, and four said that they were specifically trained by researchers or people linked to animal parks/zoos.

3.4.4. Household Livelihood Return (HLR)

Trapping of reptiles and amphibians was the most profitable activity in terms of monetary benefit per unit of effort (Table 3.4.4) and yielded a median annual net

income of 104.7 USD per person. This equated to an average HLR of 0.70 USD per hour. Many of the other activities were subsistence-based agriculture and yielded zero or low monetary profit, for example, lowland rice, cassava and sweet potatoes (staple subsistence crops farmed by the largest proportion of households (Supporting Information, Table S3.8.1)) yielded annual median net incomes of 0.00 USD. Minimal amounts of produce from these crops were sold in a given year (sometimes instead being exchanged for labour) and households frequently cultivated more than one crop as part of their livelihood portfolio. However, even when accounting for the subsistence value by calculating total revenue as if 100% of produce was sold (HLR1), reptile and amphibian trapping remained the most profitable activity (Table 3.4.4).

Table 3.4.4. Evaluation of 'Household Livelihood Return' (HLR) for livelihood activities carried out by households in the Moramanga district of Madagascar.

Livelihood Activity	% sold	Revenue (USD)	Costs (USD)	Net Income 1 (USD)	Net Income 2 (USD)	Total hours	HLR1		HLR2	
	Median (Q1, Q3)	Median (Q1, Q3)	Median (Q1, Q3)	Median (Q1, Q3)	Median (Q1, Q3)	Median (Q1, Q3)	Median (Q1, Q3) USD/hr	*n*	Median (Q1, Q3) USD/hr	*n*
HLR2 ≥ $0.5 per hour										
R&A trapping	100	114 (84, 217)	12 (0, 55)	105 (64, 192)	105 (64, 192)	162 (97, 343)	0.7 (0.47, 1.81)	28	0.7 (0.47, 1.81)	28
Pineapple	100 (80, 100)	180 (61, 317)	0 (0, 2)	171 (64, 375)	152 (61, 303)	180 (108, 300)	0.5 (0.28, 2.65)	20	0.5 (0.28, 2.61)	19
HLR2 ≥ $0.1 per hour										
Geese	75 (50, 88)	92 (59, 203)	0 (0, 0)	92 (58, 203)	81 (24, 154)	182 (91, 455)	0.4 (0.18, 1.13)	25	0.3 (0.06, 0.74)	23
Daily farm labour	NA	111 (33, 223)	0 (0, 0)	111 (33, 223)	111 (33, 223)	526 (263, 1334)	0.2 (0.13, 0.27)	21	0.2 (0.13, 0.27)	21
Chicken/laying hens	43 (0, 75)	86 (37, 186)	0 (0, 0)	73 (28, 182)	17 (0, 64)	91 (61, 182)	0.5 (0.20, 1.70)	121	0.1 (0.00, 0.75)	125
Bananas	90 (50, 100)	51 (17, 143)	0 (2, 0)	51 (14, 114)	26 (2, 90)	156 (68, 520)	0.2 (0.05, 0.68)	68	0.1 (0.00, 0.52)	75
Pigs	100 (50, 100)	148 (68, 290)	25 (2, 67)	125 (18, 236)	60 (4, 127)	364 (182, 727)	0.3 (0.06, 0.74)	44	0.1 (0.01, 0.27)	41
Beans	50 (26, 80)	65 (34, 141)	4 (0, 13)	60 (24, 138)	20 (0, 64)	336 (169, 548)	0.2 (0.06, 0.57)	102	0.1 (0.00, 0.26)	108
Peanuts	50 (0, 75)	24 (13, 43)	2 (0, 4)	21 (12, 34)	11 (-0, 24)	113 (45, 192)	0.2 (0.08, 0.50)	25	0.1 (0.00, 0.22)	30
HLR2 < $0.1 per hour										
Ducks/Muscovy	58 (0, 100)	43 (24, 75)	0 (0, 0)	41 (24, 78)	10 (0, 42)	182 (91, 364)	0.2 (0.11, 0.65)	42	0.0 (0.00, 0.22)	43
Ginger	80 (73, 100)	43 (21, 88)	0 (0, 10)	29 (13, 60)	26 (4, 54)	606 (277, 1143)	0.1 (0.02, 0.15)	51	0.0 (0.00, 0.13)	51
Bambara groundnut	67 (27, 90)	39 (15, 86)	3 (0, 9)	30 (13, 77)	9 (0, 51)	494 (260, 870)	0.1 (0.02, 0.17)	38	0.0 (0.00, 0.07)	41
Irrigated rice	10 (0, 37)	206 (108, 459)	27 (13, 53)	167 (57, 327)	-1.9 (-20, 33)	970 (740, 1377)	0.1 (0.40, 0.62)	38	0.0 (-0.01, 0.04)	29
Leaf vegetables	50 (15, 75)	11 (6, 18)	1 (0, 2)	11 (6, 16)	0 (-0, 8)	208 (78, 424)	0.0 (0.00, 0.09)	39	0.0 (-0.01, 0.04)	40
Corn	25.0 (0, 73)	17 (8, 38)	0 (0, 1)	13.3 (5, 36)	0 (0, 13)	364 (152, 727)	0.1 (0.02, 0.13)	86	0.0 (0.00, 0.04)	107
Taro	0 (0, 50)	17 (10, 26)	0 (0, 0)	17 (6, 25)	0 (0, 6)	540 (234, 940)	0.0 (0.00, 0.04)	34	0.0 (0.00, 0.01)	43
Cassava	0 (0, 50)	21 (11, 45)	0 (0, 4)	21 (7, 43)	0 (-1, 4)	831 (468, 1559)	0.0 (0.01, 0.06)	111	0.0 (-0.00, 0.01)	160
Sweet potato	0 (0, 5)	9 (4, 24)	0 (0, 0)	9 (4, 23)	0 (0, 0)	260 (128, 520)	0.0 (0.01, 0.09)	72	0.0 (0.00, 0.00)	126
Oxen/cows	0.0 (0, 0)	867 (578, 1413)	26 (13, 70)	727 (445, 1228)	-25 (-41, -13)	2182 (1819, 2448)	0.3 (0.15, 0.54)	42	-0.0 (-0.03, -0.01)	39

Upland rice	0 (0, 25)	105 (48, 255)	26 (6, 64)	63 (6, 189)	-10 (-39, -1)	909 (646, 1221)	0.1 (0.01, 0.25)	47	-0.0 (-0.05, 0.00)	45
Lowland rice	10 (0, 30)	216 (105, 409)	23 (9, 51)	157 (70, 324)	-5 (-27, 27)	1039 (695, 1364)	0.2 (0.08, 0.41)	194	-0.0 (0.03, 0.03)	199

*Economic information presented includes median (first quartile, third quartile): percentage of produce sold (‘% sold’), 'revenue', 'costs', 'net income' (revenue - costs) and 'HLR'. ‘Revenue’ does not consider percentage sold and therefore indicates the total monetary value if 100% of produce was sold. 'Net income 1' is calculated without incorporating percentage sold. 'Net Income 2' is adjusted to account for percentage sold. HLR1 is calculated from 'net income 1' divided by 'total hours' in order to give 'value per unit of effort’ (USD/hour). 'HLR 2' is calculated from 'Net income 2' (therefore incorporating percentage sold). Time information includes the median (first quartile, third quartile) total number of hours the activity is carried out per year, calculated from information on months per year, days per week, and hours per day. R&A trapping = reptile and amphibian trapping.

Amongst wildlife trapping households, trapping was ranked most important for income by the highest proportion of respondents (Figure 3.4.4), corroborating results of the HLR analysis. The ranking exercise validated other patterns revealed in the HLR analysis, with many respondents ranking staple produce such as cassava and rice highly important for food, oxen of little importance for income or food (largely working animals), and pineapples and pigs of reasonably high importance for income. It also highlighted differences between the HLR calculations and perceived importance, including the rice plantations, which were perceived as important for income but did not score highly in the HLR analysis (Figure 3.4.4).

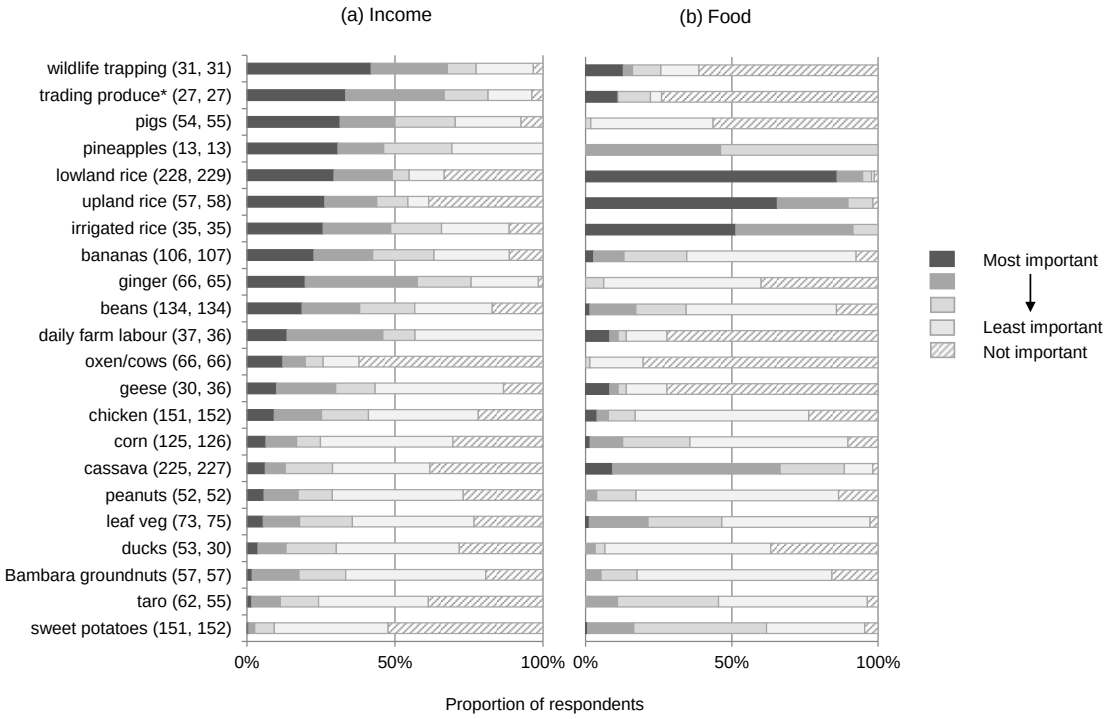


Figure 3.4.4. Respondents ranking of household livelihood activities in terms of importance for (a) providing income and (b) providing food. Shading indicates the proportion of respondents involved in the activity that ranked it as: 1=most important (darkest shading); 2=second most important (second darkest shading); 3=third most important (third darkest shading), 4+ (lightest shading). Data are sorted by the percentage of people that ranked livelihood activities as most important for providing income. *n* numbers are provided in brackets after the name of the livelihood activity (n_{income}, n_{food}).

*We were able to include an additional activity 'trading produce' in the ranking exercise for which it was not possible to calculate detailed HLR.

3.4.5. Barriers to engagement in reptile and amphibian collection

Respondents cited a number of limitations to engaging in reptile and amphibian trapping, including weather (rain, cyclones, etc.) mentioned by 45% of trappers (n=12) and 'limited orders or quotas' referred to by 37% (n=10). Thirty percent reported illness as a limiting factor and 26% stated that it was limited by other activities (e.g. time needed to spend on plantations or studying). Four respondents (15%) referred to low availability of animals during winter (including hibernation) and three respondents (11%) stated that there were fewer animals or habitat in general with one stating *'the forest is destroyed, because of agriculture'* and another stating *'there are fewer geckoes in the wild'*.

Some trappers perceived the activity to be risky from a livelihood, or economic perspective, with one stating *'you never know if you will get orders'* and another saying *'I found stable work…and animal collection is not sure, you never know if you will get money or not'*. There was also concern regarding payments from middlemen (*'people dare to order and not pay'*) and regarding legal paper work. One trapper explained how he considered the job to be risky: '*We, trappers, work in very hard conditions, we have to reach very far places, we work at night and barely sleep, it's a tiring job. There is no guarantee for our security…we also make a risky job compared with collectors and exporters, we work without legal paper…collectors bring legal papers when they buy animals from us'*.

3.4.6. Perceptions towards traded and non-traded animals

Respondents gave mixed views when asked how important different wildlife groups were for providing income, with slightly more people agreeing that frogs, chameleons and geckoes were more useful, than other groups (Supporting Information, Table

S3.8.5). However, systematically sampled trappers were significantly more likely than non-trappers to agree that traded groups: chameleons (Mann-Whitney $U=4471.5_{205,31}$ $p<0.001$), geckoes ($U=4538_{205,31}$ $p<0.001$), snakes ($U=3912.5_{205,31}$, $p=0.02$), frogs ($U=4296.5_{205,31}$ $p=0.001$), invertebrates ($U=4312_{205,31}$ $p<0.001$) and tenrecs (consumed locally) ($U =3823.5_{205,31}$ $p=0.41$) were useful for income. There were no significant differences in how likely trappers or non-trappers were to agree that lemurs or birds were useful for income ($p>0.05$ in both cases). Respondents were most afraid of invertebrates, snakes and chameleons and least afraid of birds. However, wildlife trappers were significantly less afraid of invertebrates ($U=2341.5_{204, 31}$, $n=0.001$) and tenrecs ($U=2430_{205, 31,}$ $p=0.004$) than non-trappers.

Whilst over 76% of respondents' agreed that all wildlife groups were important for the environment (Supporting Information, Table S3.8.5), there were no differences between wildlife trapper and non-trapper opinions. Many respondents felt that chameleons (58%), geckoes (61%), snakes (51%), frogs (69%), invertebrates (51%), birds (72%), lemurs (71%) and tenrecs (70%) should be increased in the wild, rather than eliminated or reduced but again, there were no significant differences between trappers' and non-trappers' opinions. Additionally, over 66% of respondents felt that the amount of natural habitat should be increased (33% felt it should be kept at the same level, and 1% said it should be reduced), but there were no differences between trappers and non-trappers opinions.

3.5. Discussion

Global trade in biodiversity is big business, and as collection from the wild usually involves local people, it can frequently make important contributions to livelihoods. Our study provides the first comprehensive analysis of livelihoods associated with commercial live animal collection, in a global biodiversity hotspot.

We estimated that 13% of households in our study area collected live animals for trade and ~5% trapped reptiles and amphibians. This equates to 110 households engaging in wildlife trapping as part of their livelihood strategy, and 45 trapping reptiles and amphibians. We employed multiple approaches (systematic and snowball sampling) to identify trappers, allowing cross-validation of various sources of information, and identified a total of 69 people potentially trapping reptiles and amphibians in the study area. However, despite visiting three villages in addition to the 16 selected at random, we were not able to verify the involvement of all 69 people, and suspect some may no longer be engaged in the activity. Indeed, ~8% of systematically sampled households stated that they no longer trapped reptiles and amphibians for trade and we expect that engagement in this activity is somewhat fluid in response to fluctuations in supply and demand, as well as wider economic conditions. Occasionally, despite our survey being anonymous and investigating legal collection of wildlife, some respondents were reluctant to discuss the topic (particularly for reptiles and amphibians), suggesting that people may not have a thorough understanding of the rules associated with wildlife trade. As our research team included guides local to the villages, we were able to triangulate and verify much of the information provided concerning involvement in the trade. However, our estimate that ~5% of households trapped reptiles and amphibians may be conservative.

Wildlife collection forms part of a diverse livelihood strategy, and was a part-time, opportunistic activity, carried out alongside other activities (predominantly agricultural). Indeed, diversification is considered the norm in rural Africa, with very little income coming from a single source (Barrett et al., 2001). Equally, our models suggest that wildlife trapping may support some of the poorest households. Previous studies have documented that wild products often form an important risk-reduction strategy for rural poor in developing countries, supporting vulnerable households (Brashares et al., 2010). In terms of value per unit of effort (HLR), trapping of reptiles and amphibians proved relatively profitable, providing an important source of cash income. Trappers could earn a median income of 105 USD per year, whereas the 2015 Gross National Income (GNI) per capita was 420 USD (The World Bank, 2016). Thus, households could potentially earn a quarter of their annual income from fewer man-hours relative to other employment. Analysing relative livelihood contributions in a meaningful way is complex, hence we only attempted to compare profitability of different activities relative to each other, rather than make interpretations based on each households complete livelihood portfolio. For example, as outlined in the methods, we did not calculate HLR for activities that fewer than 5% of households engaged in, due to low sample sizes. Whilst recall accuracy is a concern, there is evidence that prior-year recalls can be more accurate than shorter recall periods, particularly when concerning rare or seasonal events (Golden et al., 2013). By focusing on current livelihood activities, which are mostly seasonal and/or rare (i.e. agriculture and wildlife trapping) steps were taken to minimise recall bias in order to provide a snapshot of household livelihood strategies. Additionally, Jones et al., (2008) showed that rapid assessment interviews with villagers in Madagascar can provide reliable information on harvesting activities.

Whilst reptile and amphibian trapping was relatively profitable, it was limited by various factors including seasonal and quota restrictions, animal availability, demand (orders) and opportunity cost (involvement in other activities such as agriculture). Trappers' health was mentioned as a limitation as was absence from home while travelling long distances. It was also perceived risky from a livelihood, or economic perspective, because of inconsistency and unreliability of orders and payments, and concern regarding legality. This insecurity may arise because some species are not permitted in trade, and any quotas in place may be unclear to people in rural areas. Additionally, local trappers are usually employed by middlemen, who are required to carry collection permits, but there is no paperwork for trappers themselves. These limitations mean that wildlife collection is generally a supplementary activity, with most households preferentially allocating their resources to agriculture (which appeared more consistent, reliable and possibly yielded higher overall wealth given that households cultivated multiple crops along with keeping livestock). However, given that the households engaged in trapping may be among the poorest, the activity may support those with more limited alternative livelihood choices, forming an important source of cash. Family involvement was also a significant determinant, suggesting 'who you know' may be an important entry point.

As trapping households were significantly more likely to agree that traded wildlife groups were important for income compared to non-trappers, we might expect those benefitting financially to have more positive opinions regarding its conservation. Previous studies have shown that projects focussed on enhancing commercial value of resources can improve attitudes towards conservation and provide economic incentives for resource protection (Salafsky & Wollenberg, 2000). However, despite high levels of agreement that animals were important for the environment and their numbers and

habitats should be increased, there was no evidence of improved perceptions towards conservation amongst wildlife trappers, suggesting trapping may not offer sufficient incentives to lead to enhanced stewardship of traded species and their habitats. However, we recognise that wildlife is valued for both social and economic reasons (Brooks, 2010), and perceptions towards conservation may be confounded by other values besides economic use for trade (e.g. medicine, food). Additionally, wildlife collection in this area is not currently managed as part of a specific incentive-based project, but is regulated under wider national and international legislation (e.g. CITES) concerning biodiversity conservation. This study therefore provides an understanding of the situation in areas outside of such targeted projects, which are arguably more representative of wider national and international landscapes where the majority of wildlife collection occurs.

In order to maximise the conservation and livelihood benefits of wildlife trapping a number of factors require combined consideration and our study constitutes part of a more complex picture. These factors include 'species-level', 'governance', 'supply chain' and 'end-market' factors (Cooney et al., 2015). Species-level factors include species suitability for harvest such as resilience and accessibility. For example, Madagascar's panther chameleon (*Furcifer pardalis*) is abundant in disturbed areas and appears able to sustain collection for export (Andreone et al., 2005), whereas the harlequin mantella (*Mantella cowanni*) has a low population size and its collection could lead to local extinction (Andreone et al., 2006). Governance factors include property rights and policy settings. In Madagascar, property rights are often poorly defined (Bojö et al., 2013) and without security of tenure over land and resource rights, there may be little incentive for local people to invest in the long-term sustainability of the wildlife resource (Roe, 2008). Supply chain factors include the organisation and

operation of the supply chain including barriers to entry and length of the chain. In this case, the supply chain appeared to be poorly organised leading to mistrust between trappers and intermediaries, and concern over payments and legal paperwork. Finally, end-market factors include market size, demand elasticity and consumer preferences. This illustrates the complex range of factors that require consideration in order to better understand the dimensions of wildlife supply chains and inform appropriate management. Research is ongoing to understand further aspects regarding benefits, and information flow along the entire supply chain in Madagascar.

3.5.1. Conclusion

This study provides the first detailed information on the contribution of wildlife collection to rural livelihoods in a country supplying the trade in live animals. Whilst being potentially profitable and providing cash income to some households as part of a diverse livelihood strategy, wildlife trapping was perceived to be unreliable and risky. Consequently, there is limited evidence that income from the trade creates incentives for wider species and habitat protection at the local scale in Madagascar. Further studies are required to understand if this is representative of other parts of Madagascar, and in other countries where collection for the pet trade occurs. Interventions aimed at enhancing benefits to local communities, improving coordination and management of the trade at the local level, and minimising impacts on collected species, could be considered to promote opportunities from the trade. Improved understanding of the social and economic dimensions of wildlife trade supply chains is necessary if the global trade in wildlife is to be understood and appropriate legislation and management systems put in place.

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3.8. Supporting Information

Table S3.8.1. Summary of livelihood and subsistence activities carried out by 240 systematically sampled households (HH), including the number and percentage of households involved in each activity.

Livelihood and Subsistence Activity	no. HH's involved	% HH's involved
Collecting animals for trade (reptiles, amphibians & invertebrates)	**32**	**13.3**
Hunting & gathering	**82**	**34.2**
collecting animals for food (tenrecs, edible frogs, fish, shrimps)	10	4.2
collecting plant products for food/medicine/use (e.g. wild black nightshade)	42	17.5
firewood collection (mostly domestic use, occasionally for sale)	52	21.7
Other (collecting honey, charcoal)	12	5.0
Cultivation (listing those where >5% of people are involved)	**234**	**97.5**
lowland rice	214	89.2
cassava	214	89.2
sweet potatoes	146	60.8
beans	127	52.9
corn	118	49.2
banana	102	42.5
leaf vegetables	72	30.0
ginger	62	25.8
taro	57	23.8
upland rice	51	21.3
Bambara groundnuts	53	22.1
peanuts	50	20.8
irrigated rice	28	11.7
pineapples	23	9.6
sugar cane	14	5.8
other cultivation[a]	43	17.9
Livestock keeping (>5% of people involved)	**184**	**76.7**
chicken/laying hens	159	66.3
oxen/cows	66	27.5
pigs	58	24.2
ducks/Muscovy ducks	56	23.3
geese	29	12.1
other livestock[b]	18	7.5
Farm labour (e.g. sowing, ploughing)	**35**	**14.6**
Non-farm labour	**71**	**29.6**
trading produce/goods (e.g. livestock, harvest, charcoal)	23	12.1
shop, restaurant, pub	10	4.2
handicrafts (plaiting mats, weaving baskets)	9	3.8
other employment and self-employment[c]	43	21.0

[a]chayote, 'ovy tsatoka' (root vegetable), potatoes, coffee, avocado, pumpkin, carrots, cucumber, zucchini, cabbage, cress, green beans, black-eyed beans, peas, cauliflower, spices, sorghum, orange, papaya, mango, litchi, peach, persimmon.

[b]poultry (unspecified), guinea pigs, turkey, goats, rabbits, gamecocks, pigeons.

[c]goldmining, selling cooked rice to miners, cook, making rum, laundry, butcher, photography, guide, mechanic, carrier, masonry, bricklayer, carpenter, dress maker, woodcutter, babysitter, house guard, truck driver, working in Ambatovy mine, teacher, pastor, secretary of commune, JIRAMA, VOI member, pension, house trade, cart rental, field rental.

S3.8.2. Demographic information

Households consisted of one to 11 household members (median=5, IQR=2, n=240). The median age of the household head was 45 (IQR=20, n=237) and 65.0% (n=156) were male. A large proportion of respondents had partially or completed primary education (66.3%, n=159), whilst 21.3% (n=51) had some secondary education and 12.5% (n=30) had no education at all. The majority (86.5%, n=205) of respondents were born within the district of Moramanga, whilst the remaining 13.5% (n=32) had migrated into the area from another district. Most (74.7%, n=177) were Benzanozano or Benzanozano mixed ethnicity, 13.1% (n=31) were Merina or Merina mixed ethnicity and the remainder (12.2% n=29) belonged to other ethnicities including Antandroy, Antanosy-Merina, Betsileo, Betsimisaraka, St Marians, Sakalava and Sihinaka. Table S3.8.2. shows demographic parameters broken down for trapping and non-trapping households.

Table S3.8.2. Selected demographic information for systematically sampled non-trapping households (HHs), wildlife trapping households and households only involved in trapping reptiles and amphibians.

	Non-trapper HHs (*n*=208)*	**All trapper HHs (*n*=32)***	**Subset: Reptile & amphibian trapper HHs (*n*=13)***
Household size	median=5, IQR=2.8	median=4.5, IQR=1.8	median=5, IQR=3.5
Education	Primary 67.3%, (n=140) Secondary 21.2%, (n=44) none=11.5% (n=24)	Primary 59.4% (n=19) Secondary 21.9% (n=7) none 18.8% (n=6)	Primary 61.5% (n=8) Secondary 15.4% (n=2) None 11.9% (n=3)
Residency	Resident 86.8% (n=178) Migrant 13.2% (n=27)	Resident 84.4% (n=27) Migrant 15.6% (n=5)	Resident 69.2% (n=9) Migrant 30.8% (n=4)
Ethnicity	Bezanozano or Bezanozano mixed: 74.1% (n=154) Merina or Merina mixed: 14.0% (n=29)	Bezanozano or Bezanozano mixed: 71.9% (n=23) Antandroy (n=1)	Bezanozano: 53.8% (n=7) Antanosy-Merina (n=1)

	Betsileo (n=5) Betsimisaraka (n=9) St Marians (n=1) Sakalava (n=1) Sihanaka (n=6)	Antanosy (n=1) Betsileo (n=1) Betsimisaraka (n=4) Merina (n=2) Sihanaka (n=1)	Betsileo (n=1) Betsimisiraka (n=3) Sihanaka (n=1)
Yrs lived in village	median=27, IQR=27, n=199	median=25, IQR=28.3	median=30, IQR=33.5
No. activities	median=8, IQR=5	median=10.5, IQR=4	median=9, IQR =3.5
No. livelihood categories	median=2, IQR=1	median=3, IQR=1	median=3, IQR=1

*****unless otherwise indicated within table

Table S3.8.3. Summary of averaged linear model (LM) fitted with normal errors to investigate predictors associated with household (HH) wealth in villages in the Moramanga district of Madagascar (data from systematic and snowball samples).

Response	Predictor	β	SE	LCI	UCI	P	RI
Asset Index	(Intercept)	3.05	0.033	2.99	3.12	<0.001	
N=227	Farm labour: TRUE	-0.29	0.10	-0.48	-0.12	0.001	1.00
	Hunter-gatherer: TRUE	-0.20	0.07	-0.34	-0.06	0.006	1.00
	No. cultivation activities	0.05	0.01	0.05	0.34	<0.001	1.00
	No. working in HH	0.27	0.07	0.13	0.41	<0.001	1.00
	Education	0.18	0.07	0.04	0.32	0.011	1.00
	Trapper of animals: TRUE	-0.19	0.09	-0.38	-0.02	0.028	0.85
	Non-farm labour: TRUE	-0.09	0.08	-0.24	0.06	0.252	0.40
	Migrant: TRUE	0.02	0.11	-0.19	0.23	0.874	0.22

*Averaged parameter estimates (β), unconditional standards errors (SE), upper and lower confidence intervals (UCI, LCI), p-values and relative variable importance factors (RI) are reported. The Akaike Information Criterion correction (AICc) was used to rank models and any model that ranked $\Delta AIC_c<4$ was averaged to obtain final estimates presented. Non-significant explanatory parameters, where confidence intervals cross zero, are italicized. Relative importance (RI) refers to the summed Akaike weights across all models in which the variables were present. Response variable (Asset index) was log10 transformed to improve model fit. Farm labour, hunter-gatherer, non-farm labour, trapper of animals and migrant were all binary variables, whilst no. cultivation activities, no. working members in HH and education were treated as continuous variables.

Table S3.8.4. Summary of averaged generalized linear model (GLM) with binomial error to investigate predictors associated with trapping households (HH) in villages in the Moramanga district of Madagascar (data from systematic and snowball samples).

Response	Predictor	β	SE	LCI	UCI	P	RI
Trapper/ non-trapper *N*=225	(Intercept)	-2.11	0.26	-2.63	-1.59	<0.001	
	Family involved in WT: TRUE	2.24	0.47	1.32	3.15	<0.001	1.00
	Hunter gatherer: TRUE	-1.37	0.52	-2.38	-0.35	0.008	1.00
	Asset index	-1.58	0.72	-3.01	-0.15	0.030	1.00
	Mean fear	-1.00	0.43	-1.84	-0.15	0.021	0.95
	Age	-0.61	0.42	-1.45	0.24	0.159	0.50
	Migrant: TRUE	0.45	0.59	-0.73	1.62	0.457	0.28
	No. people in HH	0.26	0.41	-0.54	1.06	0.524	0.26
	Education	0.24	0.41	-0.56	1.04	0.553	0.26

*Averaged parameter estimates (β), unconditional standards errors (SE), upper and lower confidence intervals (UCI, LCI), p-values and relative variable importance factors (RI) are reported. The Akaike Information Criterion correction (AICc) was used to rank models and any model that ranked $\Delta AIC_c<4$ was averaged to obtain final estimates presented. Non-significant explanatory parameters, where confidence intervals cross zero, are italicized. Relative importance (RI) refers to the summed Akaike weights across all models in which the variables were present. 'Family involved in WT' (wildlife trade), 'hunter gatherer' and 'migrant' were all binary variables. 'Asset index', 'age', 'no. of people in household' and 'education' were all treated as continuous variables. 'Mean fear' was calculated by averaging the responses given to the Likert scale questions across the different wildlife groups: chameleons, geckoes, snakes, frogs, insects, birds, lemurs and tenrecs, where the question 'I am afraid of this animal' was asked and responses were coded as disagree=1, neither agree nor disagree=2 and agree=3.

Table S3.8.5. Evaluation of respondent's agreement scores with various statements concerning values of traded and non-traded wildlife groups.

For each animal group please indicate how much YOU agree or disagree with the following statements:												
	I think that this animal is good for providing money				I am afraid of this animal				I think that this animal is important for the environment			
	n	disagree (%)	agree nor disagree (%)	agree (%)	*n*	disagree (%)	agree nor disagree (%)	agree (%)	*n*	disagree (%)	agree nor disagree (%)	agree (%)
chameleons	236	45.0	16.9	37.3	236	37.7	0.8	61.4	236	3.8	8.9	87.3
geckoes	236	49.6	16.1	34.3	236	48.3	0.4	51.3	236	4.2	9.3	86.4
snakes	236	55.5	22.9	21.6	236	27.1	0.8	72.0	236	6.8	11.9	81.4
frogs	236	47.5	17.8	34.7	236	80.9	1.3	17.8	236	5.1	8.9	86.0
invertebrates	236	57.2	15.7	27.1	236	18.3	0.9	80.9	235	9.3	14.4	76.3
birds	236	60.2	15.7	24.2	236	88.1	1.7	10.2	236	3.8	6.4	89.8
lemurs	236	53.0	17.4	29.7	236	48.3	7.2	44.5	235	4.7	6.4	88.9
tenrecs	236	56.4	16.1	27.5	236	76.3	2.1	21.6	236	5.5	8.1	86.4

	I think that the current numbers of this animals should be:					I think the natural habitat should be:				
	n	eliminated (%)	reduced (%)	kept at same level (%)	increased (%)	*n*	eliminated (%)	reduced (%)	kept at same level (%)	increased (%)
chameleons	236	2.1	7.6	32.6	57.6	83	0	1.2	32.5	66.3
geckoes	236	2.5	5.5	30.5	61.4					
snakes	236	7.6	5.5	30.1	51.3					
frogs	235	0.4	6.0	24.3	69.4					
invertebrates	236	10.6	8.1	30.1	51.3					
birds	236	0.4	4.2	23.3	72.0					
lemurs	236	0.8	3.8	24.6	70.8					
tenrecs	236	1.7	10.2	18.2	69.9					

S3.8.6. Uses of income from wildlife trapping

Trappers used the income from reptile and amphibian collection for a number of purposes, the most frequently listed being subsistence purchases, which was listed by 57.1% of trappers (n=16), followed by children's schooling (28.6%, n=8). Other uses of income from collection included clothes (17.9%, n=5), agricultural costs (10.7%, n=3), fuel (n=2), personal needs (n=2) and 'other' (n=3), Figure S3.8.

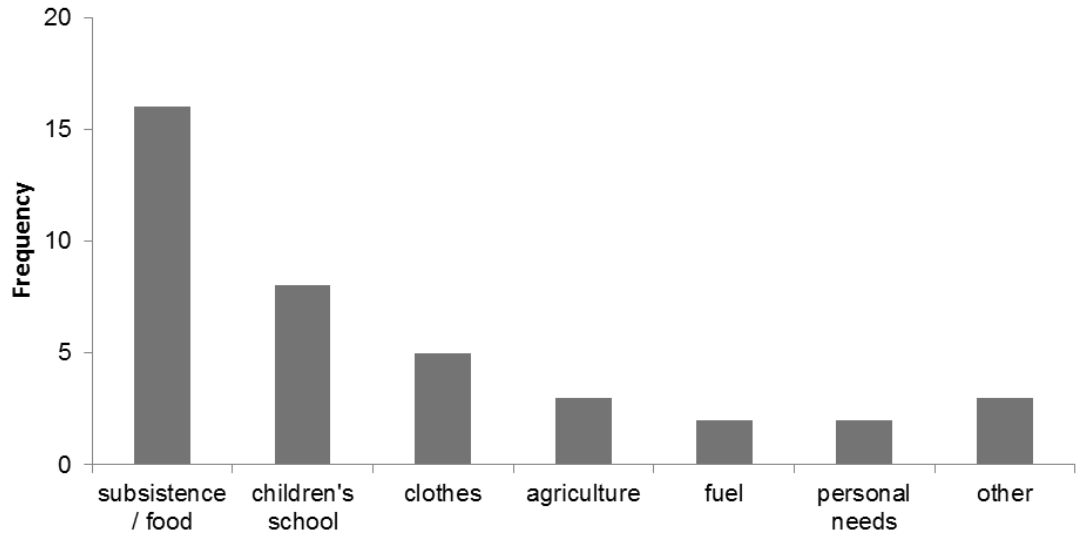

Figure S3.8. Uses of income earned from reptile and amphibian collection. Bars represent the frequencies of reported uses of wildlife collection income including subsistence (sugar, salt, coffee, rice), children's school (fees, tools), clothes, agriculture (seeds, salary), fuel (kerosene, batteries), personal needs (pocket money, games) and other (rent, emergencies) (n=28).

S3.8.7. Extended methodology

Household Livelihood Return (HLR)

In order to calculate the total time households spent engaged in a given activity, respondents were asked which months the activity was carried out, the average number of days per week, and the hours per day spent for each activity. Total time was calculated by multiplying the number of hours per day, the number of days per week and the number of weeks per year. In the case of wildlife trapping, which was a more 'opportunistic' activity, total time was calculated by multiplying the number of hours per day, the number of days per order and the total number of orders received in a period.

Revenue was calculated by asking respondents the amount of produce per period (e.g. 50 kg rice), the market value of that produce (e.g. 1 kg rice=900 MGA/0.39 USD) and the average percentage of produce that was sold in that period. For wildlife trapping, respondents were asked the average amount of money they received per order, and this was multiplied by the number of orders in a period.

When assessing costs, respondents were asked to differentiate start-up costs, which were the costs associated with the first time they did an activity (e.g. purchase or loan of land), and ongoing variable costs (excluding fixed costs), which were those associated with continuing the activity (e.g. fertiliser, seed), and the frequency each cost was incurred (e.g. fertiliser – once per year). The ongoing costs (excluding fixed costs e.g. purchase of land) were used in the HLR analysis.

For the above calculations, where a range of values was given e.g. 'two to four hours', the middle value (i.e. three) was used. Median values were also used in cases of

missing price data, for example if one person failed to report the market price of their agricultural produce, then the median value according to all the other respondents was used. For wildlife trapping, where specific information on the number of hours worked per day was missing, then a median value of six hours calculated from respondents who did give the information was used. In cases where respondents stated ‘an entire night’, then an entire night was presumed to be 10 hours (e.g. 8 pm to 6 am).

Household asset bundle

Table S3.8.7. Household asset bundle including the number and percentage of households that owned each item. The asset bundle ranged from inexpensive to expensive physical items, and livestock. This list was used to create a household asset index based on Morris et al. (2000) where an index is calculated for each household based on the quantity of a particular asset the household in question owns, and the proportion of households owning that asset. Livestock were included given their local importance regarding wealth. Data from systematic sample only.

Item	*n*	% Households (valid %, excl missing answers)
cooking pot	231	100.0
mattress (filled rice sack)	208	91.2
shovel	231	99.1
bed	205	88.7
lamp (kerosene)	203	88.6
table	190	83.3
radio	190	82.3
chair	183	80.3
lamp (battery/electric)	153	66.8
clock	120	51.9
bicycle	111	47.8
mobile phone	97	42.7
watch	60	25.1
mattress (foam)	51	22.0
plough	53	22.8
charcoal stove	52	22.5
music player (CD/DVD)	42	18.3
television	40	17.3
generator (battery/electric)	30	12.9
motorbike	8	3.5
Motor cultivator	5	2.2
solar stove	1	0.4
car	1	0.4
chicken	180	79.3
zebu	67	28.6
pig	52	22.3

CHAPTER 4

From Village to Export: Structure, Operation and Value of Commercial Wildlife Trade in Madagascar

Due for submission to Ecology and Society

Robinson, J.E., Fraser, I.M., St. John, F.A.V., Randrianantoandro, J.C., Andriantsimanarilafy, R.R., Griffiths, R.A., Roberts, D.L., From village to export: structure, operation and value of commercial wildlife trade in Madagascar.

4.1. Abstract

The international wildlife trade is a vast and complex multi-million dollar industry. To supply this trade, many animals are extracted from the wild, sourced from biodiversity-rich, developing countries. The trade therefore has broader implications from safeguarding wildlife, to development, the economy, health and security. To improve its management, a better understanding of the combined costs and benefits of wildlife supply chains is required. We used value chain analysis to explore the structure and operation of wildlife trade in Madagascar, estimate the number of actors involved, the scale and value of the trade, and profit distribution along the chain. The supply of wildlife provided economic benefits to a number of actors from local collectors in rural areas, to local authorities. Exports of CITES-listed reptile and amphibians were worth a minimum of 230,795 USD per year, and comprised a substantial proportion of the quantity and value of live animal exports from the country. The mean sales price of reptiles and amphibians increased over 100-fold between local collectors and exporters, with exporters capturing ~92% of final export price (or 57% when their costs are deducted). However, exporters shouldered the largest costs, investment and financial risk. Local collectors obtained ~1.4% of the final sales price, and opportunities for poverty alleviation and incentives for sustainable management from the trade appear to be limited. Our results contribute towards the limited knowledge base concerning socio-economic implications of supplying international wildlife trade from priority conservation areas. We also reveal the complex and informal nature of wildlife supply chains, which makes design and implementation of policy instruments to enhance the trade for both conservation and livelihoods challenging.

4.2. Introduction

The scale of the legal and illegal global trade in wildlife is vast, with legal trade alone estimated to be worth 323 billion USD (TRAFFIC 2008). To supply this trade, fauna and flora is often extracted from the wild, frequently sourced from countries with high importance to global biodiversity conservation, and also subject to high levels of poverty. Consequently, wildlife trade has implications for biodiversity conservation (Kenney et al. 1995; Garcia-Diaz et al. 2015), human and environmental health (Karesh et al. 2005; Smith et al. 2009), human development (Roe 2002, 2008) and security (Duffy 2014). In order to improve its management, a better understanding of the costs and benefits of wildlife trade chains are required. However, as wildlife trade is multifaceted, obtaining a thorough understanding of its implications is complex. For example, the dependency of people on forests and their products such as traditional medicines, bushmeat, live animals, fungi and nuts, goes far beyond village boundaries, contributing to rural, urban, migrant and resident livelihoods, as well as national and global economies (Ambrose-Oji 2003; Jensen 2009; Roe et al. 2009). Therefore, threats to species and habitats are partly driven by economic activity and consumer demand across the world, far removed from the place of origin (Lenzen et al. 2012). Additionally, as well as providing livelihood benefits to local people, economic, cultural or spiritual benefits obtained by those engaged in wildlife trade - may or may not - provide incentives for conservation and sustainable management of natural resources at the local level (Hutton & Leader-Williams 2003; Jones et al. 2008; (Chapter 3)).

Within conservation biology, there is a need for research to adopt interdisciplinary approaches to address socio-ecological challenges (Mascia et al. 2003; Milner-Gulland 2012). This is particularly important when considering wildlife trade, where an

understanding of the ecological consequences of trade alone, would fail to illuminate the economic and social benefits associated with ongoing business. Therefore an understanding of socio-economic factors, including markets, is paramount. One method for understanding trade-chains is the value chain approach (VCA). The VCA is a descriptive tool and analytical instrument which can incorporate the whole range of activities and relations associated with production, exchange, transport and distribution of a commodity (Kaplinsky & Morris 2001; Jensen 2009). Value chain analysis has been used to examine markets (including financial analyses, competition, governance, entry barriers, and geographic coverage) and has emerged on the research agenda for various non-timber forest products (Avocèvou-Ayisso et al. 2009; Jensen 2009) including charcoal (Shively et al. 2010), bushmeat (Boakye et al. 2016; Cowlishaw et al. 2005) and fisheries (Hempel 2010; Johnson 2010). It provides a method to understand not only the structure, operation and profit distribution through the value chain, but also to identify entry points for policy initiatives and value addition.

With increasing globalisation and awareness of the impact of international trade on the world's biological diversity (Lenzen et al. 2012), initiatives such as certification or labelling schemes that require producers of goods and services to adhere to environmental and social welfare production standards, have become increasingly popular (Blackman & Rivera 2011). For example, there are an estimated 600 eco-labels worldwide, covering ~15% of the global trade in bananas, 12% of wild fisheries, 10% of global forestry products and 7% of global coffee (Eilperin 2010). Whilst much of the trade in live wild animals does not currently fall under such schemes, there is increasing pressure from environmental groups and other stakeholders, to ban the trade on the grounds of welfare, biodiversity loss, health and/or moral considerations (Check 2004; Huyton 2015). The Convention on International Trade in Endangered Species of

Wild Fauna and Flora (CITES) provides some means of assurance regarding ecological sustainability of wildlife trade, through its requirement for trading countries to determine that exports of listed-species will not be detrimental to their populations in the wild (a 'non-detriment finding'). However, not all species are listed by CITES, and in general there is limited information available regarding wider implications of the trade on livelihoods and economies in supply countries. Therefore, debates concerning regulation of the trade in live animals, supplying industry such as the exotic pet trade, are largely uninformed and data-poor. Consequently, there is a need for thorough understanding of trade chains supplying such animals, including information on the actors, livelihood benefits, and potential conservation implications.

To address this data gap, we used value chain analysis to understand the commercial trade in live animals, with particular emphasis on herpetofauna, in a priority biodiversity hotspot, Madagascar. Madagascar has unprecedented levels of biological diversity and endemic species (Myers et al. 2000) which are threatened by continued habitat degradation, driven by economic activities, population growth and high human poverty (Harper et al. 2007; Quéméré et al. 2012). Over the last 15 years, Madagascar has emerged as a significant exporter of reptiles and amphibians to supply the trade in exotic pets (Carpenter et al. 2004; Rabemananjara et al. 2008; Robinson et al. 2015; Chapter 3). Using a combination of primary data collected through interviews with actors along the wildlife trade chain and data provided by the Malagasy government, we describe the structure and operation of the supply chain; estimate the number of actors involved; the scale and value of the trade on a national scale; and the profit distribution and value along the chain from village to export. This study expands our understanding of the conservation and socio-economic implications of wildlife trade,

and contributes towards discussions concerning sustainability and management of trade in wildlife in Madagascar, and more generally.

4.3. Methods

We carried out semi-structured interviews with a range of stakeholders involved in the wildlife trade in Madagascar between 22nd November 2013 and 8th June 2014. This included registered wildlife exporters, intermediaries, local collectors, and the CITES Management Authority of Madagascar (the General Director of Forests, Ministry of Environment, Ecology and Forests).

4.3.1. Sampling

To identify the different actors involved in the wildlife trade, we used snowball sampling, whereby actors involved are used to establish contacts with others in the trade chain (Bryman 2015). In the first instance, we conducted interviews with the CITES Management Authority of Madagascar, who provided a list of registered wildlife exporters. During subsequent interviews, exporters were asked to list the names and locations of intermediaries they worked with in order for us to obtain an estimate of the number of intermediaries, and approach them for interviews. Subsequently, intermediaries were asked to provide names and village locations of local collectors. Local collectors were identified through a combination of systematic household sampling in identified villages and snowball sampling, whereby village leaders, local guides and respondents from the household sample were asked to identify other local collectors of reptiles and amphibians (see Chapter 3 for further detailed methodology on sampling of local collectors).

4.3.2. Semi-structured interviews

Interviews with exporters (Appendix C), intermediaries (Appendix D) and local collectors (Appendix B) covered several topics including: demographic attributes (age, education etc.); livelihood information relating to wildlife trade (time in job, working hours, income, costs and alternative livelihood activities); wildlife groups traded and prices (purchase and sale prices of species); structure and operation of the supply chain (suppliers used, procedures followed, specific instructions received/provided, questions relating to supply/demand, collection practices); legislation and quotas. Additionally, we asked exporters information about the exporting facility (location, date established, number of staff employed and types of jobs, revenue and costs). To understand profit distribution across the supply chain, we asked each respondent belonging to each stage in the supply chain (exporters, intermediaries, and local collectors) purchase and sale prices of 24 pre-selected Malagasy species known to be traded. This was facilitated through the use of Latin, English and Malagasy names of each species and photographic cue cards. In cases where it was felt that no new relevant information was emerging for particular questions and therefore saturation had been achieved (Bryman 2012), particular lines of questioning were dropped or adapted; therefore not all respondents were asked exactly the same set of questions. Triangulation was used to verify information received from different actor groups, for example, both exporters and intermediaries were asked the prices that animals were exchanged for.

We informed all respondents that we were interested in studying legal collection of wildlife for trade, participation was voluntary and that they could stop at any time. Interviews were carried out in English (for some exporters) or in Malagasy/French and interpreted by JCR and RRA. On permission from respondents, exporter and

intermediary interviews were recorded for subsequent verification. Consent was recorded by means of a tick box on the data form and persons under 18 were interviewed with agreement of their parent or guardian. Ethical approval was received from the School of Anthropology and Conservation Ethics Advisory Group, University of Kent.

4.3.3. Data request

Data were requested from the General Director of Forests, Ministry of Environment, Ecology and Forests (CITES Management Authority of Madagascar) on the volume of animals and plants belonging to different species exported from Madagascar in 2013; the individual value declared by exporters for individual species; and the total value of wildlife exports. Price information was converted into US dollars (USD) based on an exchange rate of 1 USD=2283.11 Malagasy Ariary (MGA) valid at the time of the study (29.01.2014) (www.coinmill.com).

4.3.4. Data analysis

Prices declared by exporters to the authorities were compared with price information provided in person during interviews using a non-parametric Wilcoxon Signed-Rank Test. We calculated median prices for each of the 24 pre-selected species at each stage of the chain across respondents, resulting in median purchase and sales prices for each species from exporters and intermediaries, and median sales prices declared by local collectors. Prices provided by different actor groups were compared using a Wilcoxon Signed-Rank Test. We then calculated the mean price across all 24 species and using this value calculated the mark-up of prices along the chain, the marketing margins (proportion of final sales price captured by different actor groups), and the value of the herpetofauna trade to different actor groups.

We estimated marketing margins of actor groups following Cowlishaw et al. (2005) and Avocèvou-Ayisso et al. (2009). This was calculated as (Ps – Pp)/Pf where Ps is the mean sales price, Pp is the mean purchase price (i.e. the sales price reported by the previous actor in the chain) and Pf is the final sales price at the end of the chain (at export). We then adjusted this figure to allow for estimated costs (transport, equipment etc.) using (Ps-Pp-Pc)/Pf where Pc is the estimated costs incurred by the actor group. Marketing margins were then calculated for each of the 24 species individually, and Spearman's Rank correlations used to test for relationships between species value and marketing margins received by different actor groups to explore if respondents received a greater share of export value for more valuable species.

To calculate the potential value of the reptile and amphibian trade to different actor groups along the chain, we calculated the proportion of the final export value declared by exporters (provided in data request from the CITES Management Authority) that reached the different actor groups. To do this we used mean sales and purchase prices provided by respondents (across the 24 pre-selected species) to calculate the proportion of the sales price the cost of purchasing animals from the previous actor in the chain comprised. This represented the amount of money being passed to the previous actor group. We then incorporated additional cost information based on expenses (equipment, transport, etc.) into the calculations, reducing the profit received by each actor group accordingly. Based on this, we estimated the proportion of the final declared export value that was made up of profit and costs for each actor group. Since we obtained price data from multiple sources (to allow comparison and triangulation), we conducted a sensitivity analysis to incorporate the variation in the prices given by the different actor groups. For example, exporters told us the prices they paid to purchase animals from intermediaries, and intermediaries told us prices they charged

to exporters. Therefore the proportion of the final export value made up of exporter's animal purchase costs could be calculated in two ways; from the exporter-declared mean sale price divided by exporter-declared mean purchase price, or from the exporter-declared mean sales price divided by the intermediary-declared mean sales price, resulting in a minimum proportion of 7.7 and a maximum of 9.3. Therefore, in the results we report the minimum and maximum potential values.

4.4. Results

4.4.1. Scale and value of wildlife trade from Madagascar

Data provided by the CITES Management Authority of Madagascar indicated that a total of 31,871 reptiles and amphibians were exported from Madagascar during the calendar year 2013 (including CITES and non-CITES species). CITES reptiles and amphibians comprised 87.9% of the trade in all animals in terms of numbers of individuals (Figure 4.4.1.1).

The live trade in wildlife from Madagascar, including both flora and fauna was recorded to be worth 346,249 USD in 2013. Reptiles and amphibians (CITES and non-CITES) accounted for 66.7% of this total, with CITES reptiles accounting for a considerable proportion (50.4%) of the total wildlife export income (Figure 4.4.1.2). The 2013 Ministry records show the total declared export value of reptiles and amphibians from Madagascar amounted to 230,795 USD, generating 14,621 USD in taxes to the Ministry of Environment and Forests. However, the mean sales price provided by exporters during our interviews was 2.8 times higher than declared export prices (Wilcoxon Signed-Rank $Z=-4.29$, $n=24$, $p<0.001$, Supporting Information, Table S.4.8.1). Therefore, based on the proportional difference, the total export value of reptiles and amphibians for 2013 may total 646,226 USD.

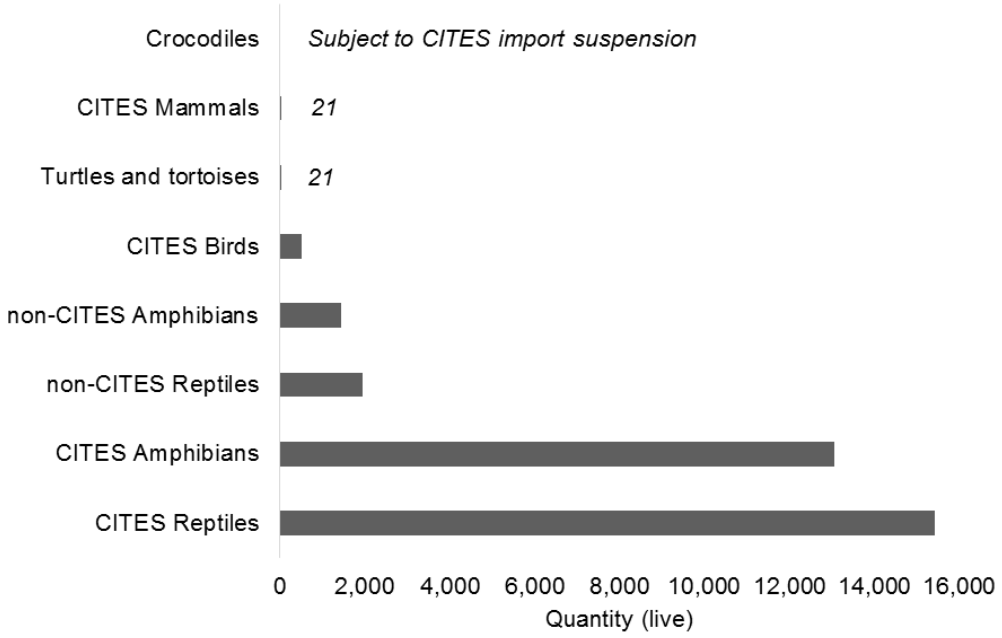

Figure 4.4.1.1. Quantity of live fauna exported from Madagascar in 2013, as provided by the CITES Management Authority of Madagascar. Flora are excluded from this figure as some are exported by weight (e.g. kilograms of seed) rather than as whole plants and are therefore not directly comparable. No data were provided for non-CITES mammals or birds and we have been unable to verify whether this is because there is no trade in these groups or just no data.

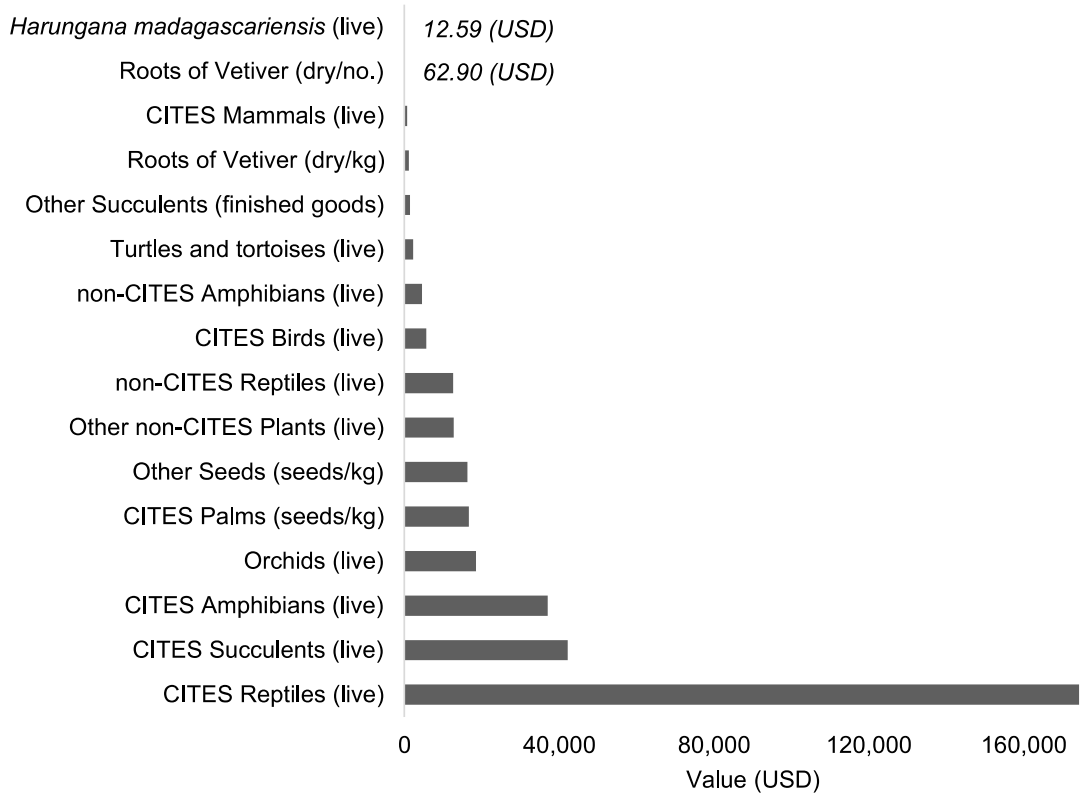

Figure 4.4.1.2. Value in USD of all wildlife exports (including both flora and fauna) from Madagascar in 2013, as provided by the CITES Management Authority of Madagascar. Data were missing for non-CITES palms, shells, and Apanga (*Pteridium aquilinum*). Additionally, partial data were provided for 'other succulents: finished goods' but were missing for 'other succulents: tubes' and 'other succulents: number'. Data were converted from Malagasy Ariary (MGA) to US dollars (USD) based on an exchange rate of 1 USD=2283.11 MGA valid 29/01/2014 (www.coinmill.com).

4.4.2. Structure and operation of the supply chain

The wildlife supply chain comprised registered exporters, local collectors who trapped animals in the wild and intermediaries who brought animals from local collection areas to export facilities (Figure 4.4.2). In some cases, however, the distinction between

different actors in the chain was not clear cut, for example the role of local collectors and intermediaries sometimes overlapped, and on occasion exporters by-passed intermediaries to obtain animals directly from local collectors, sent their own staff to collection areas, or supplied other exporters (particularly when exporters were located in different parts of the country). We were able to conduct in-depth interviews with eight of the 11 wildlife exporters (72.7% of exporters), 12 intermediaries and 28 local collectors of reptiles and amphibians. In total, 48 actors were interviewed.

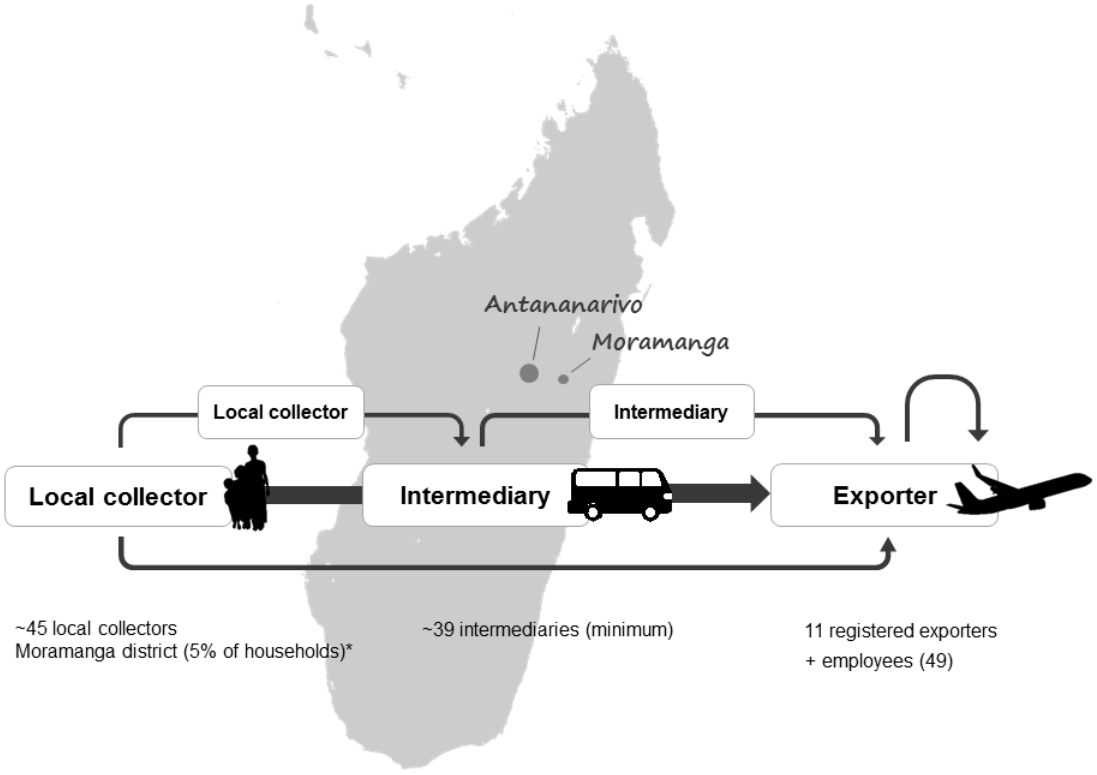

Figure 4.4.2. Structure of the wildlife trade supply chain in Madagascar and approximate numbers of people belonging to different actor groups. The supply chain comprised local collectors who trapped animals in the wild, intermediaries who brought animals from local collection areas to export facilities and registered wildlife exporters.

*5.4% of randomly selected households in trapping villages in the Moramanga district of Madagascar trapped reptiles and amphibians for trade (See Chapter 3).

Animal exporters were mainly situated in or around the capital Antananarivo, with one in Toamasina (East) and one in Toliara (South). Exporters estimated there were between 20 and 30 intermediaries in Madagascar, but provided 32 different names between them. However, over the course of the study (asking exporters and other actors in the chain to provide the names of intermediaries) we were given an additional seven names, totalling 39 overall. Intermediaries were identified in several locations including (amongst others) Moramanga (6), Tulear (6), Tamatave (3), Fort Dauphin (2), Diego Suarez (3), Nosy Be (1), Antananarivo (2), Mahujunga (1) and Sambava (2).

Fifty seven percent (n=4) of exporters had other jobs often including additional businesses, and they employed between one and 13 people each (median=6, IQR=3.75, n=8), sometimes part-time/seasonally, in jobs such as guards, feeding animals, packing, transport to airport and general help. Most intermediaries (82%, n=9) also had other jobs (e.g. agriculture, minibus driver, shop, mechanic) and generally worked alone with occasional help from family and friends to conduct tasks such as counting animals. Local collectors engaged in wildlife collection as part of a diverse livelihood portfolio and occasionally engaged family members or others to help complete orders. All respondents had been engaged in the trade for a long time (exporters: median=20 years, IQR=10, n=8; intermediaries median=22 years, IQR=8.3, n=12 and local collectors median=17 years, IQR=16, n=17).

Animal export usually occurred from September to July (exporter interviews: median=6.6 months a year, IQR=2, n=7), and all year for plants. At the time of research one of the exporters interviewed was temporarily not exporting reptiles and amphibians, the other seven exported reptiles and amphibians and other animals such as mammals (n=6, in all cases these were tenrecs), invertebrates (n=4), birds (n=4, e.g.

Agapornis canus), fish (n=2), plants (n=2) and cultivated and non-CITES coral (n=1). In all cases, respondents reported that animals were exported live (as opposed to skins or other products or derivatives), and mainly supplied wholesalers, pet shops and specialised reptile outlets around the world. Ministry data indicates that the USA, Japan and Canada were the most significant importers in terms of volume, respectively importing 45%, 13% and 9% of Malagasy herpetofauna in 2013.

Informal verbal contracts existed between different actor groups in the supply chain, and intermediaries were required to carry a collection mandate obtained from the exporter (in turn obtained from the Management Authority) detailing the order specifics. In almost all cases animals were collected to order, with specific information on number/species/sex transferred down the chain from exporter to local collector, only occasionally were animals collected opportunistically. When local collectors were asked: 'if you were to collect more animals, how likely is it that you could sell them', the majority (82%, n=23) said 'unlikely'. When asked 'if you were paid more for each animal, how would it influence the number you collect', the majority (86%, n=24) stated that they would collect the same quantity with most commenting that they stick to the number ordered because no-one will buy extra animals, or, if someone would buy them, it would be for a much lower price. All nine intermediaries corroborated this stating it was 'very unlikely' that if they themselves requested more animals they would find a buyer.

Exporters were permitted by authorities to collect 10% above quotas to allow for mortality, but this was not perceived to be economically viable for all species, depending on how robust they were in captivity. Exporters kept animals for three days to one month prior to export (median=7, IQR=2.5), and gave intermediaries between two days and one month to supply animals (median=15 days, IQR=10.5). One exporter

commented that *'it's not in our interest to keep them in the facility as it says 'W' (wild) on application and the animals may lose health if kept'*. Local collectors stated that it took between one and 15 days to collect and supply animals to the intermediary (median=2.5, n=24). Therefore, the total time from collection to export was between a few days and up to two months.

4.4.3. Economics of the supply chain

Comparison of price information provided by actor groups

Purchase prices for 24 species provided by exporters were slightly higher (mean proportional difference=1.2 ± 0.11, n=23 taxa) than equivalent sale prices provided by intermediaries, but there was no significant difference when these prices were compared between actor groups (Wilcoxon Signed Rank Z=1.15, p=0.249). However, there was a significant difference between purchase prices provided by intermediaries and equivalent sale prices provided by local collectors (Z=3.88, p<0.001), with prices declared by intermediaries more than double (mean proportional difference=2.5 ± 0.73, n=20 taxa) the sale prices declared by local collectors (Supporting Information, Table S4.8.2).

Summary of costs encountered by actor groups

Exporters had considerably higher costs than other actor groups along the chain (Table 4.4.3.1). These costs included setup and maintenance of facilities (e.g. land, facilities, staff, utility bills), transport, packing materials, agent/broker, collection permit (one-time fee each year), price of animals, collection fees (paid to local branch of the Ministry of Environment and Forests; set price of 400 FMG (0.04 USD) per reptile and 150 FMG (0.01 USD) per amphibian), local informal fees to communities (varies), and

various taxes. Taxes included an export tax for wild animals payable to the Ministry of Environment and Forests (4% of shipment value), voluntary fees to support the CITES Scientific Authority (2%), taxes to the Ministry of Commerce, veterinary certificate fees (2%), fees to GasyNet (private company that deals with import/export at airport, one exporter quoted this as 2% of total invoice per shipment). According to detailed price information provided by one exporter, 35% of revenue generated from shipments went on costs (Table 4.4.3.1). Another exporter corroborated this by estimating that 30-50% of final shipment value went on costs.

Compared to exporters, local collectors and intermediaries declared minimal costs. Exporters usually covered intermediaries' costs of transport, accommodation, equipment, in addition to the agreed price for animals. Some intermediaries stated they had to pay for materials such as cages, plastic bottles, cloth bags, torches and other sundries, and also informal fees to communities. Local collectors' main costs included torches, batteries, food and coffee, medicines, and in some cases, items for transporting animals (baskets, sacks, cloth bags, bottles, and gloves).

Table 4.4.3.1. Median income and cost information provided by exporters, intermediaries and local collectors during interviews for the 2012-2013 collection season (~September to July). Percentage costs were calculated based on median revenue and median cost information across respondents, with the exception of exporters (because only one exporter gave a monetary value for costs, the percentage cost was calculated from that individuals declared revenue, rather than the median revenue across all four exporters). IQR=interquartile range.

	n	**Median (USD)**	**IQR (USD)**	**% costs**
Exporters net revenue	4	24,381	40,278	-
Exporter costs	1	13,500		35.3[a]
Intermediary income	8	325	1105	-
Intermediary costs	4	0.66	25	0.18
Local collector income per season	20	114	133	-
Local collector costs per season	25	12	54	10.6

[a]Another exporter did not give detailed cost information but estimated that 30-50% of the value of one shipment will go on expenses.

Price mark-up across supply chain and marketing margin

Based on sale price information provided by each actor group (Supporting Information, Table S4.8.2), animals were sold by intermediaries for around seven times the price they were purchased for from local collectors (mean proportional difference=7.3 ± 1.32 (n=19 species)). The intermediary sales price increased a further 15 times by exporters prior to sale/export (mean proportional difference=14.98 ± 1.8, n=23 taxa). The sale price increased by 105 times (mean proportional difference=105.28 ± 21.2, n=20 taxa) from local collector to exporter.

The marketing margin (at export) captured by each actor group was greatest for exporters (92.3%), followed by intermediaries (6.2%) and then local collectors (1.4%) (Table 4.4.3.2). Consideration of cost information reduced the share captured by exporters to 57.0%, but had minimal effect on the share captured by intermediaries (6.1%) and local collectors (1.3%) (Table 4.4.3.2). When calculated for individual species, the marketing margin varied between 0.2 and 4.0% for local collectors, 2.8 to 31.3% for intermediaries and 67.0 to 97.3% for exporters (Supporting Information, Table S4.8.3). However, there was no significant relationship between final sales prices at export and the marketing margins received by local collectors (r_s=-0.095, n=20, p=0.690), intermediaries (r_s=-0.371, n=23, p=0.082) or exporters (r_s=0.335, n=23, p=0.118), suggesting that the share received by actors was not related to the export value of the species.

Exporters estimated that ~35% of their shipment value was used on expenses, therefore based on a final declared export value of 230,795 USD logged with the Ministry for all exporters in 2013, this represents a profit of 149,324 USD (Figure 4.4.3). According to the sensitivity analysis, we estimated that purchase prices paid by exporters for animals comprised 7.7 to 9.3% of prices they sold them for, representing a transmission of 17,708 to 21,511 USD to intermediaries. Incorporating animal purchase costs paid by intermediaries (ranging from 15.5 to 47.7% of sales prices) and additional costs (0.18%, Table 4.4.3.1), the estimates for profit received by intermediaries in 2013 ranged from 9,238 to 18,144 USD. Local collectors did not encounter costs of purchasing animals but based on estimated additional costs (10.6%, Table 4.4.3.1); this resulted in an estimate of between 2,449 and 9,163 USD reaching local collectors in Madagascar (Figure 4.4.3). However, based on the discrepancy in prices between declared export values reported in Ministry data, and the prices exporters reported

during the interviews, these values may be considerably higher. For example, based on a cumulative export value of 646,226 USD (based on sales prices reported by exporters being 2.8-times higher than prices reported in Ministry data), exporters could receive a profit of 418,108 USD; intermediaries from 25,866 to 50,804 USD and local collectors from 6,857 to 25,658 USD.

Table 4.4.3.2. Marketing margins of the different actor groups involved in the live reptile and amphibian trade in Madagascar. Marketing margins were calculated as (Ps - Pp)/Pf where Ps is the mean sales price, Pp is the mean purchase price (i.e. the sales price reported by the previous actor in the chain) and Pf is the final sales price at the end of the chain (at export). We then adjusted this figure to allow for estimated costs (transport, equipment etc.) using (Ps-Pp-Pc)/Pf where Pc is the estimated costs incurred by the actor group.

Category of actor	**Mean selling price[1] (USD)**	**Costs[2] (USD)**	**Local collectors marketing margin**		**Intermediaries marketing margin**		**Exporters marketing margin**		**Total marketing margin**
			(Ps/Pf) %	**with costs (Ps-Pc)/Pf)) %**	**(Ps_i-Pp)/Pf %**	**with costs ((Ps_i-Pp-Pc_i)/Pf) %**	**((Pf-Pp_i)/Pf) %**	**with costs ((Pf-Pp_i-Pc_{ii})/Pf) %**	**(Pf-Pp)/Pf %**
Local collector	0.28 (Ps/Pp)	0.03 (Pc)	1.44	1.29					
Intermediary	1.49 (Ps_i/Pp_i)	0.02 (Pc_i)			6.23	6.14			
Exporter	19.42 (Pf)	6.86 (Pc_{ii})					92.33	57.00	**98.56**

[1]Mean selling price is calculated by taking the median selling price across respondents for each species, and then taking the mean price across the 24 species. Selling prices declared by each actor group (exporter, intermediary and local collector) are used.

[2]Costs refer to all additional expenses such as transport, packaging etc. but do not include purchase of animals. Values are calculated using the percent costs information provided in Table 4.4.3.1.

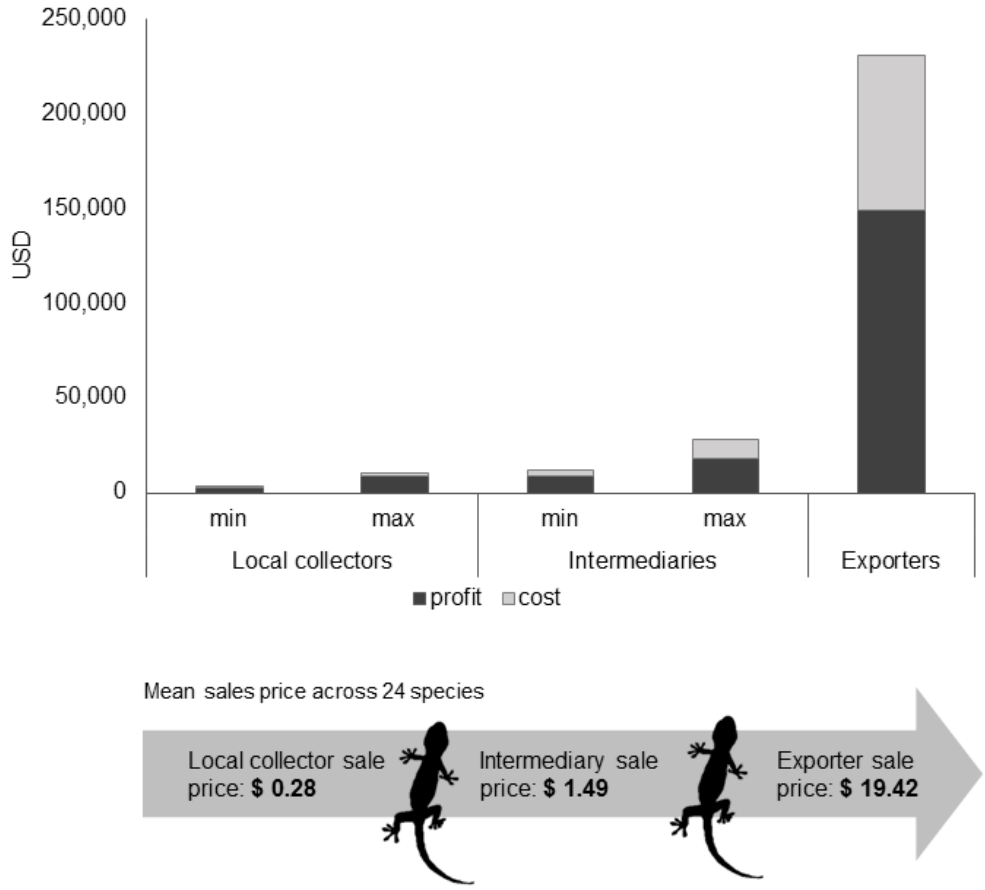

Figure 4.4.3. Minimum and maximum estimated profit and costs received by local collectors, intermediaries and exporters engaged in the commercial reptile and amphibian trade in Madagascar. Mean sales prices estimated across 24 different traded species are displayed below the x axis. Individual sales prices for each of the 24 species are provided in Supporting Information, Table S4.8.2.

4.5. Discussion

The reported export of live (particularly CITES-listed) reptiles and amphibians from Madagascar forms a significant component of the country's wildlife trade in terms of both number of individual animals, and value. However, Madagascar's highly endemic herpetofauna is threatened, primarily by habitat destruction but also in some cases by

collection for trade (Andreone et al. 2005; Jenkins et al. 2014). Therefore, ensuring trade is sustainable, and tackling illegal wildlife trade, remains amongst Madagascar's management challenges for preservation of its biodiversity. Our analysis of the supply chain allows us to understand not only the operation of the wildlife trade, in order to better inform its management, but also the extent and distribution of economic benefits obtained. These benefits extend beyond local collection areas, to intermediaries in urban areas, export businesses and their employees, to local authorities and the national economy.

Although the general structure of the herptofauna supply chain in Madagascar appears to have changed little over the last decade (Carpenter et al. 2005; Rabemananjara et al. 2008), there has been a reduction in the number of animal exporters from 13 in 1996-1999 (Carpenter et al. 2005) and 17 between 2003-2004 (Rabemananjara et al. 2008), to 10 active exporters in the current study. Additionally, whilst in 2003-2004 intermediaries were described as 'solely involved in the wildlife trade' and 'for most exporters, animal and plant export is the main source of income' (Rabemananjara et al. 2008) we found very few people involved in the trade as their sole occupation. The flexibility of the chain, particularly the sometimes overlapping roles of intermediaries and local collectors, may explain the discrepancies in price information received from different actors. Depending on their role and position, prices could vary, for example a local collector who had been subcontracted by another local collector to fulfil an order may only receive half the price that the subcontractor receives. Other factors such as location of village or collecting site may also influence prices. Price differences between what exporters provided during interviews and those declared to the Ministry may be explained by under-declaration of prices to the Ministry, exaggeration of prices during interviews, price increases since the data request, or general noise in the data.

The trade consisted of well-established actors, as individuals all along the chain had mostly been in the business for long periods of time (~20 years). Importantly, the trade operated on the basis of informal verbal contracts between actors, based on trust. Therefore knowledge of the supply chain participants, contacts and reputation were particularly important in coordination of activities within the chain. Animals were not collected opportunistically, as was sometimes the case in the past (Carpenter et al. 2005), but were collected to order, with specific details (e.g. species/sex/quantity) passed down the chain from exporters to local collectors. In the majority of cases, it was not considered economically worthwhile for people to collect opportunistically as buyers were not available, or would pay a lower price. Only occasionally, if a rare, difficult to find, or valuable specimen was encountered opportunistically, which the local collector knew would be desirable, would they collect that animal. Once collected, animals were not kept in-country for long thus minimising exporter costs. Additionally, although we did not verify health of animals in trade, with payments frequently delivered in-part (50% before and 50% on delivery), and often with no payment for poor quality animals, this created incentives for suppliers to deliver animals in good condition.

Whilst exporters captured by far the largest proportion of the final sales price, they also incurred the largest proportion of costs associated with running and licencing their facilities, paperwork, taxes, packing and shipment. Consideration must also be given to risk associated with export of Malagasy herpetofauna. For example, exporters must factor in the number of animals that may die in transit, for which they may not get paid. Comparably, intermediaries and local collectors had minimal costs and therefore much lower investment. However, even when taking into account the estimated costs exporter's face, the proportion of final sales price received by local collectors appears

relatively low (1.3-1.5%). It is difficult to find recent comparable examples, but whilst caiman hunters in Venezuela received 1.8% of the final export price of skins in 1989 (Thorbjarnarson & Velasco 1999) hunters in Louisiana received 5-15% (Moyle 2013); collectors of chameleons in Tanzania received ~8.3% of minimum export price (Roe 2002); collectors of parrots in Indonesia received 5.2% (Swanson 1992), collectors of Coral Beauty (ornamental fish) received 10% (Baquero 1999) and local collectors of cardinal tetras (ornamental fish) in Brazil received almost 19% of export value (Watson & Roberts 2015). Carpenter et al. (2005) noted that local collectors and intermediaries in Madagascar suffered disproportionately greater price reductions than exporters following trade restrictions, in particular the Experimental Management Program (EMP) implemented in 1999. This was predominantly a national initiative, in compliance with exporters, to address CITES concerns. It initially restricted trade, with the aim of increasing the number of species permitted based on good management, but was essentially dominated by a cartel of powerful exporters and resulted in a ~100-fold differential between prices paid to exporters and local collectors (Carpenter et al. 2005), which still appears to be the case today despite its collapse.

4.5.1. Summary and recommendations

This research provides insight into the economic benefits received by actors along the entire wildlife supply chain in Madagascar, and suggests that a large proportion of benefits are captured by exporters. However, notwithstanding consideration of costs and risk different actors face, the income people obtain is not straightforward to interpret. For example, a small amount of money will go a lot further amongst local collectors, compared with intermediaries and exporters who reside in larger towns and cities, and local collectors in poor rural communities may be more in need of employment no matter how small the financial benefits may be. Our recent

complementary research in villages supplying the trade, suggests that while some households benefit from local harvest of reptiles and amphibians (including some of the poorest households), it does not appear to result in sufficient incentives to promote conservation of species and habitats (Chapter 3). Equally, in their study of Mantella frog trade in Madagascar, Rabemananjara (2008) observed that because collection permits are issued to exporters rather than local collectors and collectors are paid low prices, the system becomes counterproductive in terms of promoting sustainable harvesting and incentives to conserve resources based on benefits received. Therefore, whilst the trade in herpetofauna from Madagascar brings some benefits to stakeholders along the chain, at the local level, both incentives for conservation, and opportunities to alleviate rural poverty are limited.

Aside from banning trade (which is likely to remove benefits to local communities) or incorporating traded species into initiatives such as Payments for Ecosystem Services (PES) projects, a number of options could be explored to enhance both conservation and livelihood benefits utilising the trade. These may include: (1) increase supply through captive breeding or ranching of traded species; (2) diversify the market by incorporating additional species (3) add value to traded animals through certification or similar initiatives; (4) increase market share to local collectors (e.g. cutting out intermediaries); (5) implement capacity building initiatives and promote collective management of the resource amongst local collectors. Whilst PES projects could add value to species at the local level and promote their conservation, many areas where wildlife is collected are mosaics of farmland and degraded habitat, are difficult to access, and may be sources of few and specific species, and therefore this approach may be localised. Of the approaches to enhance benefits utilising the trade, many are limited by capacity and resources and have received inadequate attention. For example,

capacity and resources to implement captive breeding of traded species in-country is limited (J.E. Robinson, unpublished data), and if permitted in Madagascar, is likely to be carried out at the exporter level (thus further limiting benefits and incentives to local communities). In terms of ranching (where gravid females or eggs are removed from the wild and young reared in captivity), and introducing additional species to diversify the market, further research would be required to understand demand and biological factors of species (such as resilience to collection, and rearing success). There are limited opportunities to add value to live animals throughout the chain (as they do not undergo any form of 'processing'), yet certification or labelling systems aimed at improving ecological and social sustainability might allow higher prices to be realised at export, with an increase in benefits passed down the chain. However, certification systems have large cost and bureaucratic implications, and whilst receiving limited attention in the pet trade, have been largely unsuccessful for ornamental fish (Vosseler 2015) and it is unknown whether there would be demand for such products amongst consumers. Whilst occasionally exporters go straight to local collection areas, cutting out intermediaries would be impractical in many situations, due to inaccessibility of collection sites, and the valuable knowledge, experience and communication intermediaries provide.

The final option to promote collective management of species harvest at the local level may be the most feasible in terms of enhancing both conservation and livelihood benefits from the trade. Capacity building programmes could focus on raising awareness of traded species (e.g. legislation, value, ecology and collection methods), improving communication between local collectors and coordinating collecting activities (e.g. sharing information on trapping requests, setting prices), and promoting empowerment and ownership of the resource. However, in some cases, local collectors

can be isolated and widely distributed, making communication between them difficult. Additionally, property rights in Madagascar are often poorly defined (Bojö et al. 2013), meaning that the collector typically does not usually own the resource from which the animals are being harvested, so it is unknown whether they can control management of the resource, or if the social capital exists to do so. Nonetheless, users have been shown to develop rules that limit use of common resources in the absence of central control (Ostrom 2008).

Our analysis reveals the complex and informal nature of wildlife trade supply chains, and illustrates the challenges faced by practitioners attempting to enhance the trade for both livelihoods and conservation. The information provided in this study may be useful in informing future dialogue concerning sustainable management of wildlife trade in Madagascar, whilst also providing a more comprehensive understanding of the wider socio-economic implications of wildlife trade chains.

4.6. Acknowledgements

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4.8. Supporting Information

Table S4.8.1. Median ± interquartile range (IQR) prices for 24 species, provided by exporters during interviews ([a]) and as declared according to data received from by the General Directorate for Forests, Ministry of Environment and Forests (CITES Management Authority of Madagascar) for 2013 ([b]).

Species	**Interview data (USD)[a]**			**Declared price (USD)[b]**			**Proportional difference**
	median	**IQR**	***n* (exporters)**	**median**	**IQR**	***n***	**([a] / [b])**
Brookesia stumpffi	29.63	14.81	4	8.00	6.96	180	3.70
Brookesia superciliaris	22.78	8.09	4	8.00	8.00	194	2.85
Brookesia therezieni	22.78	8.09	4	6.50	7.50	95	3.50
Brookesia thieli	22.78	8.09	4	6.50	6.50	89	3.50
Furcifer campani	29.50	29.50	4	14.00	30.00	217	2.11
Furcifer lateralis	20.00	25.00	5	10.00	9.92	1797	2.00
Furcifer oustaleti	11.00	1.00	5	9.00	7.25	1660	1.22
Furcifer pardalis	80.00	32.50	5	25.00	35.00	1793	3.20
Furcifer verrucosus	12.00	9.00	5	8.00	5.38	1558	1.50
Mantella aurantiaca	8.22	5.50	5	2.00	2.00	490	4.11
Mantella baroni	5.00	2.74	4	2.00	0.38	5628	2.50
Mantella betsileo	4.00	1.37	4	2.00	0.00	4294	2.00
Mantella nigricans	4.00	6.00	5	2.00	1.00	1716	2.00
Mantella pulchra	6.11	4.54	4	2.00	1.00	351	3.06
Paroedura masobe	22.50	24.25	3	11.12	1.12	2	2.02
Phelsuma laticauda	12.00	5.00	5	4.00	3.00	569	3.00
Phelsuma lineata	9.00	4.10	3	3.00	4.00	2656	3.00
Phelsuma madagascariensis	18.00	10.00	5	6.00	5.75	799	3.00
Phelsuma quadriocellata	11.00	5.00	5	3.00	5.75	1667	3.67
Scaphiophryne gottlebei	16.00	24.00	5	3.00	3.50	184	5.33
Uroplatus ebenaui	20.28	8.29	4	10.00	11.75	75	2.03
Uroplatus fimbriatus	36.55	18.08	4	10.00	10.00	433	3.66
Uroplatus phantasticus	20.28	8.29	4	10.00	13.00	56	2.03
Uroplatus sikorae	22.78	10.59	4	10.00	10.00	760	2.28
Mean difference between price estimates:							2.80

Table S4.8.2. Median purchase and sale prices (USD) for 24 traded species as declared by exporters, intermediaries and local collectors during interviews.

Species	Exporter sale price (median)[a]	min-max	*n*	Exporter purchase price (median)[b]	min-max	*n*	Intermediary sale price (median)[c]	min-max	*n*	Intermediary purchase price (median)[d]	min-max	*n*	Local collector sale price (median)[e]	min-max	*n*	Comparison of exporter ([b]) vs intermediary ([c]) declared prices ([b]/[c])	Comparison of intermediary ([d]) vs local collector ([e]) declared prices ([d]/[e])
Brookesia stumpffi	29.63	7-40	4	1.75	1.31-4.38	5				0.22		1	0.07	0.04-0.22	3		3.14
Brookesia superciliaris	22.78	7-30	4	1.53	1.31-2.63	5	1.10	0.31-1.76	5	0.50	0.22-0.88	6	0.22	0.07-1.31	10	1.39	2.25
Brookesia therezieni	22.78	7-30	4	1.75	1.31-2.63	5	1.10	0.31-1.76	4	0.55	0.22-0.88	5	0.22	0.09-0.44	9	1.59	2.50
Brookesia thieli	22.78	7-30	4	1.53	1.31-2.63	4	1.10	0.31-1.76	4	0.55	0.22-0.88	5	0.22	0.09-0.44	10	1.39	2.50
Furcifer campani	29.50	10-80	4	2.19	2.19-2.63	3	1.43	1.21-2.20	3	0.88	0.66-1.32	3				1.53	
Furcifer lateralis	20.00	14-40	5	1.53	0.66-2.19	6	0.88	0.13-1.32	4	0.48	0.04-0.79	3	0.15	0.09-0.22	2	1.74	3.23
Furcifer oustaleti	11.00	10-20	5	1.09	0.44-2.19	5	1.32	0.44-2.11	6	0.88	0.09-1.32	4	0.30	0.09-0.88	4	0.83	2.93
Furcifer pardalis	80.00	35-342.50	5	6.49	3.5-17.52	6	2.20	1.32-7.04	4	1.32	0.88-3.52	4				2.95	
Furcifer verrucosus	12.00	10-20	5	1.86	1.09-2.19	6	2.20	1.98-2.20	3	0.88	0.88-1.32	2				0.85	
Mantella aurantiaca	8.22	3-10	5	0.54	0.31-2.19	6	0.46	0.13-0.88	2	0.29	0.09-0.40	3	0.10	0.04-0.22	4	1.18	2.86
Mantella baroni	5.00	2.5-6	4	0.44	0.31-0.44	5	0.44	0.22-3.30	5	0.23	0.09-1.10	5	0.07	0.03-0.22	9	1.00	3.30
Mantella betsileo	4.00	2.5-6	4	0.44	0.31-0.66	5	0.79	0.70-1.32	3	0.44	0.26-0.44	3	0.16		1	0.55	2.75
Mantella nigricans	4.00	4-10	5	1.39	0.31-2.19	6	1.32		1	0.88		1	0.07		1	1.05	12.57
Mantella pulchra	6.11	3-9	4	0.39	0.44-0.88	6	0.66	0.22-1.32	5	0.40	0.09-0.55	6	0.05	0.04-0.26	9	0.60	7.92
paroedura masobe	22.50	20-50	3	6.68	5.26-8.76	4	4.40	2.64-8.80	4	2.31	0.44-4.40	5	0.88	0.07-2.19	9	1.52	2.63
Phelsuma laticauda	12.00	6-15	5	1.09	0.44-2.19	6	0.73	0.66-0.79	2	0.34	0.24-0.44	2				1.51	
Phelsuma lineata	9.00	5-10	3	0.44	0.35-0.44	4	0.33	0.13-1.10	4	0.18	0.09-0.44	3	0.04	0.00-0.15	11	1.33	4.40
Phelsuma madagascariensis	18.00	8-30	5	1.75	0.44-2.19	5	1.20	0.44-2.20	4	0.55	0.22-0.88	4	0.66	0.44-0.88	2	1.46	0.83
Phelsuma quadriocellata	11.00	6-15	5	0.66	0.44-2.19	6	0.40	0.18-1.10	5	0.24	0.09-0.44	4	0.09	0.03-0.18	11	1.66	2.69

Scaphiophryne gottlebei	16.00	5-25	5	1.12	0.31-0.66	6	1.76	1.32-2.20	2	0.88	0.66-0.88	2	0.07	0.04-0.22	4	0.64	12.57
Uroplatus ebenaui	20.28	12-50	4	1.75	0.79-2.63	5	1.98	0.70-4.18	5	0.88	0.35-2.09	6	0.28	0.07-1.10	9	0.88	3.14
Uroplatus fimbriatus	36.55	14-60	4	3.50	2.63-6.57	5	4.40	2.20-5.28	4	1.32	0.48-4.40	5	1.04	0.66-2.63	12	0.80	1.27
Uroplatus phantasticus	20.28	12-50	4	1.75	0.79-3.07	5	2.42	1.32-3.52	5	1.10	0.66-1.76	6	0.44	0.04-1.10	12	0.72	2.50
Uroplatus sikorae	22.78	10-50	4	1.75	0.88-2.19	5	1.54	0.88-2.20	5	0.66	0.22-1.32	6	0.37	0.09-1.10	14	1.14	1.78
Mean	19.42			1.81			1.49			0.71			0.28		7.30	**1.23**	**2.53**

Table S4.8.3. Marketing margins of the different actor groups (local collectors, intermediaries and exporters) involved in the reptile and amphibian trade in Madagascar, calculated for 24 individual species.

	Marketing margin		
Species	**Local collector**	**Intermediary**	**Exporter**
Brookesia stumpffi	0.24	-	-
Brookesia superciliaris	0.97	3.86	95.17
Brookesia therezieni	0.97	3.86	95.17
Brookesia thieli	0.97	3.86	95.17
Furcifer campani	-	4.85	95.15
Furcifer lateralis	0.75	3.65	95.60
Furcifer oustaleti	2.73	9.27	88.00
Furcifer pardalis	-	2.75	97.25
Furcifer verrucosus	-	18.33	81.67
Mantella aurantiaca	1.22	4.40	94.38
Mantella baroni	1.40	7.40	91.20
Mantella betsileo	4.00	15.80	80.20
Mantella nigricans	1.75	31.25	67.00
Mantella pulchra	0.82	9.98	89.20
Paroedura masobe	3.91	15.64	80.44
Phelsuma laticauda	-	6.05	93.95
Phelsuma lineata	0.44	3.22	96.33
Phelsuma madagascariensis	3.67	2.99	93.34
Phelsuma quadriocellata	0.82	2.78	96.40
Scaphiophryne gottlebei	0.44	10.56	89.00
Uroplatus ebenaui	1.38	8.38	90.23
Uroplatus fimbriatus	2.85	9.19	87.96
Uroplatus phantasticus	2.17	9.77	88.06
Uroplatus sikorae	1.62	5.14	93.24

*Marketing margins were calculated using price information in Table S4.8.2, according to the following formula: (Ps – Pp)/Pf, where Ps is the mean sales price, Pp is the mean purchase price (i.e. the sales price the previous actor in the chain) and Pf is the final sales price at the end of the chain (at export).

CHAPTER 5

Captive Reptile Mortality Rates in the Home and Implications for the Wildlife Trade

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5.1. Abstract

The trade in wildlife and keeping of exotic pets is subject to varying levels of national and international regulation and is a topic often attracting controversy. Reptiles are popular exotic pets and comprise a substantial component of the live animal trade. High mortality of traded animals raises welfare concerns, and also has implications for conservation if collection from the wild is required to meet demand. Mortality of reptiles can occur at any stage of the trade chain from collector to consumer. However, there is limited information on mortality rates of reptiles across trade chains, particularly amongst final consumers in the home. We investigated mortality rates of reptiles amongst consumers using a specialised technique for asking sensitive questions, additive Randomised Response Technique (aRRT), as well as direct questioning (DQ). Overall, 3.6% of snakes, chelonians and lizards died within one year of acquisition. Boas and pythons had the lowest reported mortality rates of 1.9% and chameleons had the highest at 28.2%. More than 97% of snakes, 87% of lizards and 69% of chelonians acquired by respondents over five years were reported to be captive-bred and results suggest that mortality rates may be lowest for captive-bred individuals. Estimates of mortality from aRRT and DQ did not differ significantly which is in line with our findings that respondents did not find questions about reptile mortality to be sensitive. This research suggests that captive reptile mortality in the home is rather low, and identifies those taxa where further effort could be made to reduce mortality rates.

5.2. Introduction

The global legal trade in live animals (including primates, cage birds, birds of prey, reptiles and ornamental fish) was estimated to be worth €406 million in 2005, involving hundreds of millions of animals (Engler and Parry-Jones 2007). Reptiles are popular exotic pets (Auliya 2003; Hoover 1998), and comprise an estimated 21% of the value of the live animal trade, excluding ornamental fish (Engler and Parry-Jones 2007). Reptiles entering trade are sourced directly from the wild, or are captive-bred, with a large number produced in private and commercial breeding operations within consumer countries (EUARK 2012; Herrel and van der Meijden 2014; Robinson et al. 2016). In the UK, the reptile sector of the pet industry alone is estimated to be worth £200 million, with approximately 250,000 reptiles and amphibians bred each year (EUARK 2012). Due to concerns raised regarding biodiversity loss (O'Brien et al. 2003; Webb et al. 2002), environmental, human and animal health (Masin et al. 2014; Check 2007; Chomel et al. 2007), animal welfare (Baker et al. 2013) and also ethical and moral considerations (Warwick 2014), the trade attracts debate between reptile keepers, conservationists, veterinarians, animal welfare and animal protection groups.

The trading and keeping of exotic pets is subject to varying degrees of regulation, from international legislation such as the Convention on International Trade in Endangered Species (CITES) to national and regional legislation, including highly regulated (e.g. Australia, New Zealand, Norway), or a largely permitted trade with only certain species prohibited (e.g. European Union (de Volder 2013)). The trade is also influenced by a range of different environmental policy debates, for example, US regulations were recently amended to add large constrictor snakes to the Species Listed as Injurious Wildlife under the Lacey Act, on the grounds of ecosystem damage (USFWS 2012), whilst recent discussions in the EU have concerned EU legislation on

Invasive Alien Species. In Norway, the keeping of exotic animals is prohibited under the Animal Welfare Act and despite attempts to open trade in a limited number of reptile and amphibian species, in 2013 this was rejected by the Norwegian government amidst opposition from groups opposed to the trade (Anderson 2013; CABI 2014). Additionally, in early 2015, Scotland announced plans to review exotic pet keeping legislation, following discussions with animal welfare charities (BBC 2015).

Animals may die during any part of the trade chain, from collection in the wild, in transit, or in the home. This not only raises animal welfare concerns, but can also have conservation implications if animals are unsustainably sourced from the wild. However, there are few data in peer-reviewed literature concerning mortality of reptiles in the home (i.e. in the hands of an end-consumer). Indeed, much of the research regarding traded reptile mortality is outdated (Lawrence 1987a; 1987b; 1988), in grey literature (Clark 2013), concentrated on isolated cases (Ashley et al. 2014) and considers alternative locations along the supply chain other than 'the home'. For example, the most comprehensive study to date concerning mortality in transit, analysed data for more than 7.4 million individual animals and reported an average dead on arrival (DOA) mortality rate of 3.14% for reptiles (Schutz 2003). Additionally, of around 3000 reptile shipments, less than 1% had mortality of over 50% DOA, whilst 72.7% had zero mortality (Schutz 2003). Previous studies have also revealed low levels of mortality; less than 0.5% of 8000 reptiles and amphibians coming into the UK died in transit (Smart and Bride 1993); and less than 1% of tortoises transported over 21 years from the Mediterranean to the UK via air transport and long distance lorries were DOA or dead within a week of delivery (Lawrence 1987a). In retail, mortality rates ranging from 1.69 to 4.4% in shops prior to sale have been reported (Lawrence 1987b; Smart and Bride 1993). Whilst these results suggest that typical

mortality rates at the transport and retail stages of the chain are relatively low, there have been reported examples of much higher losses. Such incidents often concern isolated cases but they are typically the ones that receive considerable media attention. For example, 400 reptiles and amphibians from Madagascar died in transit in South Africa (BBC 2014; Europe GN 2014) due to flight delays following bad weather (Europe GN 2014), and a mortality rate of 72% was reported during a six week stock turnover period in one wildlife wholesaler (Ashley et al. 2014).

The limited studies regarding mortality rates after purchase from pet shops report vastly different mortality rates. For example, Lawrence (1988) reported annual mortality rates of 23% and 29%, between 1982 and 1986, for Spur-thighed (*Testudo graeca*) and Hermann's tortoises (*T. hermanni*), respectively. These mortality rates were attributed to problems associated with hibernation (Lawrence 1988) as well as low pricing and consequent use as pets for children (Hailey 2000). Additionally, the composition of tortoises in trade is likely to have changed significantly since this time following an EU wide ban on wild-caught Mediterranean tortoises implemented in 1984 through EU Wildlife Trade Regulations (Council Regulation 3626/82). A more recent study using online questionnaires with over 800 respondents reported an annual reptile mortality rate of 3.25% (Clark 2013). In contrast, a much higher mortality of over 75% was obtained based on the difference between the estimated number of reptiles coming into the UK and the estimated number in the home (Toland et al. 2012). Given the lack of published studies and widely conflicting available reports, it is evident that current primary data on mortality rates of reptiles in the home would be welcomed by all interested stakeholders.

Obtaining data on mortality of reptiles in the home relies on gathering information from consumers. However, given the potential sensitivity of issues surrounding the

exotic reptile trade, estimating mortality rates using a conventional questionnaire may be problematic and prone to a number of biases (Nuno and St. John 2015). Two such biases are social-desirability bias and non-response bias. Social-desirability bias occurs when respondents provide dishonest answers to present themselves in a more favourable manner relative to existing social norms (King and Bruner 2000). Non-response bias results from a non-random and significant proportion of individuals refusing to take part in a survey (Lahaut et al. 2002). Specialised questioning techniques have been developed within the social sciences to help improve the validity of sensitive data. These techniques work by ensuring respondents' answers cannot be linked to them directly, even when questions are delivered via face-to-face interviews, thereby increasing the level of protection afforded to respondents and their willingness to answer honestly (Nuno and St. John 2015). The Randomized Response Technique (RRT) (Warner 1965) is one such specialised technique, which has been shown to significantly improve the validity of data when investigating sensitive or illegal behaviours (St. John et al. 2010; Razafimanahaka et al. 2012).

We investigated mortality rates of pet reptiles amongst domestic reptile keepers at two major herpetological events in the UK, using both direct questions (DQ) and additive RRT (aRRT). Specifically, we addressed the following questions: (1) What proportion of reptiles die within one year of acquisition? (2) Which commonly kept reptile groups are most susceptible to dying within one year of acquisition? (3) Are captive-bred or wild caught reptiles more likely to die within one year of acquisition? The findings are intended to inform the ongoing debate concerning the regulation of the reptile trade and help safeguard species threatened by international commerce.

5.3. Methods

5.3.1. Data collection

A questionnaire (Appendix E) was administered through face-to-face interviews by a team of six to 10 trained research assistants, at two major herpetological events in the UK: the Federation of British Herpetologists Accredited Breeders Meeting at Kempton Park (London) in August 2013, and the International Herpetological Society's Breeders Meeting at Doncaster Racecourse in September 2013. Survey work was conducted with permission from event organisers. Both meetings attract between 2000 and 5000 visitors annually. Non-probability convenience sampling (Newing 2011) was used to select respondents entering the venue (whilst queueing for entry), and within the venue, making use of breakout areas (e.g. cafeteria) to approach respondents. Names and contact details were not collected in order to assure anonymity. Only respondents who had acquired a reptile in the preceding five years were interviewed in order to minimise recall bias. By 'acquired' we refer to reptiles brought into the respondent's home via purchase, gifting or loan, but excluding animals bred by the respondent. These were excluded in order to avoid juvenile mortality during breeding biasing results.

The survey consisted of a series of questions relating to: reptile ownership; reptile mortality rates experienced by respondents; number of years keeping reptiles; demographic questions (e.g. age, gender, area of residence), and questions designed to explore the sensitivity of the topic and evaluate the aRRT methodology. Questions concerning reptile ownership and mortality initially focussed on three reptile groups: snakes, chelonians (tortoises and turtles), and lizards, and then focussed on more specific categorisation of reptile groups. For snakes, this included: 'boas and pythons', 'king and rat snakes' and 'other snakes'; for chelonians this included: 'tortoises and

box turtles' and 'turtles and terrapins'; and for lizards: 'chameleons', 'geckoes', 'skinks', 'iguanas', 'tegus and monitors', 'agamids' and 'other lizards'. Respondents were asked to indicate whether the reptiles they had acquired were captive-bred, wild, captive-farmed, or of unknown source. According to CITES, captive-bred refers to animals bred in a controlled environment to second generation or beyond, and captive farmed or 'ranched' usually refers to reptiles reared in countries where the species naturally occur, either from young or eggs collected in the wild, or from wild collected pregnant/gravid females (CITES 2013).

To investigate mortality rates, respondents were asked the following questions using aRRT and DQ with 'X' representing each reptile group the respondent had acquired: 'Of the X that you acquired over the last five years, how many died within 12 months of acquisition'. Following this, respondents were asked how many individuals of each reptile group they had acquired in the preceding five years. To understand how people perceived difficulty and survival of their reptiles in captivity, respondents were asked, based on their own experience and not preconceived ideas about the reptile group, to rate the difficulty in keeping each of the reptile groups they had owned, and to rate the survival of each group in captivity, according to a five point Likert scale. All respondents were asked the average amount of time that they kept their reptiles for in order to exclude any that sold or exchanged their animals within a year.

5.3.2. Additive Randomized Response Technique

All forms of RRT use a randomizing device, such as a deck of cards or dice, to scramble respondents' answers to sensitive questions. This increases respondent privacy and ensures that researchers cannot directly link answers to individuals. However, the aggregate proportion of people holding the sensitive characteristic can be

estimated using probability theorem (Nuno and St. John 2015; Warner 1965). RRT typically estimates the proportion of the study population holding the stigmatizing characteristic, yet we often want to understand the quantitative nature of sensitive acts (Nuno and St. John 2015). Additive RRT (Pollock and Bek 1976) can be used when quantitative responses are required, rather than binary (yes-no) responses. Our aRRT followed a 'partial' (two-stage) quantitative randomisation model (Gupta and Thornton 2013), whereby a proportion of respondents were instructed to answer the sensitive question truthfully and a proportion were asked to add a number to their true response based on a randomisation device. The randomisation device consisted of a standard deck of playing cards, including four Queens but excluding Jacks and Kings, therefore comprising a total of 44 cards. If the respondent picked a Queen (probability=0.09) they were instructed to answer the question about the number of reptiles that had died truthfully. If the respondent picked any number card (probability=0.91), they were instructed to add the number on the card to their true response and report the sum (e.g. seven hearts + two dead reptiles = nine). Respondents were instructed not to reveal their selected card to their interviewer, as such, interviewers could not distinguish truthful responses from scrambled ones; they simply recorded a number. However, as the numbers in the deck followed a known probability distribution and the mean and variance of the number cards was known, a mean value for the true responses could be calculated using the following formula:

$$\mu_x = Y - (1-T)\mu_s$$

where T is the proportion of cards asking respondents to answer truthfully, Y is the reported response, X is the true sensitive variable of interest with unknown mean μ_x and unknown variance σ^2_x, and S is the scrambling variable with known true mean μ_s and known variance σ^2_s (Gupta and Thornton 2013)

Additive RRT was explained to respondents using a simple example and they were asked to follow the method carefully so that their answers were scrambled and the data were not compromised. An instruction card (Appendix F) was also handed to the respondent stating: 'Queen – answer the question truthfully, number card – add the number on the card you have picked to your true response and report the total' and reminded them of the question: 'Of the X that you acquired over the last five years, how many died within the first 12 months?' The questionnaire commenced once the interviewer was satisfied that the respondent understood the method. See Supporting Information S5.8.2 for additional information regarding the aRRT methodology.

5.3.3. Direct questions

In order to explore the relative utility of aRRT compared to conventional DQ, at the end of the questionnaire, respondents were asked to directly answer the same questions asked previously using aRRT, this time not using the cards: 'Of the X that you acquired over the last five years, how many died within 12 months of acquisition'.

5.3.4. Data analysis

The mean number of reptiles that died within one year of acquisition and associated 95% confidence intervals were calculated from 1000 samples (St. John et al. 2010) bootstrapped by respondent identification number for both aRRT and DQ responses, in the former case, incorporating the above formula to calculate the true responses from reported responses. We considered that there was no significant difference between estimates achieved via aRRT and DQ when the bootstrapped 95% confidence intervals for the mean number of reptiles dying overlapped with each other. Subsequently, mean mortality rates (i.e. the *proportion* of respondents' reptiles that died within a year)

along with 95% confidence intervals were generated by incorporating the number of reptiles acquired over the previous five-year period into the bootstrap.

Spearman's rank correlations were used to investigate the relationship between mortality rates obtained by DQ, and: respondents' opinions regarding how sensitive they thought the questions about reptile mortality were and how likely respondents' thought people would be to tell the truth about their reptiles dying. Spearman's Rank correlations were also used to explore the relationship between reported mortality rates, and how respondents rated survival and difficulty level for different reptile groups.

Ethical approval was granted by the School of Anthropology and Conservation Research Ethics Advisory Group (University of Kent). Written consent was obtained from all respondents prior to interview by means of a tick box on the questionnaire and persons under 18 were not interviewed. Data were analysed using R v3.0.1 (R Development Core Team, 2014).

5.4. Results

Two hundred and sixty five questionnaires (91 from Kempton Park and 174 from Doncaster) were completed by private keepers and breeders of reptiles, owning a total of 6689 reptiles. Data from four commercial operations were analysed separately. Three respondents were excluded from the analysis as they refused to follow aRRT instructions. Respondents ranged in age from 18 to 72 years (median=32, interquartile=19, n=255) and 72% of respondents were male (n=189). Respondents came from all over the UK residing in 74% of the 121 recognized postcode areas in the UK.

Individual respondents reported keeping between 1 and 1003 snakes (median=9, interquartile=20, n=203), 1 and 30 chelonians (median=2, interquartile=3, n=62) and 1 and 60 lizards (median=5, interquartile=6, n=185) over the five-year period preceding the study. The total time respondents' had kept reptiles varied with 9% (n=24) having kept reptiles for less than one year, 21% (n=54) for 2-5 years, 24% (n=62) for 6-10 years, 26% (n=67) for 11-20 years and 20% (n=53) for 21 years or more. Thirty six percent (n=32, asked at Kempton Park only) of respondents belonged to a herpetological group or society, including the International Herpetological Society (IHS), British Herpetological Society (BHS), a local or regional herpetological society (e.g. Thames & Chiltern Herpetological Group), or any other taxon specific (e.g. British Chelonian Group), herpetological or conservation society (e.g. Amphibian and Reptile Groups ARG UK).

Over 97% of snakes, 69% of chelonians and 87% of lizards acquired by respondents over the preceding five years were reported to be captive-bred (Table 5.4).

Table 5.4. Percentage of reptiles acquired over five years preceding the study which were reported by respondents (N=265) to be captive-bred, wild, captive farmed or of unknown origin. Also includes the number of respondents and the total number of individual animals used in the analysis.

Taxa	% captive -bred	% wild	% captive farmed	% unknown	*n* (respon dents)	*n* (animals)[a]
All snakes	97.1	1.2	0.8	0.4	203	4954
Boas & pythons	96.2	0.8	1.1	0.1	165	3517
King & rat snakes	97.4	0.8	0.0	1.6	134	1038
Other snakes	92.3	2.6	0.0	0.5	55	417
All chelonians	69.2	9.1	5.1	12.3	62	276
Tortoises & box turtles	70.9	9.1	9.1	10.9	49	165
Turtles & terrapins	48.4	9.9	0.0	25.3	18	91
All lizards	86.8	6.3	2.1	2.3	185	1459
Chameleons	88.8	3.1	1.0	5.1	39	98
Geckoes	93.2	2.8	0.0	2.9	120	782
Skinks	83.3	11.1	0.0	2.8	17	36
Iguanas	76.1	15.2	2.2	6.5	22	46
Tegus & monitors	68.3	9.9	12.9	2.0	43	101
Agamids	84.1	7.8	0.0	2.6	84	271
Other lizards	58.6	20.0	0.0	0.0	20	70

[a]Some respondents' were unable to provide data for the more detailed categories e.g. 'boas and pythons', therefore their sum is not always equal to the total for that group e.g. 'all snakes'. The total number of reptiles used in the study is calculated from the sum of the 'all snakes', 'all chelonians' and 'all lizards' categories.

5.4.1. Mortality rates

There were no significant differences between the mean number of reptile deaths reported via aRRT and DQ for all taxonomic groups (Table 5.4.1.1) suggesting that respondents were generally amenable to reporting directly (i.e. via DQ) the quantity of reptiles that had died in their care. As aRRT did not appear to increase data validity

(e.g. an increase in honest reporting indicated by estimates significantly higher than DQ) mortality rates obtained via DQ are used for the remaining analyses.

Table 5.4.1.1: Bootstrapped mean number of reptiles that died within a year of acquisition, over five years preceding the study, including 95% confidence intervals, estimated for additive (aRRT) and direct questions (DQ) via 1000 bootstrap samples.

		aRRT			DQ		
Taxa	***n***	**Mean no. reptiles that died**	**lower CI**	**upper CI**	**Mean no. reptiles that died**	**lower CI**	**upper CI**
All reptiles[a]	256	NA	NA	NA	0.89	0.62	1.17
All snakes	201	0.35	-0.13	0.83	0.55	0.37	0.72
Boas & pythons	163	0.06	-0.49	0.61	0.28	0.16	0.41
King & rat snakes	132	0.21	-0.36	0.79	0.40	0.17	0.63
Other snakes	53	0.33	-0.57	1.23	0.35	0.08	0.61
All chelonians	62	0.54	-0.30	1.39	0.17	-0.01	0.34
Tortoises & box turtles	49	0.54	-0.47	1.54	0.07	-0.01	0.14
Turtles & terrapins	18	0.60	-0.89	2.09	0.38	-0.15	0.92
All lizards	178	0.21	-0.31	0.73	0.66	0.38	0.94
Chameleons	36	0.47	-0.77	1.72	0.74	0.03	1.45
Geckoes	115	0.21	-0.45	0.87	0.39	0.26	0.51
Skinks	17	0.49	-1.35	2.34	0.20	-0.08	0.50
Iguanas	22	0.62	-1.11	2.35	0.10	-0.04	0.23
Tegus & monitors	41	-0.19	-1.26	0.88	0.21	0.03	0.39
Agamids	78	0.46	-0.27	1.19	0.23	0.08	0.39
Other lizards	19	0.18	-1.45	1.81	0.00	0.00	0.00

*Note that mean number of reptiles that died refers to the actual number not the mortality rate. Mortality rates incorporate the numbers of reptiles owned and are presented in Figure 5.4.1.
[a]estimates for 'all reptiles' were derived post-data collection by combining 'all snakes', 'all chelonians' and 'all lizards' for individual respondents, therefore an aRRT response is not available for this category.

The combined estimated mortality rate for snakes, lizards and chelonians was 3.6% (Figure 5.4.1). Overall, lizards had higher mortality rates than chelonians and snakes. When split by groups, of the snakes, boas and pythons had the lowest mortality rates and king and rat snakes had the highest. Of the chelonians, tortoises and box turtles had lower mortality rates than turtles and terrapins, and of the lizards, iguanas had the lowest mortality rates whilst chameleons had the highest.

Data from four commercial operators analysed separately indicated a combined mortality rate of 0.7% for snakes, 1.1% for lizards and 0.03% for chelonians. This could not be bootstrapped due to the low sample size so error is not presented and the animals were kept for periods of between one week to two years for snakes (median=8 weeks); one week to one year for chelonians (median=2 weeks) and two weeks to 1.5 years for lizards (median=3 weeks).

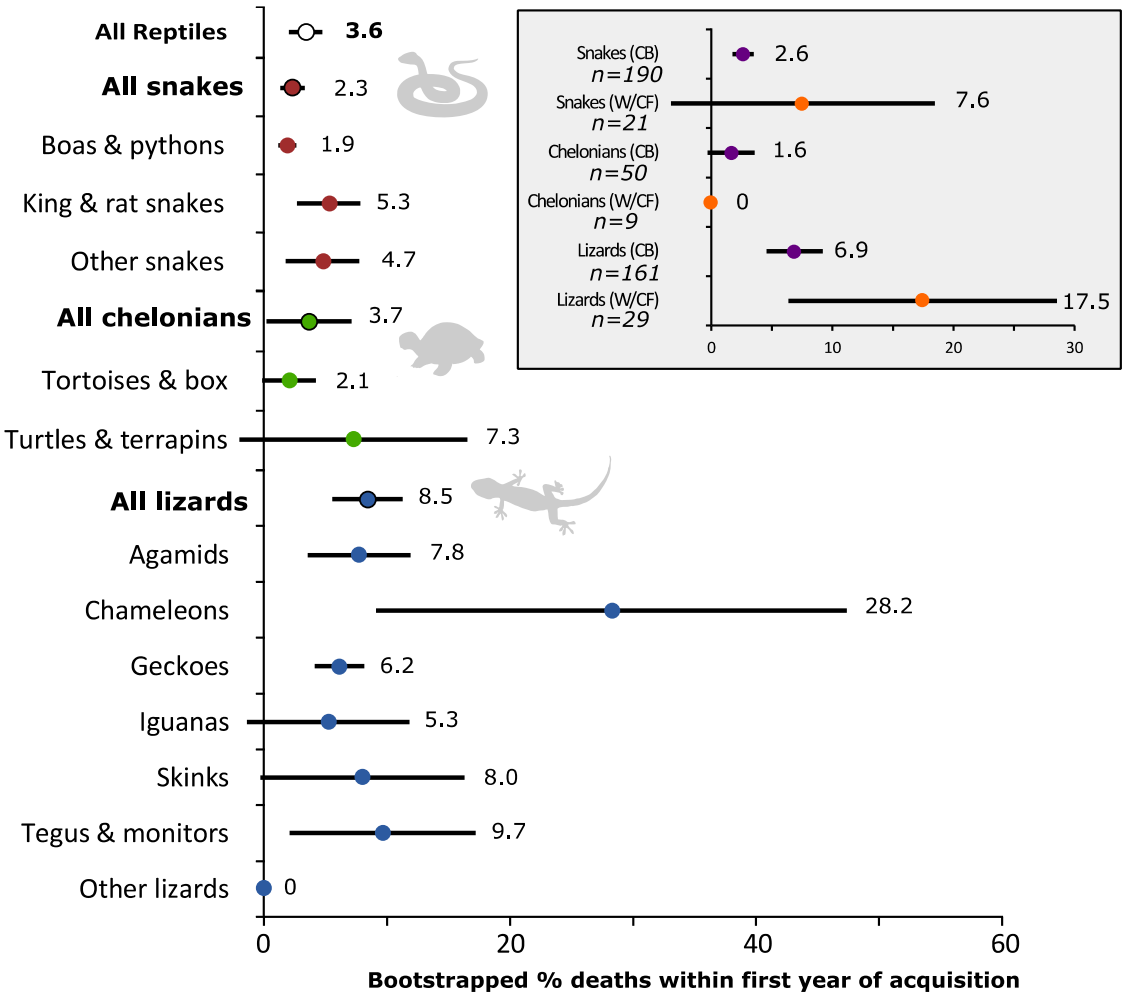

Figure 5.4.1. Bootstrapped reptile mortality rates within first year of acquisition. The bootstrapped proportion of deaths within first year of acquisition for commonly kept reptile groups. Circles indicate mean mortality rate based on x 1000 bootstrap samples obtained from direct questions, lines represent 95% confidence intervals. Inset displays mean mortality rates for snakes, chelonians and lizards analysed separately for those reported to be captive-bred (CB) and those reported to be either wild (W), or captive farmed (CF). Reptiles reported to be unknown origin (U) may represent captive-bred or wild individuals and were therefore excluded. Refer to Table 5.4.1.1 for *n* numbers used in analysis of mortality rates.

When mortality rates are explored in association with the source of the reptiles, there is an indication that captive-bred reptiles have lower mean mortality rates than those of wild or captive farmed origin (Figure 5.4.1 inset). However, differences were not considered significant given overlapping confidence intervals.

There was a significant positive relationship between the perceived difficulty of keeping reptiles and the perceived survival rates, with those rated more difficult to keep also rated as having poorer survival rates (snakes: r_s=0.25, n=199, p<0.001; lizards: 0.42, n=176, p<0.0001; chelonians: r_s=0.47, n=61, p<0.001). In addition, mortality rates reported via DQ were significantly and positively correlated with poorer perceived survival rates for snakes (r_s=0.30, n=199, p<0.001) and lizards (r_s=0.26, n=176, p<0.001); this relationship was not significant for chelonians (r_s=0.06, n=61, p=0.63). There were no significant relationships between actual mortality rates reported via DQ and perceived difficulty in keeping different reptile groups (Table 5.4.1.2).

Table 5.4.1.2. Evaluation of respondents' rating of 'difficulty' and 'survival' for different reptile groups, which they had acquired. Questions were asked using a five point Likert scale, with categories condensed for data presentation.

	Based on your experience and not preconceived ideas about the group, how easy or difficult is this group to keep?				Based on your experience and not preconceived ideas about the group, how do you rate the survival of this group in captivity?			
Taxa	***n***	**Easy/ very easy (%)**	**Neither easy nor difficult (%)**	**Very difficult/ difficult (%)**	***n***	**Good/ very good (%)**	**Neither good nor poor (%)**	**Very poor/ poor (%)**
All reptiles		NA	NA	NA		NA	NA	NA
All snakes	201	75.6	20.9	3.5	203	97.0	1.5	1.5
Boas & pythons	165	73.3	21.2	5.5	165	98.2	1.2	0.6
King & rat snakes	134	91.0	7.5	1.5	134	96.3	2.3	0.8
Other snakes	54	57.4	33.3	9.3	54	96.3	1.9	1.9
All chelonians	61	50.8	34.4	14.8	62	90.3	6.5	3.2
Tortoises & box turtles	49	63.3	26.5	10.2	49	93.9	2.0	4.1
Turtles & terrapins	17	64.7	23.5	11.8	18	88.9	11.1	0.0
All lizards	183	63.4	27.3	9.3	184	86.4	12.0	1.6
Chameleons	39	28.2	30.8	41.0	39	76.9	15.4	7.7
Geckoes	119	80.7	16.8	2.5	119	94.1	4.2	1.7
Skinks	18	61.1	27.8	11.1	18	88.9	11.1	0.0
Iguanas	22	45.5	18.2	36.4	22	72.7	22.7	4.6
Tegus & monitors	43	46.5	32.6	20.9	43	79.1	18.6	2.3
Agamids	83	62.0	17.0	4.0	83	90.4	9.6	0.0
Other lizards	20	65.0	15.0	20.0	20	95.0	0.0	5.0

5.4.2. Evaluation of additive RRT

Respondents found aRRT easy to use with over 70% scoring it as 'easy' or 'very easy' to understand and only 9% scoring it as 'difficult' or 'very difficult'. Over 56% of respondents felt that their answers were protected by aRRT compared to 13% who did not feel that their answers were protected. A large proportion (>58%) of respondents

felt that the questions regarding mortality were ‘not very’ or ‘not at all’ sensitive (Supporting Information, Table S5.8).

There were no significant relationships between mortality rates (reported via DQ) and how sensitive people felt the questions regarding reptile mortality were: ‘all snakes’ (r_s=0.12, n=190, p=0.09); chelonians (r_s=0.12, n = 60, p = 0.34); lizards (r_s=0.10, n=172, p=0.17). There were no significant relationships between reported mortality rates and how likely respondents felt people were to tell the truth for snakes (r_s=-0.12, n=190, p=0.11), chelonians (r_s=0.08, n=60, p=0.52) and lizards (r_s=-0.03, n=172, p=0.72).

5.5. Discussion

We estimated the overall mortality rate of pet reptiles (snakes, chelonians and lizards) amongst private breeders and keepers of reptiles, to be 3.6% within the first year of acquisition, which is considerably lower than some previous estimates. However, this rate varies amongst different reptile groups from 1.9% (boas and pythons) to 28.2% (chameleons). Additionally, there are indications that mortality rates are lower for captive-bred individuals. As far as we know, this is the first survey to investigate reptile mortality rates amongst domestic consumers which also differentiates between commonly kept reptile groups. Our findings are intended to inform the ongoing debate concerning the regulation of the reptile trade both at national and international levels, and is also of conservation relevance when considering the implications of collecting reptiles from the wild. As governments and other stakeholders increasingly strive for an evidence base to inform policy, our findings may be seen as a robust mortality estimate for reptiles kept in the home by those who attend reptile shows.

5.5.1. Mortality rates

Our study shows that among the commonly kept pet reptile groups, snakes had the lowest overall mortality rates in captivity, followed by chelonians, and then lizards. When this is compared with the wild, a comprehensive published study (based on a review of 20 species of snakes, 20 species of lizards and 17 species of turtles) reported annual adult survival rates to be lowest among lizards (~38% survival), followed by snakes (~64%), and then chelonians (~88%) (Pike et al. 2008). If these survival rates are expressed as mortality rates then mortality in nature far exceeds our estimated mortality rates for reptiles in captivity. Whilst an understanding of the life histories of wild reptiles provides context and is useful to consider in relation to survival in captivity, wild and captive individuals are subject to somewhat different factors affecting their fitness, and therefore comparisons of wild and captive mortality rates should be made with caution. Additionally, in the example above, there are likely to be phylogenetic and geographical differences in the species studied. For example, the species composition of our dataset is representative of that in the home, which amongst the snakes, comprises a high proportion of boas and pythons. These are large bodied and long-lived, which may partly explain why we found snakes to have relatively low mortality rates. Indeed, according to a recent publication which collated longevity data, life history traits and environmental factors for 1000 species of lizards and snakes (10% of the known species diversity), longevity in the wild is related to body size, brood frequency, age at first reproduction, predation pressure, environmental factors such as latitude and climate, and diet (Scharf et al. 2014).

Whilst our estimates for mortality rates of most lizards were between 5% and 10%, chameleons had a higher mortality rate of 28%. Chameleons require specialised husbandry (Bustard 1989) and published reports on the longevity of this group in

nature are limited. In the available studies, Cape dwarf chameleons (*Bradypodion pumilumare*) are reported to have annual survival rates of approximately 5% (Katz et al. 2013); female panther chameleons (*Furcifer pardalis*) seldom live longer than one year, whilst males live longer (Andreone et al. 2005) and studies have revealed particularly short post-hatching life spans of four to five months for Labord's chameleon (*Furcifer labordi*) (Karsten et al. 2008). However, due to the paucity of research in this area it is difficult to draw solid conclusions about chameleon survival in the wild, and some species do have the capacity to reach ages of up to nine years in captivity (Tacutu et al. 2013). In any case, specialism does not necessarily correspond with high mortality in captivity, as indicated by our finding that actual mortality rates were significantly correlated with perceived survival rates (high mortality, poor rated survival), but not with how difficult respondents felt the reptile groups were to keep. Difficulty keeping a reptile may therefore not always equate to high mortality, but may instead indicate higher requirements of husbandry and investment, which experienced keepers may be able to provide.

The majority of reptiles acquired over the previous five years were captive-bred, and captive-bred individuals appeared to have lower mortality rates. However, more data are required to thoroughly explore the difference in mortality rates between wild and captive-bred individuals as this was a non-significant trend. There are reports of wild reptiles in trade being sold as captive-bred (Lyons and Natusch 2011), and given that there may be some degree of sensitivity surrounding the topic, it can be difficult to verify their source. Differences between captive-bred and wild individual mortality rates may arise from the fact that captive-bred reptiles are thought to be easier to maintain in captivity, due to perceived lower aggression (Auliya 2003), lower levels of parasitic infection (Auliya 2003; Bartlett 2006) and easier acclimatisation to new

conditions (Bartlett 2006). Whereas wild reptiles are subject to the additional stresses of capture in the wild, along with a potentially longer trade chain with more transit exchanges, which may in turn reduce the fitness of those animals. However, many captive-bred individuals are also shipped internationally and little data exist on mortality of wild versus captive-bred individuals along the trade chain or in captivity. A recent global review showed that the number of live, wild sourced reptiles (CITES Appendix II) in international commercial trade is decreasing whilst an increasing proportion appear to be sourced from more intensive systems such as 'ranching' (the rearing of young or eggs from the wild), and from countries where they do not exist naturally in the wild (i.e. captive-bred) (Robinson et al 2015). The implications of this are complex as in some circumstances and under the appropriate regulatory requirements, sustainable use of wild animals may contribute to conservation and livelihoods in developing countries where the species originate (Gordon and Ayiemba 2003). However, there is currently little comparable information on the benefits and impacts of alternative production systems of pet reptiles, and analysis is complicated by reports that captive production and ranching systems are sometimes used to launder illegally wild caught animals (Lyons and Natusch 2011) and can have negative impacts on wild populations (Haitao et al. 2007).

It is important to consider that whilst respondents represented a range of experience levels and a wide catchment area in terms of postcode areas, they represent only a subset of reptile keepers in the UK, many of whom may not visit annual reptile shows. Additionally, the data presented here represent only one part of the trade chain, with mortality occurring at any stage of that chain before animals reach the home (e.g. during transit, wholesale, or in the pet shop), meaning the cumulative mortality may be much higher. Data concerning mortality all along the trade chain from source to

consumer are scarce, but estimates during shipment and in retail suggest that average mortality rarely exceeds 4.5% at each stage (Lawrence 1987a; Lawrence 1987b; Lawrence 1988, Clark 2013), apart from in some isolated cases (Ashley et al. 2014; BBC 2014). Additionally, data from four commercial operations in this study, which represent an additional stage prior to the reptiles reaching the final consumer, indicated low mortality rates of less than 1.2%, however as the reptiles were kept for varying durations they are not directly comparable to the annual mortality rates we present for private breeders and keepers of reptiles. More comprehensive and recent research at different points of the chain or by following specimens along the trade chain will allow greater understanding of overall mortality.

5.5.2. Method comparison

We found no significant differences between mortality rates estimated via aRRT and DQ. Previous studies have reported that although RRT may improve data validity (Lensvelt-Mulders et al. 2005), the benefits of using such specialised questioning techniques decrease with decreasing topic sensitivity (Nuno and St. John 2015; St. John et al. 2010). Contrary to our beliefs when embarking upon this study, only 16% of respondents thought that the questions regarding reptile mortality were sensitive, which explains why there were no detectable differences between estimates achieved with the two methods. Accordingly, we have an increased level of confidence in the estimates obtained from using direct questions. The low level of sensitivity also explains why there were no significant correlations between reported mortality rates and how sensitive respondents found the questions, or how likely they felt people would be to tell the truth. Nonetheless, the majority of people (>70%) found aRRT easy to use and most felt that their answers were protected by the method suggesting that there is utility in the technique.

5.5.3. Conclusion

Our research suggests that the number of reptiles that die in the home within one year of acquisition by private keepers and breeders of reptiles who attend reptile shows is relatively low (3.6%), and corresponds with a recent study conducted using an online questionnaire, which reported mortality rates of 3.25% (Clark 2013). However, some taxa evidently have higher mortality rates than others and may therefore be candidates for further research and targeted improvements regarding trade chain management and captive care requirements. Despite reporting a low mortality rate within the first year, mortality rates in the home after the first year are unlikely to be linear and are therefore not necessarily accumulative at the same rate. Additionally, we are unable to draw conclusions regarding specific welfare conditions of those reptile groups in captivity as this was not the purpose of this study. From a welfare perspective, and in order to add context, it may be interesting to compare our mortality rates with those of other commonly kept pet animals. Whilst there is limited data available, the only broadly comparable available study conservatively estimated that over a one year period (1996) in the US, 8.3% and 7.9% of cats and dogs died respectively (New et al. 2004).

An improved understanding of mortality rates of reptiles in the home may guide the regulation of the reptile pet trade and have direct policy implications. Whilst species may survive collection, breeding or transport, if they cannot be adequately maintained in captivity by end-users, then as long as demand exists for those animals, elevated numbers will be required to replace dead animals. In cases where species are harvested from the wild, this may directly impact species conservation where inadequate monitoring or sustainable use programs exist at the source. With improved understanding of reptile mortality, this can be taken into account when impact statements for traded species (‘non-detriment findings’) are considered for species

regulated under CITES. The EU Wildlife Trade Regulations, which implement CITES in the EU, contain a clause (Council Regulation (EC) No 338/97, Article 1.6) relating to 'live specimens of species listed in Annex B which have a high mortality rate during shipment or for which it has been established that they are unlikely to survive in captivity for a considerable proportion of their potential life span'. Under this clause, trade of reptiles shown to have high mortality rates in captivity could be suspended.

Whilst this study considers mortality of reptiles in the home, mortality may occur at various points in the trade chain and therefore the length and management of the supply chain is likely to be an important factor concerning overall survival. Cases of high mortality in the trade are reported (Ashley et al. 2014; BBC 2014), but these cases do not appear to be frequent. Nevertheless, efforts must be made to prevent these. It remains to be seen whether certified trade chains could be feasible within the pet trade, in order to help understand and improve the process from supplier to consumer. This has the potential to increase transparency and consumer confidence in reptiles shipped cross globally, particularly in cases where wild trade supports sustainable use and conservation in developing countries.

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5.8. Supporting Information

Table S5.8. Respondents' evaluation of Additive RRT. Evaluation of additive RRT, including percentage responses for each category. Questions were asked according to a five point Likert scale, with categories condensed for data presentation.

Questions	Responses		
How easy or difficult did you find the card method to use?	Very easy / easy	Neither easy nor difficult	Difficult / very difficult
	73.6% (n=190)	**17.4% (n=45)**	**8.9% (n=23)**
When using the card method, how protected or unprotected did you feel your answers were?	Very protected / Somewhat protected	Neither protected nor unprotected	Not very protected / not at all protected
	56.5% (n=143)	**30.4% (n=77)**	**13.0% (n=33)**
How sensitive do you consider the questions about the quantity of your reptiles that have died in the first year of you owning them?	Very sensitive / somewhat sensitive	Neither sensitive nor insensitive	Not very sensitive / not at all sensitive
	15.9% (n=41	**26.0% (n=67)**	**58.1% (n=150)**
When asked directly, how likely do you think people would be to tell the truth when asked about the quantity of reptiles that have died in the first year?	Very likely / likely	Neither likely nor unlikely	Unlikely / very unlikely
	41.2% (n=105)	**25.5% (n=65)**	**33.3% (n=85)**

S5.8.2. Additive RRT extended methodology

During model development, a number of models were conducted using bootstrapped artificial data (in which mean μ_x and variance σ^2_x were known), in order to determine the most appropriate model. This included deciding on the proportion of people who should be instructed to tell the truth (T), and the composition of numbers to make up the scrambling device (mean μ_s and variance σ^2_s). These factors were determined based on a combination of model efficiency (best predictive power and least error), and what would work practically in the field and lead to the least confusion amongst respondents. For example, in order to minimise variance associated with the model, according to the following formula for estimating variance (Sehra 2008[1]), T should be >0.8 or <0.2:

$$Var(\mu_x) = \frac{\sigma_x^2}{n} + \frac{(1-T)(\sigma_x^2 + T\mu_s^2)}{n}$$

T >0.8 would have required a high proportion (more than 80%) of respondents to answer the sensitive question truthfully which we felt would result in respondents feeling less protected than if less than 20% were required to answer truthfully.

In order to allow the best protection it was important to have an idea of the approximate range of responses that would be given by the respondents. As the numbers in the cards ranged from one to 10, respondents were most protected if their true responses were low numbers. For example, a respondent giving a reported response of one is completely protected: they may have had one reptile die and reported their true answer, or they may have had no reptiles die and picked a number

[1] Sehra S. Two-stage Optional Randomized Response Models: ProQuest; 2008.

card of one to report. The same goes for respondents reporting answers between one and 10. However, if a respondent gives a reported response of 11, then the interviewee knows that they have had at least one reptile die, but they do not know the exact number as any number card between one and 10 may have been added to their true value. Presuming that the question is sensitive, this means that although their exact true answer is still masked, this person has slightly less protection, as one element of their true response (the fact that at least one animal died) is revealed. If you get to a reported response of 20, you know that at least 10 of their reptiles had died. Therefore, the level of protection the respondent is afforded, decreases as the upper range of true responses increases. Conversely, if a respondent reported a response of zero, the interviewee knows that the respondent has not had any reptiles die at all, however this was not considered to be a sensitive scenario.

It was difficult to know the number of reptiles' people may report owning and the expected mortality rates of those reptiles, as there is little primary data in this area. However, we used a recent study based on online questionnaires with a reported mortality rate of 3.3% (Clark 2013), and informal discussions with reptile keepers to inform our model choice. We also decided to exclude commercial operations from the analysis, as they are likely to have owned a much larger numbers of reptiles and therefore fit less well with our model.

Following data collection we tested for a relationship between the number of reptiles respondents reported owning and how protected those respondents' felt when using the aRRT. There were no significant correlations for snakes (r_s=0.08, n=194, p=0.24), lizards (r_s=0.07, n=179, p=0.32) or chelonians (r_s=-0.17, n=60, 0=0.19), suggesting that the concerns referred to above regarding those with larger numbers of reptiles not feeling as much protection by the model, did not appear to be an issue in this case.

CHAPTER 6

Discussion

6.1. Background

The trade in wildlife is vast, diverse and multifaceted, with implications for the environment, society, and the economy (Brashares et al. 2004; Broad et al. 2003; Lenzen et al. 2012; Roe 2002; Smith et al. 2009). There are varying views amongst stakeholders on how best to manage wildlife trade, and a number of strategies are implemented. These strategies range from community-based natural resource management and legalised regulated trade, to trade bans and strict enforcement; and are implemented in accordance with multilateral agreements such as the Convention on International Trade in Endangered Species (CITES), the Convention on Biological Diversity (CBD), and other forms of international and national legislation. In order to inform wildlife trade policy and management, a better understanding of the socio-economic implications of wildlife trade chains, and consequent impact of varying forms of management on livelihoods and sustainable use in range countries supplying the trade, is required. This thesis set out to expand our knowledge of the costs and benefits of the commercial trade in live animals to both conservation and livelihoods, drawing on interdisciplinary and novel research approaches.

6.2. Thesis Synthesis

Reptiles and amphibians represent two priority threatened wildlife groups prevalent in the wildlife trade (Section 1.3.2), and are therefore the focal taxa of this thesis.

Starting at a global scale, Chapter 2 investigated spatial and temporal trends in the legal trade of live CITES-listed reptiles over 15 years in order to understand trade dynamics and identify priority areas for research. Whilst other studies have focussed on taxa or region-specific trade dynamics (Arroyo-Quiroz et al. 2007; Carpenter et al. 2004; Hoover 2000; Nijman and Shepherd 2010; Pernetta 2009; Shepherd et al. 2012), Chapter 2 provided the first extensive global analysis of live reptile trade across all taxonomic groups. The analyses revealed the changing modes of production used to supply reptiles from source countries, including a shift in supply from predominantly wild-caught reptiles to increasing numbers being sourced from ranching and captive breeding operations, and a decreasing proportion being sourced from their range states. The discussion highlighted a significant data gap regarding the livelihood and conservation implications of supplying the trade in live animals in range states, and consequent limited understanding of how these countries may be affected by the shifting supply-trends, or policy changes to regulate wildlife trade. This work highlighted the need for more research to be conducted on costs and benefits of the trade in range countries, in particular assessing different modes of wildlife production such as ranching.

Chapters 3 and 4 contributed to this knowledge gap by focussing on the socio-economic implications of supplying the wildlife export trade from Madagascar, a country identified in Chapter 2 as a major international supplier of live reptiles. Madagascar also represents an important global biodiversity hotpot, with unprecedented levels of endemic and threatened reptile and amphibian species, and high levels of poverty, making it a top conservation priority (Section 1.4.1).

Chapter 3 provided insights into the importance of live animal collection to the livelihoods of rural communities living a subsistence lifestyle. Whilst numerous

studies have sought to understand socio-economic determinants of bushmeat and wild food consumption in rural areas (Coad et al. 2010; de Merode et al. 2004; Fa et al. 2002; Grande Vega et al. 2013; Kümpel et al. 2010; Schulte-Herbruggen et al. 2013) few have explored benefits associated with live animal trade (but see Gordon and Ayiemba 2003; Jepson et al. 2011; Rabemananjara et al. 2008), and there are no comprehensive studies focussed on the role of reptile and amphibian collection in supporting local livelihoods. This research also went one step further than many others, by examining the potential for the trade to provide incentives for conservation of species and habitats. The analysis revealed that wildlife collection was profitable and supports some of the poorer households, but was also unreliable, part-time and financially risky, providing limited incentives for conservation at the local level.

Chapter 4 further expanded our knowledge concerning the benefits and costs of wildlife trade to different actor groups across the entire supply chain in Madagascar, from collection to export. To do this value chain analysis was employed, a technique increasingly used to understand supply chains for other non-timber forest products (Avocèvou-Ayisso et al. 2009; Bowen-Jones et al. 2003; Cowlishaw et al. 2005; Johnson 2010), but which has not previously been applied to the study of live animal trade. The findings documented the type of economic benefits received by local collectors, intermediaries, exporters and the national government and highlighted the disproportionate share of profit that local collectors appear to capture. This study also revealed the complex and informal nature of the supply chain and isolation of local collectors; such factors create challenges regarding the design and implementation of policy to enhance conservation and livelihood benefits from the trade at the local level. The findings suggest that initiatives focussed on cooperative management of traded resources at the local level may be most effective in enhancing benefits from the trade

(Section 6.3.2). Combined, Chapters 3 and 4 provide the most thorough understanding of costs and benefits of the reptile and amphibian pet trade in a source country.

Finally, to address a significant data gap regarding biological sustainability of the wildlife trade, Chapter 5 provided the first cross-taxon analysis of mortality of reptiles kept as pets in the UK. The study utilised a novel method of specialised questioning, the additive Randomised Response Technique (Pollock and Bek 1976), which thus far had rarely been used in the field. This study therefore contributed to expanding the methodological toolkit for others investigating sensitive or illegal topics in conservation and beyond. Chapter 5 demonstrated that mortality rates are relatively low, but identified those taxa where further effort could be made to reduce mortality rates. This research has particular relevance to policy makers within consumer countries where the pet keeping debate continues to divide opinion, and therefore provides essential primary data required to inform decision making.

6.3. Contribution to Conservation Science, and Wildlife Trade Policy and Practice

The issues addressed in this thesis are high on the agenda for multiple stakeholders and policy makers, and have direct relevance to CITES, the CBD and the UN Sustainable Development Goals (SDGs). CITES supports trade in species provided that trade does not threaten their survival (CITES 2016). The CBD promotes the sustainable use of biological diversity as one its key objectives and recognises the rights of people to benefit from use of natural resources (CBD 2014). The SDGs contain specific targets to end poverty in developing regions (Goal 1), promote fair and equitable sharing of the benefits arising from the use of genetic resources, support countries to conserve and sustainably use biodiversity, and combat poaching and trafficking, including by

increasing capacity of local communities to pursue sustainable livelihood opportunities (Goal 15) (United Nations 2016). Together, Chapters 2-5 fill a number of significant gaps in our knowledge and understanding of the risks and benefits of legal wildlife trade chains. This can be used to inform management and enhance opportunities from the trade, thereby contributing to the above targets concerning conservation, sustainable wildlife trade and development. The following sections highlight key focal areas where this thesis makes a particular contribution to conservation science, policy and practice.

6.3.1. Expanding knowledge of costs and benefits of wildlife trade across disciplines

Sustainable development or sustainability is often conceptualised across three spheres: i) environment, ii) economy and iii) society (Figure 6.3.1). Whilst various adaptations have been made to these three spheres over the years (e.g. to include four domains representing economics, ecology, politics and culture (Magee et al. 2013) similar dimensions are relevant to achieving a sustainable wildlife trade.

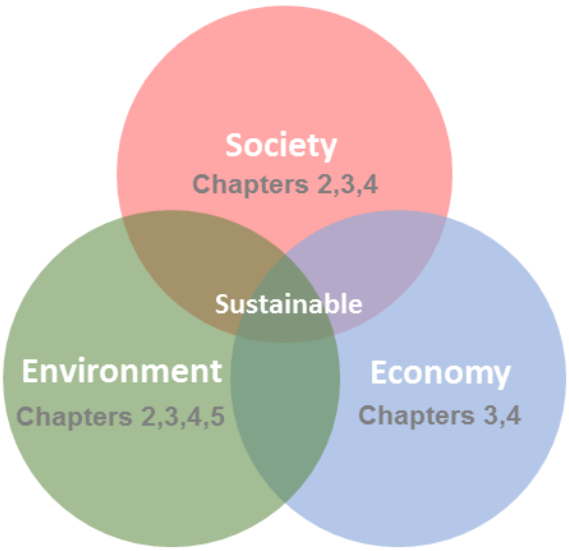

Figure 6.3.1. Schematic of sustainable development with relevance to achieving a sustainable wildlife trade, indicating the environment (e.g. species biological factors, habitat integrity, sustainability), society (e.g. livelihoods, governance) and the economy (e.g. market factors such as supply and demand). Schematic includes indication of where each chapter in this thesis contributes.

In this thesis, social science methods were used to bridge our understanding of the costs and benefits of wildlife trade chains across these spheres. This is based on the perspective that integrated and interdisciplinary approaches are required to understand wildlife trade, and apply appropriate management solutions (Bowen-Jones et al. 2003). The spheres are not independent of one another, for example, economic incentives created through wildlife trade can create incentives for conservation at the local scale (Hutton and Leader-Williams 2003). The Kipepo butterfly farming project in Kenya is one such example which has had significant positive effects on both livelihoods and conservation, providing farmers with an economic resource dependent on intact forest (Gordon and Ayiemba 2003). Projects involving crocodile ranching have also boasted

success in improving status of populations in the wild by providing commercial incentives to protect adult crocodiles (e.g. Hutton and Webb 2003). However, the situations under which such mutual benefits are realised are complex and poorly understood for many trade chains. This is further limited by the lack of studies documenting livelihood implications of wildlife trade in supply countries, in particular for the supply of reptiles and amphibians for the exotic pet trade – for which virtually nothing is published.

Accordingly, Chapters 3 and 4 provide an extensive understanding of the socio-economic benefits obtained by stakeholders involved in the trade in Madagascar (economy, society), but also explore economic incentives for biodiversity conservation (environment). In this case study, the trade in live animals has reduced over the last two decades, and is currently limited by both supply and demand (including regulation via quotas), and consequently the benefits received by local people appear to be insufficient to promote conservation. Even if payments from the trade were increased, it is not clear whether existing land ownership rights would be sufficient to generate a sustainable outcome.

Recently, a framework has been developed by Cooney et al. (2015) identifying a number of factors that affect the livelihood and conservation outcomes of wildlife trade, which interact with each other and require combined consideration. These include: ‘species-level’ factors such as suitability for harvest including resilience and accessibility; ‘governance’ factors including property rights and policy settings; ‘supply chain’ factors including organisation and operation of the supply chain, such as barriers to entry and length of the chain; and ‘end-market’ factors, including market size, demand elasticity and consumer preferences (Cooney et al. 2015). Chapters 3 and 4 substantially contribute towards our understanding of these factors for the trade in

live animals from Madagascar, particularly regarding supply chain factors. In particular, Chapter 4 reveals the structure and operation of the entire supply chain, as well as costs, barriers to entry, and a better understanding of where the supply chain appears to be monopolised. This not only contributes to the knowledge gap regarding social, economic and environmental implications of the live animal trade in supply countries, but can also be used to directly inform management interventions in Madagascar.

6.3.2. Informing wildlife trade policy and management in Madagascar

This thesis provides an improved understanding of the wildlife trade in Madagascar, which can be used to identify opportunities to enhance conservation and livelihood outcomes from the trade, and also identify risks associated with policy and/or managerial changes on the ground.

In Chapter 4 a number of options are discussed, focussing specifically on initiatives that might bring both conservation and livelihood benefits from the legal trade in Madagascar. Strategies such as trade bans are not discussed, which may remove benefits to local communities (Roe 2002) and have mixed consequences for conservation (Cahill et al. 2006; Conrad 2012; Cooney and Jepson 2006; Section 1.2.4). The options explored in Chapter 4 encompass a range of strategies including increasing supply and/or expanding the market by introducing additional species into trade or by breeding or ranching suitable species. Larger markets do not inherently create a conservation risk, as they typically create greater livelihood benefits and incentives to manage the resource. Conversely, smaller markets do not necessary protect natural resources, as incentives to manage or protect the resource may be lost (Cooney et al. 2015). However, species-level, supply chain and governance factors

(Section 6.3.1) would also need consideration to ensure they do not create competing conditions for overharvest. Any such initiative would also need a consideration of demand, which is already variable amongst species exported from Madagascar. For example, colour variations of the Panther chameleon (*Furcifer pardalis*) still command high demand, whilst the market for *F. oustaleti* and *F. verrucosus* has reduced considerably, requiring exporters to offer them in 'packages' with more desirable species (personal communication with exporters in Madagascar). Increasing availability of species in consumer countries through captive breeding, a trend identified in Chapter 2, may also affect demand and feasibility of breeding in-country, as well as consumer preference for wild or captive-bred specimens. Given that the trade in reptiles for the exotic pet trade is relatively small and dispersed, it is possible that the market size and demand is simply insufficient to provide adequate economic benefits to support conservation and development initiatives. Therefore there is much to be considered before implementing such strategies.

Other options discussed in Chapter 4 include improving or adapting organisation of the supply chain via certification, supply chain length, or through creating cooperative management at the local level. The improved understanding of the operation of the supply chain in Madagascar allows us to assess the viability of these options. For example, intermediaries tend to play an important role within the supply chain in terms of contacts, accessibility and transport, yet do not appear to capture a particularly large proportion of the profit. Understanding the landscape (inaccessibility of some villages and collection areas), and consequent isolation of some local collectors, emphasises the potential importance of the intermediaries in terms of communication across the chain. Limited communication may be creating a barrier at present for people to coordinate trade at the local level, but local initiatives may be able to address this, providing

opportunities to create cooperative management and increase potential benefits from harvesting. Incorporating intermediaries, possibly through professionalization of their networks could also be considered. In this case, greater consideration would need to be given to property rights and land-use settings, in order to enable such management to work. The information collected in Chapters 3 and 4 can be used to inform wildlife trade policy and management in Madagascar, but is also of wider relevance to management in other areas where similar types of collection may occur. For example, in the large proportion of landscape outside of protected areas where people make their living, sustainable use and community-based approaches may be among the few practical options (Hutton and Leader Williams 2003).

6.3.3. Understanding sustainability and information flow across trade chains

Policy and interventions to regulate wildlife trade are generally applied at the international or national level (e.g. CITES listings, suspensions and quotas), with little understanding of how such policies translate along the supply chain. For example, how does a quota of 2000 chameleons translate into activities on the ground? Are 2000 chameleons extracted from the wild, or do local people opportunistically collect many more than this number in the hope of making a sale, and does preferential or indiscriminate harvesting of species, sex or colouration have heightened impacts on specific wild populations? Chapter 4 answers several of these questions revealing that the supply chain is based on collection-to-order with specific information passed from exporters through to local collectors. Whist previous studies reported opportunistic collection in the past (Carpenter et al. 2005), this study revealed it was generally not considered economically worthwhile for opportunistic collection, delivery of poor quality animals, or to hold animals in-country for longer than necessary. Whilst there is likely to be variation in supply practices, this creates conditions for a more

sustainable supply chain. Subsequently, future studies elsewhere would benefit from seeking to understand similar trade dynamics which could substantially impact on sustainability.

The understating of mortality along the chain also has important sustainability implications. If animals do not survive collection, transit or captivity, their trade is less likely to be sustainable in the long term. Even if a sustained demand is created to replace animals with high mortality, and the trade is conducted at sustainable levels, this leads into moral considerations of whether the trade should continue on this basis, and also policy implications. For example, the EU Wildlife Trade Regulations (Council Regulation (EC) No 338/97), which implement CITES in the EU, contain a clause suspending imports of species that have low survival in captivity. Additionally, exporting countries are required under CITES to ensure that living specimens are prepared and shipped so as to minimise the risk of injury, damage to health or cruel treatment (CITES 1983). Whilst limited recent data exists in grey literature, reports and occasional peer-reviewed publications concerning mortality of reptiles during transit and retail (Ashley et al. 2014; Schutz 2003; Smart and Bride 1993), no recent peer-reviewed publications based on primary data collection were found regarding mortality of pet reptiles in the home. The findings in Chapter 5 provides some of the first data to begin to understand these mortality rates, and consider not only the sustainability of the trade for different taxonomic groups, but also how the shifting production of reptiles identified in Chapter 2 (e.g. captive breeding) may affect mortality, and consequent sustainability of trade chains.

6.3.4. Informing future directions - towards an enhanced wildlife trade

With increasing globalisation and awareness of the impact of international trade chains on the world's biological diversity, certification and labelling initiatives have become increasingly popular (Blackman and Rivera 2011; Eilperin 2010; Lenzen et al. 2012). Such initiatives ensure that suppliers adhere to defined environmental and social welfare standards. They can expand markets and create price premiums for certified products, which in turn creates financial incentives for producers to meet the required standards (Blackman and Rivera 2011). Well-known labelling schemes include the Forest Stewardship Council (FSC) certification for forest products and the Marine Stewardship Council (MSC) for sustainable seafood. 'Fairtrade' (Fairtrade 2016) focusses more on social sustainability, by supporting small scale farmer organisations or plantations, ensuring they receive a greater share of the final price; and relatively recent schemes such as 'FairWild' have been specifically developed to deal with ecological and social sustainability for wild collected plants (FairWild 2016). There have been limited attempts to apply labelling to the pet trade, with the exception of the Marine Aquarium Council (MAC). This was created in 1998 to provide voluntary standards and an eco-labelling scheme for the marine aquarium trade, but ceased to exist in 2008 (Vosseler 2015). Whilst most importers in the US were MAC certified along with a few retailers, large cost implications for retailers, onerous requirements, and inadequate supply of certified fish, were major contributors to its failure (Vosseler 2015). All certification schemes face substantial challenges. These include setting sufficiently stringent standards, monitoring and enforcing poorly performing producers, and in achieving high enough price premiums or new customers to offset the costs of certification (Blackman and Rivera 2011).

CITES has some similarities to certification schemes in that it provides assurance regarding ecological sustainability of trade through its requirement for trading countries to determine that exports of listed-species will not be detrimental to their populations in the wild ('non-detriment finding'). CITES is also making efforts to improve traceability of trade chains for some species in order to prevent false declarations of origin, laundering or smuggling (Mundy and Sant 2015; UNCTAD 2014). Whilst permits provide information of origin and source of most traded species, there is limited information regarding collection practices, mortality of live animals and/or wider socio-economic implications such as livelihoods of local suppliers and producers, and these may have bearings on species conservation and sustainability of the trade. Additionally, a large number of traded species are not listed by CITES and therefore not subject to its requirements.

Whether a move towards certification or labelling in order to ensure a more sustainable trade is inevitable for the trade in exotic pets, and whether the trade is ready to embrace that, remains unanswered. Whilst in theory, such schemes would benefit the trade in live animals, there may be problems with economy of scale, whereby the industry is simply not sufficient in size to provide the impetus and structure to make such schemes work or even be financially beneficial. Nonetheless, the information presented in this thesis can help build the foundations on which such schemes may emerge, and should inform future discussions concerning certification.

6.4. Limitations and Further Research Requirements

There are numerous avenues for further research following the topics covered in this thesis. The case study in the Moramanga District of Madagascar provides an in-depth understanding of the livelihood benefits and conservation incentives resulting from the

harvesting of reptiles and amphibians to supply the international trade in exotic pets. However, further studies are required to understand if this is representative of the trade in other parts of the country, and in other countries where collection for the pet trade occurs. Indeed, Chapter 2 demonstrates a number of hotspots for the supply of live reptiles for trade which would warrant further research attention. Given the diverse and variable nature of wildlife trade chains, additional case studies will not only inform site-specific management, but also expand our understanding of the circumstances under which trade benefits may outweigh costs for both the environment and society, or where stricter trade controls such as trade bans may be appropriate. Expanding such studies to include trade chains incorporating captive breeding and ranching programs will greatly improve our understanding of the implications of shifting production systems on conservation and livelihoods in source countries, and inform relevant policy and management.

Research into whether the wildlife trade can create incentives for conservation at a local scale, and under what circumstances, could be expanded. In this thesis local people in Madagascar were asked their perceptions according to a number of ‘conservation attitude statements’. This included whether they would like to see the numbers of animals or amount of natural habitat increased or decreased in the wild. However, further study could include investigating actual behaviours related to an environmental or conservation ethic (e.g. encouraging wildlife in plantations, or preventing others from clearing habitat).

There is scope to significantly expand research on sustainability of trade chains, particularly mortality of live animals along the chain. Whilst Chapter 5 comprises the most comprehensive study to-date on mortality of pet reptiles in the home, similar studies in other regions, amongst alternative respondent samples, and all along the

chain are needed to expand understanding of biological sustainability of the trade. This is required to help inform debate concerning exotic pet keeping in consumer countries, and management across the supply chain. Expanding this to include a larger sample of animals obtained from different forms of production (e.g. captive breeding, ranching etc.) will allow further insight into the sustainability of various forms of trade and better assess the costs and benefits with relevance to supply countries.

Finally, much remains to be learned regarding the feasibility of certification or labelling schemes for the trade in animals supplying the pet trade. A starting point to any such process would be to investigate whether there was sufficient interest, demand and willingness-to-pay amongst consumers to purchase labelled products.

6.5. Epilogue

The international wildlife trade is complex and has far reaching environmental and societal implications, making its regulation and management particularly challenging. Due to its diverse and dynamic nature, a range of strategies and adaptive management approaches may be required, and much can be learnt from the success or failure of such strategies. Whilst efforts to reduce illegal trade should remain a priority, efforts should also be made to recognise legal and well-managed wildlife trade which may contribute to conservation and livelihoods. Such approaches could have a role to play in reducing illegal trade through improved management and traceability, and in supporting CITES, the CBD and the SDGs to reduce poverty in developing regions, and contribute to sustainable use of biodiversity. The research presented in this thesis makes an important contribution to improving our understanding of some of these issues to help move towards a better informed, legal and sustainable wildlife trade in the future.

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APPENDIX A - HOUSEHOLD QUESTIONNAIRE *[to be completed with HH head]*

Village/commune (name):	*Household number:* *HH…..*
Date of interview:	*Corresponding LC interview number (if relevant):* *LC.....*
Interviewer (name):	*Was this survey part of the random HH sample:* *YES* ☐ *NO* ☐

Hello, my name is……. Do you have time to answer some questions? We would like to ask you some general questions about households in the village, including about your livelihood activities and main sources of income. Your answers are anonymous; we will not record your name, and your participation in this study is voluntary. You can refuse to answer if you do not feel comfortable with some questions. ☐

PLEASE COULD YOU CONFIRM THAT YOU ARE HAPPY TO TAKE PART IN THIS STUDY?

Your effort in answering the questions would be highly appreciated. Thank you very much.

For your information, when we refer to your 'household' (HH) we mean all persons who normally live together and eat from the same cooking pot/kitchen.

1. HOUSEHOLD (HH) & INTERVIEWEE PROFILE

1.1	How many people live in your household? *(number)*	
1.2	Who lives in the household? *(fill in table below starting with HH head)*	

HH Member *(Record identifying code)*	Kin to HH head *(Spouse, child, grandparent, sibling, cousin…)*	Gender	Age	Highest level of education completed *(class)*
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		
		Male ☐ *Female* ☐		

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2. RESIDENT OR MIGRANT

2.1	Where were you born? (place)	
2.2	How long have you lived in this village? *(give years if possible)*	
2.3	What is your ethnicity?	

3. HH LIVELIHOOD PROFILE

3.1	Which livelihood activities are members of your HH involved with for money or food? Please include activities such as HUNTING, FORAGING and COLLECTION OF LIVE ANIMALS TO SELL/TRADE
3.2	*List all livelihood activities for all HH members.*
3.3	Which members of the HH are involved with each activity? *List the initials of each HH member involved in each*
3.4	RANK each livelihood activity in terms of current monetary income provided(1 = most important)
	RANK each livelihood activity in terms of current food provided (1 = most important)

	3.1 Livelihood activity/occupation	3.2HH member *(code from table 1)*	3.3 Importance for HH income	3.4 Importance for HH food
	Wildlife collection (Cross if not)			
1				
2				
3				
4				
5				
6				
7				
8				
9				
1				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

4. HOUSEHOLD LIVELIHOOD DETAILS

4.1	*For wildlife collection only – only complete if HH involved in wildlife collection*
4.1.1	Which animals do you collect?
4.1.2	Which months of the year do you do this activity?
4.1.3	For which purpose do you collect?
4.1.4	How many collection trips do you have in this period?
4.1.5	Approximately how many animals/other do you collect in typical trip?
4.1.6	How much money do you earn from each trip? [Ariary]
4.1.7	During this time, how many hours per day do you spend doing this activity?
4.1.8	During this time, how many days per week do you spend doing this activity?
4.1.9	Which costs did you incur in order to START doing this activity (e.g., purchase of tools)?
4.1.10	Which ONGOING costs do you incur in order to continue doing this activity (e.g., purchase of seed, employment of other people)? COST / PRICE / FREQUENCY
4.1.11	What are the factors that limit your ability or the time period that you do this activity, e.g. season, licenses, land, ability to sell…?

4.2 Other activities (NON WILDLIFE COLLECTION) - fill in table for EACH LIVELIHOOD ACTIVITY of each working member in the HH												
4.2.1. Livelihood activity/occupation	1.			2.			3.			4.		
4.2.2 Which months of the year do you do this activity?												
4.2.3 During this time, how many hours per day do you spend doing this activity?												
4.2.4 During this time, how many days per week do you spend doing this activity												
4.2.5 How much do you produce in a typical year (from Jan – Dec)? Please give physical quantities e.g. two bags, 5 chickens etc.												
4.2.6 What is the market value equivalent of the above produce per unit?												
4.2.7 How much of the produce from this activity is sold? (try to get a rough idea, e.g. 'all of produce is sold', or 'half of produce is sold p/month')												
4.2.8 Which costs did you incur in order to START doing this activity (e.g., purchase of tools)?	*Cost*	*Price [AR]*		*Cost*	*Price [AR]*		*Cost*	*Price [AR]*		*Cost*	*Price [AR]*	
4.2.9 Which ONGOING costs do you incur in order to continue doing this activity (e.g., purchase of seed, employment of other people)? COST / PRICE / FREQUENCY	*Cost*	*Price[AR]*	*Freq.*	*Cost*	*Price[AR]*	*Freq.*	*Cost*	*Price[AR]*	*Freq.*	*Cost*	*Price[AR]*	*Freq.*
4.2.10 What are the factors that limit your ability or the time period that you do this activity, e.g. season, licenses, land, ability to sell…?												

4.2.1. Livelihood activity/occupation	5.			6.			7.			8.		
4.2.2 Which months of the year do you do this activity?												
4.2.3 During this time, how many hours per day do you spend doing this activity?												
4.2.4 During this time, how many days per week do you spend doing this activity												
4.2.5 How much do you produce in a typical year (from Jan – Dec)? Please give physical quantities e.g. two bags, 5 chickens etc.												
4.2.6 What is the market value equivalent of the above produce per unit?												
4.2.7 How much of the produce from this activity is sold? (try to get a rough idea, e.g. 'all of produce is sold', or 'half of produce is sold p/month')												
4.2.8 Which costs did you incur in order to START doing this activity (e.g., purchase of tools)?	*Cost*	*Price [AR]*		*Cost*	*Price [AR]*		*Cost*	*Price [AR]*		*Cost*	*Price [AR]*	
4.2.9 Which ONGOING costs do you incur in order to continue doing this activity (e.g., purchase of seed, employment of other people)? COST / PRICE / FREQUENCY	*Cost*	*Price[AR]*	*Freq.*	*Cost*	*Price[AR]*	*Freq.*	*Cost*	*Price[AR]*	*Freq.*	*Cost*	*Price[AR]*	*Freq.*
4.2.10 What are the factors that limit your ability or the time period that you do this activity, e.g. season, licenses, land, ability to sell…?												

5. WILDLIFE TRADE AS A LIVELIHOOD

5.1	Are you or any members of your HH involved in collection of live wild animals to sell/trade?	Yes ☐ No ☐

5.2	***5.1=Yes***	
5.2.1	Who is that? What is her/his job?	
5.2.2	When did you/(he/she) start collecting live animals?	.....
5.2.3	At that time, why did you (she/he) become involved in collecting animals?	
5.2.4	Which year was the last time you collected animals?	.....
IF the last time of collection <u>is</u> in since <u>2011</u>, ask an appointment to the person to make the LC interview and go directly to the question 5.4. If before 2011 continue from 5.3.4		

5.3	***5.1=No***	
5.3.1	And before, have you or any members of your HH previously been involved in collection of live wild animals to sell/trade?	Yes ☐ No ☐
5.3.2	What was your/her/his job?	
5.3.3	At that time, why did you (she/he) become involved in collecting animals for sell/trade??	
5.3.4	How important was this activity PREVIOUSLY, in terms of providing income for your HH?	*Important* ☐ *Neither important nor unimportant* ☐ *Not important* ☐
5.3.5	Which months of the year did you used to collect animals for trade?	
5.3.6	During those months, approximately how many orders did you receive for animals?	
5.3.7	How many days did you spend for each order?	
5.3.8	How much money did you earn for each order?	
5.3.9	At what year did you/she/he collect for the last time?	.....
5.3.10	Why did (she/he) you stop?	

5.4	Do any other members of your family work in wildlife trade, for example as middlemen or exporters	*Yes* ☐ *No* ☐
	If Yes: say who and tell me the work of that person in wildlife trade	

6.HH INCOME [HOUSEHOLD HEAD]

What is the HH's average income per month? Please include income received from wages, bonuses, selling products, rents, donations, grants, remittances, social security, pensions etc. FROM ALL HOUSEHOLD MEMBERS, excluding taxes. *(If the respondent mentions an exact amount, please note this down. Otherwise, ask the household whether they earn somewhere between (higher category) and (lower category) and mark below. Please probe a bit when the amount seems very low or high)*

Income	Tick one category
No income	
AR< 50.000	`
AR 50.001 – 75.000	
AR 75.001 – 100.000	
AR 100.001 – 150.000	
AR 150.001 – 200.000	
AR 200.001 – 300.000	
AR 300.000 – 400.000	
AR 400.000 +	
Refused to answer	

7. ASSETS/WEALTH

7.1	Which of the following items does your household own?			
No.	*Item*	*Quantity owned*	*Time period owned*	*Purchase value of item*
01	Cooking pots			
02	Cooking equipment (charcoal stove)			
03	Cooking equipment (solar stove)			
04	Bed			
05	Mattress (sponge)			
06	Mattress (rice sack/filled)			
07	Table			
08	Chair			
09	Other furniture 1			
10	Other furniture 2			
11	Other furniture 3			
12	Lamp (kerosene)			
13	Lamp (battery and electric)			
14	Watch			
15	Clock			
16	Music player (radio/cassette/cards)			
17	Music player (CD/DVD)			
18	Television			
19	Mobile phone			
20	Electric generator			
21	Plough (fr:charrue)			
22	Shovel (mg:angady)			
23	Kibota/motorculter			
24	bicycle			
25	motorbike			
26	Car			
27	Land owned (hectares)			
28	Land rented (hectares)			

Item	*Item*	*Current quantity owned*	*Market value*
01	Chicken and other Poultry		
02	Zebu		
03	Pig		

7.2.1	Number of rooms in house										
7.2.2	Material used for roof	*Tin or metal*	☐	*Palm or grass*	☐	*Other .....*	☐				
7.2.3	Material used for walls	*Mud or earth*	☐	*Brick*	☐	*Concrete*	☐	*Other .....*	☐		
7.2.4	Floor type	*Earth*	☐	*Brick*	☐	*Concrete*	☐	*Other .....*	☐		
7.2.5	Outside fence	*Wood*	☐	*Earth/mud*	☐	*Stone*	☐	*Other .....*	☐		

8. TRADE CHAIN

8.1	How many people IN THIS VILLAGE do you know who are involved in collecting live wild animals to sell/trade? *(specify number)* Could you introduce us to them at the end of this interview?	
8.2	Which other villages do people who trap live wild animals to sell come from? (names of villages / no. of people)	
8.3	How many buyers/traders from outside the village do you know who come to the village to look for live wild animals to buy, or collect themselves? (specify if exporter, collector) Collectors (.....) Other..... .(.....) Exporters (.....)	

9. ATTITUDES/LAWS & AWARENESS

9.1	Are are there any national laws or legislation regarding collection of the following live wild animals to sell?*(If YES, please provide details)*				
Chameleons	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Geckoes	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Snakes	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Frogs	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Inverts (spiders, crickets etc.)	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Birds	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Lemurs	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Tenrecs	*Yes* ☐	*No* ☐	*DK* ☐	What if YES	
Comments					

9.2	Are there any penalties for COLLECTING live reptiles & amphibians to sell? *Yes* ☐ *No* ☐ *I don't know* ☐
9.2.1	If YES, please specify what the penalties are:
9.2.2	How many people do you know who have received a penalty? (.....)

9.3	'In this village are there any fady concerning any of the following animal groups: fady about collection? Food? Other?' Ok to gather.
Chameleons	
Geckoes	
Snakes	
Frogs	
Inverts	
Birds	
Lemurs	
Tenrecs	
Comments	

9.4	In this village are there any USES concerning any of the following animal groups, e.g. food, money, medicine?
Chameleons	
Geckoes	
Snakes	
Frogs	
Inverts	
Birds	
Lemurs	
Tenrecs	
Comments	

9.5	For each animal group please indicate how much YOU agree or disagree with the following statements:					
9.5.1	I think it is good for food					
Chameleons	*Disagree*		*Neither agree nor disagree*		*Agree*	
Geckoes	*Disagree*		*Neither agree nor disagree*		*Agree*	
Snakes	*Disagree*		*Neither agree nor disagree*		*Agree*	
Frogs	*Disagree*		*Neither agree nor disagree*		*Agree*	
Inverts	*Disagree*		*Neither agree nor disagree*		*Agree*	
Birds	*Disagree*		*Neither agree nor disagree*		*Agree*	
Lemurs	*Disagree*		*Neither agree nor disagree*		*Agree*	
Tenrecs	*Disagree*		*Neither agree nor disagree*		*Agree*	

9.5.3	I think that this animal is good for providing money					
Chameleons	*Disagree*		*Neither agree nor disagree*		*Agree*	
Geckoes	*Disagree*		*Neither agree nor disagree*		*Agree*	
Snakes	*Disagree*		*Neither agree nor disagree*		*Agree*	
Frogs	*Disagree*		*Neither agree nor disagree*		*Agree*	
Inverts	*Disagree*		*Neither agree nor disagree*		*Agree*	
Birds	*Disagree*		*Neither agree nor disagree*		*Agree*	
Lemurs	*Disagree*		*Neither agree nor disagree*		*Agree*	
Tenrecs	*Disagree*		*Neither agree nor disagree*		*Agree*	

9.5.3	I am afraid of this animal						
Chameleons	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Geckoes	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Snakes	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Frogs	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Inverts	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Birds	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Lemurs	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Tenrecs	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	

9.5.4	I think that this animal is important for the environment						
Chameleons	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Geckoes	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Snakes	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Frogs	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Inverts	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Birds	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Lemurs	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	
Tenrecs	*Disagree*	☐	*Neither agree nor disagree*	☐	*Agree*	☐	

9.5.5	I think that the current numbers of this animals should be:									
Chameleons	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Geckoes	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Snakes	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Frogs	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Inverts	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Birds	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Lemurs	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐
Tenrecs	*Eliminated*	☐	*Reduced*	☐	*Same level*	☐	*Increased*	☐	*Don't mind*	☐

(Finish the interview by asking to the HH head: 'Do you want to add something?' and write down what the person say) If trapper identified in HH make sure LC survey is completed.

APPENDIX B - LOCAL COLLECTOR QUESTIONNAIRE

[To be completed with a current trapper for trade/sell but NOT BUSHMEAT. If <18 years: seek informed consent from responsible adult]

Village/commune (name):	***LC number:*** ***LC…….....***
Date of interview:	*HH number (if relevant):* *HH.....*
Interviewer (name):	***Was this survey part of the random HH sample:*** ***YES*** ☐ ***NO*** ☐

This survey should be completed by the person involved in collection of live animals for trade (local collector). ENSURE HH SURVEY IS ALSO COMPLETED WITH HH HEAD FOR THE LOCAL COLLECTOR.

We would like to ask you some questions about your work collecting live wild animals to sell/trade. We are particularly interested in how important this job is to you and your household and the types of animals you collect.

Your answers are anonymous; we will not record your name, and your participation in this study is voluntary. All the answers you'll give are voluntary; you can refuse to answer some questions if you don't want to. Your effort in answering the questions would be highly appreciated. Thank you very much.

PLEASE COULD YOU CONFIRM THAT YOU ARE HAPPY TO TAKE PART IN THIS STUDY? ☐

1. INTERVIEWEE PROFILE

☐ ***Interviewed in HH interview (do not fill 2,8,9)*** ☐ ***Not interviewed in HH interview (fill 2.8,9)***

1.1	Gender	Male	☐	Female	☐	
1.2	Where were you born?					
1.3	What is your ethnicity?					
1.4	How old are you?					
1.5	What is the highest level of education you have completed? (Class)					

2. LIVELIHOOD ACTIVITIES - Fill in table for EACH NON WILDLIFE ACTIVITY LOCAL COLLECTOR IS ENGAGED WITH

2.1. Livelihood activity/occupation	1.			2.			3.			4.		
2.2. Which members of the HH do this activity?												
2.3. Which months of the year do you do this activity?												
2.4. During this time, how many hours per day do you spend doing this activity?												
2.5. During this time, how many days per week do you spend doing this activity												
2.6. How much do you produce in a typical year (from Jan - Dec)? Please give physical quantities e.g. 2 bags, 5 chickens etc.												
2.7. What is the market value equivalent of the above produce per unit?												
2.8. How much of the produce from this activity is sold? (try to get a rough idea, e.g. 'all of produce is sold', or 'half of produce is sold each month')												
2.9. Which costs did you incur in order to START doing this activity (e.g., purchase of tools)?	Cost	Price [AR]		Cost	Price [AR]		Cost	Price [AR]		Cost	Price [AR]	
2.10. Which ONGOING costs do you incur in order to continue doing this activity (e.g., purchase of seed, employment of other people)?	Cost	Price[AR]	Freq.	Cost	Price[AR]	Freq.	Cost	Price[AR]	Freq.	Cost	Price[AR]	Freq.
2.11. What are the factors that limit your ability or the time period that you do this activity, e.g. season, licenses, land, ability to sell…?												

2.1. Livelihood activity/occupation	1.			2.			3.			4.		
2.2. Which members of the HH do this activity?												
2.3. Which months of the year do you do this activity?												
2.4. During this time, how many hours per day do you spend doing this activity?												
2.5. During this time, how many days per week do you spend doing this activity												
2.6. How much do you produce in a typical year (from Jan - Dec)? Please give physical quantities e.g. 2 bags, 5 chickens etc.												
2.7. What is the market value equivalent of the above produce per unit?												
2.8. How much of the produce from this activity is sold? (try to get a rough idea, e.g. 'all of produce is sold', or 'half of produce is sold each month')												
2.9. Which costs did you incur in order to START doing this activity (e.g., purchase of tools)?	Cost	Price [AR]		Cost	Price [AR]		Cost	Price [AR]		Cost	Price [AR]	
2.10. Which ONGOING costs do you incur in order to continue doing this activity (e.g., purchase of seed, employment of other people)?	Cost	Price[AR]	Freq.	Cost	Price[AR]	Freq.	Cost	Price[AR]	Freq.	Cost	Price[AR]	Freq.
2.11. What are the factors that limit your ability or the time period that you do this activity, e.g. season, licenses, land, ability to sell…?												

3. WILDLIFE COLLECTION

3.1	*General information: beginning of activity, income for HH*	
3.1.1	What year did you start collecting live animals for sale/trade?	
3.1.2	At that time, why did you become involved in collecting animals?	
3.1.3	Do any other members of your family work in wildlife trade/collection? Yes ☐ No ☐ **If Yes**: say who and what is her/his job	
3.1.4	How important would you say this activity is in terms of providing income for yourself? Important ☐ Neither important nor unimportant ☐ Not important ☐	
3.1.5	Does this income contribute towards your HH or family? Yes ☐ No ☐	
3.1.6	How important would you say this activity is for providing income for your household? Important ☐ Neither important nor unimportant ☐ Not important ☐	
3.1.7	What do you usually use the money you earn from wildlife collection for?	

3.2	*Period of collection*
3.2.1	Which months of the year do you do this activity? *(If **all year round**, go to 3.3)*
3.2.2	If there are **any months** in the year when you **do NOT** do this activity, please explain why

3.3	*Amount collected and money earned*	
3.3.1	During this period of collection, approximately how many orders do you receive for animals?	
3.3.2	Approximately how many animals do you collect in typical order?	
3.3.3	How much time do you usually spend collecting animals for each order?	
3.3.4	How much money do you earn for each order? [Ariary]	

3.4	*Costs*	
3.4.1	Do you work alone or do you have other people working for you? *Yes* ☐ *No* ☐	
	If *YES*, provide details.	
3.4.2	And at the FIRST TIME you collected animals, did you incur any COST? *Yes* ☐ *No* ☐	
3.4.3	What if *YES*?	
3.4.4	Do YOU incur any OTHER on-going costs in order to do this activity (lamp, batteries, transport)? *Yes* ☐ *No* ☐	
	What if *YES*?	

3.5	Are there any factors that limit your ability to do this activity, e.g. season, licenses, ability to sell…?)

3.6	*More animals/better payment*
3.6.1	If you collected more animals than you currently collect, **how likely is it that you would find a buyer for them all?** Likely ☐ Not sure ☐ Unlikely ☐
3.6.2	If you were paid MORE for each animal, how would it influence the number of animals you collect?
	I would collect fewer animals ☐ I would collect same amount ☐
	I would collect more animals ☐ Other ☐
What if other.....	

4. WILDLIFE GROUPS COLLECTED

4.1	Which of the following groups of wildlife do you collect live to collect/trade?
4.2	Approximately how many do you collect in a typical period of collection? Give range
4.3	What are these animals/plants collected for, e.g., pets, food, sell alive, sell for food?
4.4	Please RANK each group in terms of income provided (1 = most important).
4.5	Provide 5 examples of the different types of species collected in each group

	Do you collect this wildlife group?	4.1 Collected	4.2 Number collected	4.3 Uses, e.g. pets, food, sell alive, sell for food?	4.4 RANK in terms of income (1 = most important)	4.5 Five examples of species collected
1	Reptiles (chameleons, geckoes, snakes, other lizards. **Excl crocodiles**)	*Yes* ☐ *No* ☐				
2	Crocodiles	*Yes* ☐ *No* ☐				
3	Amphibians (frogs, toads)	*Yes* ☐ *No* ☐				
4	Invertebrates (spiders, scorpions, crickets, millipedes etc.)	*Yes* ☐ *No* ☐				
5	Birds	*Yes* ☐ *No* ☐				
6	Mammals	*Yes* ☐ *No* ☐				
7	Plants	*Yes* ☐ *No* ☐				
8	Fish	*Yes* ☐ *No* ☐				
9	Other?	*Yes* ☐ *No* ☐				

5. REPTILES & AMPHIBIANS TRADED - from here on we are referring to collection/sale of REPTILES AND AMPHIBIANS only

5.1 Location

5.1.1	Please list the main locations that you collect reptiles and amphibians from? (please list names of places, forests etc.)
5.1.2	Please could you indicate how you travel to these places (walk/bicycle/motorbike/car/taxi-brousse/other)
5.1.3	How long does it usually take you to reach each location?

5.1.1 Location (forest, village, fokontany)	5.1.2 Transport method	5.1.3 Time taken to reach location

5.2 Top ten species

5.2.1	Please could you list up to 10 different reptile and amphibian species that you collect
5.2.2	Please indicate which location each species is collected from (name of village, forest etc.)- refer to list above
5.2.3	How many trips do you make to collect this species in a typical period of collection? Give a range
5.2.4	How many individuals of this species do you collect per trip?
5.2.5	How long does the typical trip take you?
5.2.6	What price do you receive for one individual of this species?

	5.3.1. Species	5.3.3. Location	5.3.3 Number of trips per period of collection	5.3.4 Number of individuals collected per trip	5.3.5 Time spent collecting the species	5.3.6 Price / individual
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						

5.3 *I am going to show you some photos, could you tell me which species is on the photographs.*

5.3	[SARY MB 5] For each photograph, please could you tell me the name of the species?		
1	7	13	19
2	8	14	20
3	9	15	21
4	10	16	22
5	11	17	23
6	12	18	24

5.4 Species collected

5.4.1	Do you collect this species?
5.4.2	Please indicate which location each species is collected from (name of village, forest etc.)
5.4.3	How many trips do you make to collect this species in a typical period of collection? Give a range
5.4.4	How many individuals of this species do you collect per trip? Give a range
5.4.5	How long does the typical trip take you?
5.4.6	What price do you receive for one individual of this species?

N°	Species	5.4.1 Collected	5.4.2 Location	5.4.3 Number of trips per period of collection	5.4.4 Number of individuals collected per trip	5.4.5 Time spent collecting the species	5.4.6 Price per individual
01	*Pardalisy (Furcifer pardalis)*	*Yes* ☐ *No*					
02	*Lateralisy (Furcifer lateralis)*	*Yes* ☐ *No*					
03	*Ostalety (Furcifer oustaleti)*	*Yes* ☐ *No*					
04	*Verkozisy (Furcifer verrucosus)*	*Yes* ☐ *No*					
05	*Kampany (Furcifer campani)*	*Yes* ☐ *No*					
06	*Latikôda (Phelsuma laticauda)*	*Yes* ☐ *No*					
07	*Lineata (Phelsuma lineata)*	*Yes* ☐ *No*					
08	*Kadriô (Phelsuma*	*Yes* ☐ *No*					
09	*Phelsuma madagascariensis*	*Yes* ☐ *No*					

5.4.1 5.4.2 5.4.3 5.4.4 5.4.5 5.4.6	Do you collect this species? Please indicate which location each species is collected from (name of village, forest etc.) How many trips do you make to collect this species in a typical period of collection? Give a range How many individuals of this species do you collect per trip? Give a range How long does the typical trip take you? What price do you receive for one individual of this species?						
N°	Species	5.4.1 Collected	5.4.2 Location	5.4.3 Number of trips per period of collection	5.4.4 Number of individuals per trip	5.4.5 Time spent in collecting	5.4.6 Price per individual
10	*Betsileo (Mantella betsileo)*	Yes ☐ No					
11	*Baroni (Mantella baroni)*	Yes ☐ No					
12	*Nigrikansa (Mantella nigricans)*	Yes ☐ No					
13	*Sahona mena (Mantella aurantiaca)*	Yes ☐ No					
14	*Polkra (Mantella pulchra)*	Yes ☐ No					
15	*Gotlebey (Scaphiophryne gottlebei)*	Yes ☐ No					
16	*Sikôre (Uroplatus sikorae)*	Yes ☐ No					
17	*Ebenôy (Uroplatus ebenaui)*	Yes ☐ No					
18	*Fimbriatisy (Uroplatus fimbriatus)*	Yes ☐ No					
19	*Fantastikisy (Uroplatus phantasticus)*	Yes ☐ No					
20	*Sipersiliarisy (Brookesia superciliaris)*	Yes ☐ No					
21	*Stampfy (Brookesia stumpffi)*	Yes ☐ No					
22	*Thiely (Brookesia thieli)*	Yes ☐ No					
23	*Therezieni (Brookesia therezieni)*	Yes ☐ No					
24	*Masobe (Paroedura masobe)*	Yes ☐ No					

6. SUPPLY CHAIN – REPTILES & AMPHIBIANS ONLY

6.1	Who do you sell live reptiles and amphibians to? For e.g., do you sell to other people in the village, to people from outside the village, directly to exporters/businesses, or other? *(please specify)*	
6.2	How many different people do you sell to? *(provide number)*	
6.3	Could you tell me the names of the people you sell to, and where they come from? **You can refuse to answer if it makes you uncomfortable.**	

6.4	Do you have any agreements (formal or informal) with the people you sell reptiles and amphibians to?	Yes ☐ No ☐
	Give details if YES	

6.5	Are there any formal procedures (licenses/taxes) required to collect and sell live reptiles and amphibians? Yes ☐ No ☐ Don't know ☐
	If YES, please explain

6.6	Do you collect reptiles and amphibians after receiving specific orders from people or do you collect some in anticipation of orders?
	After receiving specific order ☐ Both ☐ Obtain animals in advance ☐ Other (specify) ☐ ……

6.7	How is the price agreed? For example do the people who buy reptiles and amphibians from you pay a set price for each animal, do they pay for your time or do they pay you a fixed wage?
	Fixed price per animal ☐ Wage according to their time ☐ Other ☐ Other.....

6.8	Who decides the price that you get paid?
	You ☐ Other(specify) ☐ The person who buys the animals ☐ ……

6.9	Are you paid in advance or on receipt of reptiles and amphibians?
	Payment in advance ☐ Oher ☐ Payment in receipt ☐ What if Other?

6.10	Are there any factors which affect the price you get paid? e.g. duration of collection, season
	If ***YES***, explain.

7.COLLECTION PRACTICES

7	When people ask you for reptiles & amphibians, what instructions do they give you regarding the following:
7.1	Do they request specific **species or subspecies** to be collected? Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never ☐
7.2	Are you able to identify the species/subspecies that they request? *Always* ☐ *Often* ☐ *Sometimes* ☐ *Rarely* ☐ *Never* ☐
7.3	Do they specify the exact **quantity** of &amphibians to be collected? *Always* ☐ *Often* ☐ *Sometimes* ☐ *Rarely* ☐ *Never* ☐
7.4	Do they specify which **sex** to collect? *Always* ☐ *Often* ☐ *Sometimes* ☐ *Rarely* ☐ *Never* ☐
7.4.1	*What do they ask for*?…… ……
7.5	Do they specify the **colour or pattern** to be collected? *Always* ☐ *Often* ☐ *Sometimes* ☐ *Rarely* ☐ *Never* ☐
7.5.1	*What do they ask for*?……
7.6	Do the collectors give you any other specific instructions about the animals you collect?
7.7	What method do you use to catch reptiles & amphibians?
7.8	What is the average time period you are given to collect the animals and provide to the collector/buyer?
7.8.1	How do you keep the animals before sending them to collector?
7.9	If the buyer does not want all of the reptiles and amphibians that you have collected, what do you do with the remaining animals?
7.10	Out of every 10 reptiles that you collect, how many die before sale/exchange?
7.11	Out of every 10 amphibians that you collect, how many die before sale/exchange?

Following SECTIONS 8& 9: Only complete IF LOCAL COLLECTOR IS NOT HH HEAD

8. TRADE CHAIN

8.1	How many people IN THIS VILLAGE do you know who are involved in collecting live wild animals to sell/trade? *(specify number)* **Could you introduce us to them at the end of this interview?**	
8.2	Which other villages do people who trap live wild animals to sell come from? (names of villages / no. of people)	
8.3	How many buyers/traders from outside the village do you know who come to the village to look for live wild animals to buy, or collect themselves? (specify if exporter, collector) Collectors (.....) Other..... .(.....) Exporters (.....)	

9. ATTITUDES/LAWS & AWARENESS

9.1	Are there any national laws or legislation regarding collection of the following live wild animals to sell?*(If YES, please provide details)*		
Chameleons	Yes ☐ No ☐ DK ☐		What if YES
Geckoes	Yes ☐ No ☐ DK ☐		What if YES
Snakes	Yes ☐ No ☐ DK ☐		What if YES
Frogs	Yes ☐ No ☐ DK ☐		What if YES
Inverts (spiders, crickets etc.)	Yes ☐ No ☐ DK ☐		What if YES
Birds	Yes ☐ No ☐ DK ☐		What if YES
Lemurs	Yes ☐ No ☐ DK ☐		What if YES
Tenrecs	Yes ☐ No ☐ DK ☐		What if YES
Comments			

9.2	Are there any penalties for COLLECTING live reptiles & amphibians to sell? Yes ☐ No ☐ I don't know ☐		
9.2.1	If YES, please specify what the penalties are:		
9.2.2	How many people do you know who have received a penalty?		

9.3	In this village are there any fady concerning any of the following animal groups: fady about collection? Food? Other?
Chameleons	
Geckoes	
Snakes	
Frogs	
Inverts	
Birds	
Lemurs	
Tenrecs	
Comments	

9.4	In this village are there any USES concerning any of the following animal groups, e.g. food, money, medicine?
Chameleons	
Geckoes	
Snakes	
Frogs	
Inverts	
Birds	
Lemurs	
Tenrecs	
Comments	

9.5	For each animal group please indicate how much YOU agree or disagree with the following statements:						
9.5.1	**I think it is good for food**						
Chameleons	Disagree		Neither agree nor disagree		Agree		
Geckoes	Disagree		Neither agree nor disagree		Agree		
Snakes	Disagree		Neither agree nor disagree		Agree		
Frogs	Disagree		Neither agree nor disagree		Agree		
Inverts	Disagree		Neither agree nor disagree		Agree		
Birds	Disagree		Neither agree nor disagree		Agree		
Lemurs	Disagree		Neither agree nor disagree		Agree		
Tenrecs	Disagree		Neither agree nor disagree		Agree		

9.5.2	**I think that this animal is good for providing money**						
Chameleons	Disagree		Neither agree nor disagree		Agree		
Geckoes	Disagree		Neither agree nor disagree		Agree		
Snakes	Disagree		Neither agree nor disagree		Agree		
Frogs	Disagree		Neither agree nor disagree		Agree		
Inverts	Disagree		Neither agree nor disagree		Agree		
Birds	Disagree		Neither agree nor disagree		Agree		
Lemurs	Disagree		Neither agree nor disagree		Agree		
Tenrecs	Disagree		Neither agree nor disagree		Agree		

9.5.3	**I am afraid of this animal**						
Chameleons	Disagree		Neither agree nor disagree		Agree		
Geckoes	Disagree		Neither agree nor disagree		Agree		
Snakes	Disagree		Neither agree nor disagree		Agree		
Frogs	Disagree		Neither agree nor disagree		Agree		
Inverts	Disagree		Neither agree nor disagree		Agree		
Birds	Disagree		Neither agree nor disagree		Agree		
Lemurs	Disagree		Neither agree nor disagree		Agree		
Tenrecs	Disagree		Neither agree nor disagree		Agree		

9.5.4	**I think that this animal is important for the environment**							
Chameleons	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Geckoes	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Snakes	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Frogs	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Inverts	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Birds	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Lemurs	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		
Tenrecs	Disagree	☐	Neither agree nor disagree	☐	Agree	☐		

9.5.5	**I think that the current numbers of this animals should be:**									
Chameleons	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Geckoes	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Snakes	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Frogs	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Inverts	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Birds	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Lemurs	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐
Tenrecs	Eliminated	☐	Reduced	☐	Same level	☐	Increased	☐	Don't mind	☐

(Finish the interview by asking: 'Do you want to add something?' and write down what the person say). Make sure HH survey is completed.

APPENDIX C - EXPORTER SURVEY

Interview location:	*Interviewer (name):*
Date of interview:	*Translator (name):*

Thank you for agreeing to participate in this interview. Your answers are anonymous; we will not publish your name, and your participation in this study is voluntary. Your effort in answering the questions would be highly appreciated. Thank you very much.

PLEASE COULD YOU CONFIRM THAT YOU ARE HAPPY TO TAKE PART IN THIS STUDY? ☐

1. EXPORTING FACILITY

1.1	What is the name of the exporting facility that you work for?	
1.2	Where is the exporting facility based? (town/district)	
1.3	What year was the exporting facility set up?	
1.3.1	What year did you start exporting reptiles & amphibians?	

1.4	Is the exporting facility part of a zoo, wildlife park or any other business?	Y / N (If NO → 1.6)
1.4.1	*If YES, please provide details (what other business?)*	
1.5	*What percentage (%) of the business is wildlife trade/export related?*	

1.6	In addition to yourself, how many people are employed at this facility*?*	In total: *Wildlife trade/export:*
1.7.1 1.7.2 1.7.3 1.7.4	Please could you tell me the job titles of the other people employed at the facility (wildlife trade/export) How many people are currently employed in each role What are their working hours **(please indicate the usual working hours for full time 'FT' and part time 'PT')** Please provide a brief description of the jobs they do	

1.7.1 Job title	1.7.2 Number of people employed in this role	1.7.3 Working hours (Full time 'FT', Part time 'PT')	1.7.4 Description of job role

1.8	What was the initial set-up cost of this exporting facility?	

The following questions are optional but I would be very grateful if you could provide an answer:		2012
1.9	What was the net revenue (turnover) for 2012?	
1.10	*What % of the revenue is export related (rather than local trade)*	
1.11	What was the net revenue (turnover) for REPTILES & AMPHIBIANS for 2012?	
1.12	*What % of the revenue for reptiles & amphibians is export related (rather than local trade)*	
1.13	What was the approximate financial input (operational costs/expenses) for 2012?	

1.15	What are the main expenses that you incur as an exporter?

1.16	What government fees/taxes are you required to pay?
1.16.1	How much in total did you have to pay in government fees/taxes last year (2012)?

2. INTERVIEWEE PROFILE

2.1	What year were you born?	
2.2	Gender *(please circle)*	Male / Female
2.3	What is the highest level of education you have completed?	None / some primary / completed primary / some secondary / completed secondary / some university / completed university / beyond university
2.4	Where were you born?	
2.5	Which region are you from?	

3. EXPORT AS A LIVELIHOOD ACTIVITY

3.1	What is your job title?	
3.2	Please could you describe your job role?	
3.3	How long have you been working in wildlife trade/export (months/years)?	
3.4	Why did you become involved in wildlife trade/export?	
3.5	Do any other members of your family work in wildlife trade or export?	Y / N
3.5.1	If YES, please provide details	
3.6	*Are there other jobs that you could do if you no longer worked in wildlife trade/export?*	*Y / N / Don't know*
3.6.1	What would you do for income if you stopped working in wildlife export?	

3.7	**Usual hours spent doing activity?**	**Hours per day:**	**Days per week:** **Days per month:**
3.8	Which months of the year do you do this activity? *If all year round, go to 3.9*		
3.8.1	If there are any months in the year when you do not do this activity, please explain why:		
3.8.2	During the months that you do not do this activity, what do you do instead?		
3.9	**How much money do you earn from doing this activity in a typical:**	**Month:**	**Year:**

3.13	**Do you do any other jobs/livelihood activities?**	Y / N ***(If YES → 4, If NO → 5)***

Fill in a table for each additional occupation/livelihood activity - extra pages available

4. OTHER LIVELIHOOD ACTIVITIES

4	Livelihood activity/occupation:			
4.1	Which months of the year do you do this activity? *If all year round, go to 4.3*			
4.1.1	If there are any months in the year when you do NOT do this activity, please explain why:			
4.1.2	During the months that you do NOT do this activity, what do you do instead?			
4.2	**Usual hours spent doing activity?**	**Hours per day:**	**Days per week:**	**Days per month:**
4.3	IF LIVELIHOOD ACTIVITY IS AGRICULTURE/PRODUCTION OF GOODS/FORAGING/LIVESTOCK**:** How much do you produce in a typical month/year? *Please give physical quantities e.g. two bags, 5 chickens etc* Month: Year: What is the market value equivalent of the above produce? Month: Year:			
4.3.1	How much of the produce from this activity is kept for HH use/consumption? *(try to get a rough idea, e.g. 'all of produce is kept for HH', or 'half of produce is sold each month')*			
4.4	**How much do you earn from doing this activity in a typical:**	**Month:**	**Year:**	
4.5	Did YOU incur any costs in order to START doing this activity (e.g., purchase of tools)?			Y / N
4.5.1	If YES, please specify what the costs were incurred for and how much they cost?			
4.6	Do YOU incur any OTHER on-going costs in order to do this activity (e.g., purchase of seed)?			Y / N
4.6.1	If YES, please specify what the costs are incurred for, how much they cost, and how frequently the costs are incurred. PLEASE TELL US ABOUT ALL COSTS.			
4.7	Are there any factors that limit your ability to do this activity, e.g. season, licenses, land, ability to sell…?)			

5. INCOME

5.1	What is your average income per month? Please include income received from wages, bonuses, selling products, rents, donations, grants, remittances, social security, pensions etc., excluding taxes. *(If the respondent mentions an exact amount, please note this down. Otherwise, ask them whether they earn somewhere between (higher category) and (lower category) and mark below. Please probe a bit when the amount seems very low or high)*

Income (per month)	**Tick one category**
No income	
0 – 100,000 AR	
100,000 – 300,000 AR	
300,000 – 600,000 AR	
600,000 – 1,000,000 AR	
1,000,000 – 2,000,000 AR	
2,000,000 AR +	
Refused to answer	

For this section I would like to ask about the wildlife groups that you trade in. We are interested in all wildlife trade including export, local trade, live and products.

6. WILDLIFE GROUPS TRADED

6.1	Which of the following groups of wildlife does this facility trade in?
6.2	Approximately how many did you trade last year (including export and local trade)?
6.3	What number of each wildlife group is exported, rather than sold locally?
6.4	What are the main purposes for trade in each wildlife group? (Export *(live, meat, products),* local trade *(live (zoo, park, pets), meat, products etc.*))
6.5	Please RANK each group in terms of income provided (1 = highest).
6.6	Please list the 5 most traded species or genus (e.g. *Furcifer, mantella* etc.) within each category

Do you trade in this wildlife group?	6.1 *(tick box)*	6.2 Numbers traded (2012)	6.3 What number of each wildlife group is exported, (rather than sold locally)? *(or what % is exported)*	6.4 Uses, e.g. export (live, meat, products), local trade (live, meat, products etc.)	6.5 RANK in terms of income (1 = highest)	6.6 Five most traded species/genus within each category
Reptiles (chameleons, geckoes, snakes, lizards						
Crocodiles						
Amphibians (frogs, toads)						
Invertebrates (spiders, scorpions, crickets,						
Birds						
Mammals (tenrecs etc.)						
Plants						
Fish						
Coral						

6.7	*What % of your profit comes from trade/export in reptiles & amphibians?*	

7. REPTILES & AMPHIBIANS TRADED - **From here on we are referring to collection and sale of REPTILES & AMPHIBIANS only**

7.1	Are you aware of any local uses for reptiles & amphibians in Madagascar? If so, please provide details (which species, what are they used for?)	Y / N / Don't know

I am going to show you some photos, could you tell me which species is on the photographs.

7.2	[PHOTO CARDS] For each photograph, please could you tell me the name of the species?		
1	7	13	19
2	8	14	20
3	9	15	21
4	10	16	22
5	11	17	23
6	12	18	24

I am now going to ask you some questions regarding these 24 species

7.4 Do you export this species?
7.5 Approximately how many did you trade last years (2012)?
7.6 Is supply or demand greater for this species? *Supply (S) > Demand (D), S = D, D > S*
7.7 **What price do you receive for one individual of this species?**
7.8 **What price do you pay for one individual of this species**?

	Species	7.4 Tick if trades /exports	*7.5 Number exported*	7.6 Is supply or demand greater for this species?	7.7 **Price received** per individual (US $)	7.8 **Price paid** per individual (US $/MGA)
01	*Furcifer pardalis*			S > D / S = D / D > S		
02	*Furcifer lateralis*			S > D / S = D / D > S		
03	*Furcifer oustaleti*			S > D / S = D / D > S		
04	*Furcifer verrucosus*			S > D / S = D / D > S		
05	*Furcifer campani*			S > D / S = D / D > S		
06	*Phelsuma laticauda*			S > D / S = D / D > S		
07	*Phelsuma lineata*			S > D / S = D / D > S		
08	*Phelsuma quadriocellata*			S > D / S = D / D > S		
09	*Phelsuma madagascariensis*			S > D / S = D / D > S		
10	*Mantella betsileo*			S > D / S = D / D > S		
11	*Mantella baroni*			S > D / S = D / D > S		

12	*Mantella nigricans*			S > D / S = D / D > S		
13	*Mantella aurantiaca*			S > D / S = D / D > S		
14	*Mantella pulchra*			S > D / S = D / D > S		
15	*Scaphiophryne gottlebei*			S > D / S = D / D > S		
16	*Uroplatus sikorae*			S > D / S = D / D > S		
17	*Uroplatus ebenaui*			S > D / S = D / D > S		
18	*Uroplatus fimbriatus*			S > D / S = D / D > S		
19	*Uroplatus phantasticus*			S > D / S = D / D > S		
20	*Brookesia superciliaris*			S > D / S = D / D > S		
21	*Brookesia stumpffi*			S > D / S = D / D > S		
22	*Brookesia thieli*			S > D / S = D / D > S		
23	*Brookesia therezieni*			S > D / S = D / D > S		
24	*paroedura masobe*			S > D / S = D / D > S		
In addition to the above species, which other reptiles and amphibians are important in trade? (Could you provide us with a price list for all other reptiles & amphibians in trade?)						
1				S > D / S = D / D > S		
2				S > D / S = D / D > S		
3				S > D / S = D / D > S		
4				S > D / S = D / D > S		
5				S > D / S = D / D > S		
6				S > D / S = D / D > S		
7				S > D / S = D / D > S		
8				S > D / S = D / D > S		
9				S > D / S = D / D > S		
10				S > D / S = D / D > S		

7.9	Are there any reptile & amphibians species which have become more difficult to obtain?	Y / N / Don't know
7.9.1	If YES, please provide details (which species, why have they become more difficult to obtain?)	

8. SUPPLY CHAIN [EXPORTER-IMPORTER]

8.1	Who are your main international customers (importers) for reptiles & amphibians e.g. private breeders, wholesale?

8.2	Do you have fixed price lists for international customers?	Y / N
8.2.1 8.2.2	*If NO, please explain how you establish the prices* *How has the price changed over the last five years?*	

8.3	Who establishes the price that international customers pay you for each species of reptile or amphibian?
	Individual exporter / several exporters / importer / several importers / other *(please specify)*

8.4	Do the international customers pay you in advance or on receipt of reptiles & amphibians?
	Payment in advance / payment on receipt / in part / other *(please specify)*

8.5	Are there any costs that you are required to pay for export (e.g. freight)? Or equipment?

8.6	Are there any factors which affect the price the international customer pays you, e.g. the season, the type of animal or its size, death in transit etc.	Y / N
8.6.1	If YES, please specify	

8.7	Which months of the year to you export reptiles & amphibians, or do you export all year round?	Y / N
8.7.1	Is there a high season or a low season?	

9. SUPPLY CHAIN [EXPORTER-COLLECTOR]

9.1	Who supplies you with reptiles & amphibians? E.g. collectors, own staff, collect yourself?

9.2	Do other people who are not collectors (e.g. local people) bring reptiles & amphibians to you?	Y / N
9.2.1	*If YES, please provide details (e.g. who are they, how many, how often, do you buy animals from them?)*	

9.3	Do you have any agreements (formal or informal) with the people that supply reptiles & amphibians to you? How does the relationship operate?	Y / N
9.3.1	If YES, please specify	

9.4	Do you request reptiles & amphibians after receiving specific orders from customers or do you obtain some in anticipation of orders?

9.4.1	After receiving specific order / obtain animals in advance / both / other *(please specify)*

9.5	How do you work out the price you pay to the collectors, e.g. do you pay a set price for each animal, do you pay for their time or do you pay them a fixed wage?
	fixed price per animal / wage according to their time / other *(please specify)*

9.6	Who establishes the price that you pay to collectors for reptiles & amphibians?
	You (exporter) / many exporters / the collector / other *(please specify)*

9.7	Do you pay the collector in advance or on receipt of reptiles & amphibians?
	Payment in advance / payment on receipt / in part / other *(please specify)*

9.8	Are there any costs that you pay the collector (e.g. transport, accommodation, taxes) or provide equipment?

9.9	Are there any factors which affect the price you pay the collector? E.g. how long it takes them to find the animal, the season, the type of animal or its size?	Y / N
9.9.1	If YES, please specify	

9.10	**How many different collectors supply you with**	**all wildlife:**	**reptiles & amphibians only:**
9.11	**Can you give me the FULL NAMES and locations of the collectors that you use to supply reptiles & amphibians? CAN YOU PROVIDE THEIR CONTACT DETAILS?** This information will be used to identify how many collectors are in operation in Madagascar and to locate collectors for interview should they be willing. Information on collectors will not be shared with anyone nor will names appear in any reports.		
9.12	How many collectors do you think are there	in Madagascar:	In the Moramanga district:

9.13	How many villages or sites do you think are used for reptile & amphibian collection	in Madagascar:	In the Moramanga district:
	Can you provide details (names/districts) of the villages or sites used for reptile & amphibian collection, starting with those in the Moramanga district		

10. COLLECTION PRACTICES

10.1	**What formal procedures are required in order to carry out collection and export or reptiles & amphibians?**
10.2	Are collectors able to identify the species/subspecies that you request? Always / often / sometimes / rarely / never
10.2.1	*How do you deal with any instances where they cannot identify the species or subspecies?*
10.2.2	*What percentage (%) do they collect that is wrongly identified?*
10.3	Do you specify the exact **quantity** of reptiles & amphibians to be collected? Always / often / sometimes / rarely / never
10.3.1	Do you request the same quantity that has been ordered by the international customer, or do you request extra, or anticipate the quantity you can sell?
10.4	Do you specify which **sex** to collect? Always / often / sometimes / rarely never
10.4.1	Are there any preferences for certain sexes of reptiles & amphibians in trade?
10.5	Do you specify the **size or age** to be collected? Always / often / sometimes / rarely / never
10.5.1	Are there any preferences for certain sexes of reptiles & amphibians in trade?
10.6	Do you specify the **colour or pattern** to be collected? Always / often / sometimes / rarely / never
10.6.1	Are there any preferences for certain colours or patterns of reptiles & amphibians in trade?
10.7	Do you give instructions to collectors regarding **methods** used to trap reptiles & amphibians? Y / N
10.7.1	If YES, please provide details
10.9	Do you specify which **location** reptiles & amphibians are collected from? Always / often / sometimes / rarely / never
10.9	Do you specify the **time period** that reptiles & amphibians are held for before being brought to you? Always / often / sometimes / rarely / never
10.9.1	*If so, what is the usual time period?*
10.10	Do you specify how reptiles & amphibians should be **transported?** Y / N
10.10.1	*If so, please provide details:*

10.11	Do you specify how reptiles & amphibians are **maintained** after capture and before they are brought to you (should they be fed etc.)?	Y / N
10.11.1	*If so, please provide details:*	

10.12	Are there any other specific instructions you give to collectors	Y / N
10.12.1	If YES, please provide details	

10.13	On average how many days do you keep reptiles & amphibians for before sale/export?	Reptiles: Amphibians:
10.13.1	Please explain why Do you ever keep reptiles & amphibians in your facility?	

10.14	*Is there a quarantine period in Madagascar?*	*Y / N*
10.14.1	*If so, how long is it*	
10.14.2	*Who is it set by?*	

10.15	How do you care for reptiles & amphibians before sale/exchange?	
10.16	What % of reptiles die before SALE/EXPORT?	
10.17	What % of amphibians die before SALE/EXPORT?	
10.19	What % of reptiles die during international transport?	
10.19	What % of amphibians die during international transport?	

11. LEGISLATION/AWARENESS

11.1	What rules/legislation are you aware of concerning the trade and export of reptiles & amphibians in Madagascar?

11.2	How have these rules/legislation affected your business?

11.3	Are there any penalties in Madagascar for breaking the rules or not abiding by the wildlife trade legislation?	Y / N
11.3.1	If YES, please specify what the penalties are:	
11.3.2	How many operators do you know who have received a penalty?	

12.CAPTIVE BREEDING

12.1	Have you ever bred/or tried to breed any reptiles or amphibians in captivity?	Y / N *(If YES → 12.2, If NO → 12.3)*

12.2 Which species have you bred/tried to breed?	12.2.1 To what generation have you bred them?	12.2.2 How many of each species have you produced? (e.g. per year)

12.2.3	What did you do with the captive-bred species?
12.2.4	How did you breed the above species? (planned or incidental, closed cycle or ranched?)
12.2.5	*How did you care for them (how did you feed them etc.)? Did you have any problems keeping them alive?*
12.2.6	Why did you decide to breed these species in captivity?
12.2.7	Please could you tell me about any species you tried to breed but failed? (which species, why did it fail)
12.3	**Are there any difficulties or barriers to captive breeding of reptiles & amphibians in Madagascar? (e.g. climate/food/legislation/economics)**

12.4	Are you aware of any restrictions in Madagascar on captive breeding of reptiles & amphibians?	Y / N
12.4.1	If YES, please specify	
12.5	Are you aware of any restrictions in Madagascar on exporting captive-bred reptiles & amphibians?	Y / N
12.5.1	If YES, please specify	

12.6	Do you think you could breed reptiles & amphibians on a commercial scale?	Y / N / Don't know
12.6.2	Would you need to charge more for captive-bred reptiles than you currently do in order to make captive breeding worthwhile?	Y / N / Don't know
12.6.3	IF YES, do you think international customers would pay the higher price for captive-bred species? Do you think there would be demand?	Y / N / Don't know

12.6.4	Do you think it would be cost effective and worthwhile to breed reptiles & amphibians for export?	Y / N / Don't know
1268.5	Would you like to breed reptiles & amphibians in captivity*?*	Y / N / Don't know

12.9	**Do you think that reptiles & amphibians should be protected in the wild in Madagascar?**	Y / N / Don't know
12.9.1	If YES, for what reason do you think they should be protected?	

13.QUOTAS

13.1	What are your views on the current quotas for reptile & amphibian species?
13.2	Are the quotas strictly enforced? How do they monitor this?
13.3	When are you given your export quotas for reptiles & amphibians for the year?
13.4	What species would you like to see quotas for, or larger quotas?

Thank you for your time. Is there any further information you wish to add?

APPENDIX D - COLLECTOR/MIDDLEMAN SURVEY

Interview location:	*Interviewer (name):*
Date of interview:	*Translator (name):*

We would like to ask you a few questions about your work collecting live wild animals to sell/trade. We are particularly interested in how important this job is to you, how the supply chain works and the types of animals you collect.

Your answers are anonymous; we will not record your name, and your participation in this study is voluntary. Your effort in answering the questions would be highly appreciated. Thank you very much.

PLEASE COULD YOU CONFIRM THAT YOU ARE HAPPY TO TAKE PART IN THIS STUDY? ☐

1. INTERVIEWEE PROFILE

1.1	Gender	Male / Female
1.2	Where were you born?	
1.3	Which region are you from?	
1.4	What year were you born?	
1.5	What is the highest level of education you have completed?	None / some primary / completed primary / some secondary / completed secondary / some university / completed university / beyond university

2. WILDLIFE TRADE AS A LIVELIHOOD ACTIVITY

2.1	How long have you been working as a collector (months/years)?	
2.1.1	Please could you describe your job role?	
2.2	Why did you become involved in wildlife trade?	
2.3	**Where are you based?**	
2.4	Do you work alone or do you have people working for you?	Y / N *(If No → 2.5)*

2.4.1	Please could you tell me the job titles of the other people working for you
2.4.2	How many people are currently employed in each role
2.4.3	What are their working hours **(please indicate the usual working hours for full time 'FT' and part time 'PT')**
2.4.4	Please provide a brief description of the jobs they do

2.4.1 Job title	2.4.2 Number of people employed in this role	3.4.3 Working hours (Full time 'FT', Part time 'PT')	2.4.4 Description of job role

2.5	Do any other members of your family work in wildlife trade or export?	Y / N
2.5.1	If YES, please provide details	

Referring to collection of live wild animals for sale/trade:

2.6	How important would you say this activity is in terms of providing income for yourself?			
Very important	Quite important	Neither important nor unimportant	Not very important	Not at all important

2.7	Does this income contribute towards your household or family?	Y / N

2.8	How important would you say this activity is for providing income for your household?			
Very important	Quite important	Neither important nor unimportant	Not very important	Not at all important

2.9	Are there other livelihood activities that you could do if you no longer worked in wildlife trade?	Y / N / Don't know
2.9.1	If YES, what would you do for income if you stopped working in wildlife trade?	

2.10	If you collected more animals than you currently collect, **how likely is it that you would find a buyer for them all?**			
Very likely	Likely	Not sure	Unlikely	Very unlikely

2.11	If you were paid MORE for each animal, how would it influence the number of animals you collect?			
	I would collect fewer animals	I would collect same amount	I would collect more animals	Other *(please specify)*

3. LIVELIHOOD ACTIVITY DETAILS

3.1	**Usual hours spent doing activity?**	**Hours per day:**	**Days per week:**	**Days per month:**
3.2	Which months of the year do you do this activity? *If all year round, go to 3.9*			
3.2.1	If there are any months in the year when you do not do this activity, please explain why:			
3.2.2	During the months that you do not do this activity, what do you do instead?			
3.3	**How much money do you earn from doing this activity in a typical:**	**Month:**	**Year:**	
3.4	Did YOU incur any costs in order to START doing this activity, e.g. purchase of materials,training?			Y / N
3.4.1	If YES, please specify what the costs were incurred for and how much they cost?			
3.5	Do YOU incur any OTHER on-going costs in order to do this activity e.g., purchase of equipment?			Y / N
3.5.1	If YES, please specify what the costs are incurred for, how much they cost, and how frequently the costs are incurred. PLEASE TELL US ABOUT ALL COSTS.			
3.6	Are there any factors that limit your ability to do this activity, e.g. season, licenses, land, ability to sell…?)			

3.7	**Do you do any other jobs/livelihood activities?**	Y / N ***(If YES → 4, If NO → 5)***

Fill in a table for each additional occupation/livelihood activity - extra pages available

4. OTHER LIVELIHOOD ACTIVITIES

4	HH MEMBER (Initials):	Livelihood activity/occupation:
4.1	Which months of the year do you do this activity? *If all year round, go to 4.3*	
4.1.1	If there are any months in the year when you do NOT do this activity, please explain why:	
4.1.2	During the months that you do NOT do this activity, what do you do instead?	
4.2	Usual hours spent doing activity?	Hours per day: Days per week: Days per month:
4.3	IF LIVELIHOOD ACTIVITY IS AGRICULTURE/PRODUCTION OF GOODS/FORAGING/LIVESTOCK**:** How much do you produce in a typical month/year? *Please give physical quantities e.g. two bags, 5 chickens etc.* Month: Year: What is the market value equivalent of the above produce? Month: Year:	
4.3.1	How much of the produce from this activity is kept for HH use/consumption? *(try to get a rough idea, e.g. 'all of produce is kept for HH', or 'half of produce is sold each month')*	
4.4	**How much do you earn from doing this activity in a typical:**	**Month: Year:**
4.5	Did YOU incur any costs in order to START doing this activity (e.g., purchase of tools)?	Y / N
4.5.1	If YES, please specify what the costs were incurred for and how much they cost?	
4.6	Do YOU incur any OTHER on-going costs in order to do this activity (e.g., purchase of seed)?	Y / N
4.6.1	If YES, please specify what the costs are incurred for, how much they cost, and how frequently the costs are incurred. PLEASE TELL US ABOUT ALL COSTS.	
4.7	Are there any factors that limit your ability to do this activity, e.g. season, licenses, land, ability to sell…?)	

5. INCOME

5.1	What is your average income per month? Please include income received from wages, bonuses, selling products, rents, donations, grants, remittances, social security, pensions etc., excluding taxes. *(If the respondent mentions an exact amount, please note this down. Otherwise, ask the household whether they earn somewhere between (higher category) and (lower category) and mark below. Please probe a bit when the amount seems very low or high)*

Income	**Tick one category**
No income	
0 – 100,000 AR	
100,000 – 300,000 AR	
300,000 – 600,000 AR	
600,000 – 1,000,000 AR	
1,000,000 – 2,000,000 AR	
2,000,000 AR +	
Refused to answer	

6. WILDLIFE GROUPS TRADED

6.1	Which of the following groups of wildlife do you collect?
6.2	Approximately how many did you collect during the last year (2012)?
6.3	What number of each wildlife group is sold to exporters, rather than sold locally?
6.4	What are the main purposes for trade in each wildlife group? (Export *(live, meat, products),* local trade (*live, meat, products etc.*))
6.5	Please RANK each group in terms of income provided (1 = highest).
6.6	Please list the 5 most traded species within each wildlife group

Do you trade in this wildlife group?	6.1 *(tick box)*	*6.2 Numbers collected*	6.3 What number of each wildlife group is sold to exporters, rather than sold locally?	6.4 Uses, e.g. export (live, meat, products), local trade (live, meat, products etc.)	6.5 RANK in terms of income (1 = highest)	6.6 Five most traded species in this wildlife group
Reptiles (chameleons, geckoes, snakes, lizards etc.) **Excl crocodiles**						
Crocodiles						
Amphibians (frogs, toads)						
Invertebrates (spiders, scorpions, crickets, millipedes etc.)						
Birds						
Mammals (tenrecs etc.)						
Plants						
Fish						
Coral						

6.7	*What % of your profit comes from trade/export in reptiles & amphibians?*	

From here on we are referring to collection and sale of REPTILES & AMPHIBIANS only

7. REPTILES & AMPHIBIANS TRADED

7.1	Are you aware of any local uses for reptiles & amphibians in Madagascar? If so, please provide details (which species, what are they used for?)	Y / N / Don't know

7.2	Please could you list up to 10 reptile and amphibian species that are important in trade and that you collect?
7.3	Approximately how many did you collect during last year (2012)
7.4	**What price do you pay for one individual of this species?**
7.5	**What price do you receive for one individual of this species**?

	7.2 Species	*7.3 Numbers collected (2012)*	*7.4 **Price paid** per individual (MGA)*	*7.5 **Price received** per individual (MGA)*	*7.6. Location/collection site*
01					
02					
03					
04					
05					
06					
07					
08					
09					
10					

I am going to show you some photos, could you tell me which species is on the photographs.

7.6	[PHOTO CARDS] For each photograph, please could you tell me the name of the species?		
	7	13	19
2	8	14	20
3	9	15	21
4	10	16	22
5	11	17	23
6	12	18	24

I am now going to ask you some questions regarding these 24 species

7.7	Do you collect this species?
7.8	Approximately how many did you collect last year (2012)?
7.9	Is supply or demand greater for this species? *Supply (S) > Demand (D), S = D, D > S*
7.10	**What price do you pay for one individual of this species?**
7.11	**What price do you receive for one individual of this species?**

	Species	7.7 collects?	*7.8 No. collected*	7.9 Supply / demand	7.10 **Price paid** / ind	7.11 **Price received** / ind	7.12 Location/ site
01	*Furcifer pardalis*			S > D / S = D / D > S			
02	*Furcifer lateralis*			S > D / S = D / D > S			
03	*Furcifer oustaleti*			S > D / S = D / D > S			
04	*Furcifer verrucosus*			S > D / S = D / D > S			
05	*Furcifer campani*			S > D / S = D / D > S			
06	*Phelsuma laticauda*			S > D / S = D / D > S			
07	*Phelsuma lineata*			S > D / S = D / D > S			
08	*Phelsuma quadriocellata*			S > D / S = D / D > S			
09	*Phelsuma madagascariensis*			S > D / S = D / D > S			
10	*Mantella betsileo*			S > D / S = D / D > S			
11	*Mantella baroni*			S > D / S = D / D > S			
12	*Mantella nigricans*			S > D / S = D / D > S			
13	*Mantella aurantiaca*			S > D / S = D / D > S			
14	*Mantella pulchra*			S > D / S = D / D > S			
15	*Scaphiophryne gottlebei*			S > D / S = D / D > S			
16	*Uroplatus sikorae*			S > D / S = D / D > S			
17	*Uroplatus ebenaui*			S > D / S = D / D > S			
18	*Uroplatus fimbriatus*			S > D / S = D / D > S			
19	*Uroplatus phantasticus*			S > D / S = D / D > S			
20	*Brookesia superciliaris*			S > D / S = D / D > S			
21	*Brookesia stumpffi*			S > D / S = D / D > S			
22	*Brookesia thieli*			S > D / S = D / D > S			
23	*Brookesia therezieni*			S > D / S = D / D > S			
24	*Paroedura masobe*			S > D / S = D / D > S			

7.12	Are there any reptile & amphibians species which have become more difficult to obtain?	Y / N / Don't know
7.12.1	If YES, please provide details (which species, why have they become more difficult to obtain?)	

8. SUPPLY CHAIN [COLLECTOR – EXPORTER]

8.1	Who do you supply? (Exporters only, other businesses e.g. zoos, other collectors or local traders?)

8.2	**Please could you provide the names and locations of the people that you supply?***

8.3	Do you have any agreements (formal or informal) with the people that you supply reptiles & amphibians to?* *How does the relationship operate?*	Y / N
8.3.1	If YES, please specify	

8.4	Do you collect reptiles & amphibians after receiving specific orders from buyers/exporters or do you obtain some in anticipation of orders? *If so,* d*o you hold them somewhere?*
	After receiving specific order / obtain animals in advance / both / other *(please specify)*

8.5	How are you paid by buyers/exporters, e.g. do they pay you a set price for each animal, do they you pay for your time or do they pay you them a fixed wage?*
	fixed price per animal / wage according to their time / other *(please specify)*

8.6	Who establishes the price that buyers/exporters pay you for each species of reptile & amphibian?*
	Individual collector / several collectors / exporter / several exporters / other *(please specify)*

8.7	Do buyers/exporters pay you in advance or on receipt of reptiles & amphibians?*
	Payment in advance / payment on receipt / in part / other *(please specify)*

8.8	Do buyers/exporters cover any additional costs (e.g. transit, taxes) or provide equipment?*

8.9	Are there any factors which affect the price the buyers/exporters pay you, e.g. the season, the type of animal or its size, death in transit etc.	Y / N
	If YES, please specify	

8.10	What is the usual time period that exporters give you to bring them the animals?
8.11	Are you able to meet this time period?

9. SUPPLY CHAIN [COLLECTOR – VILLAGER/LOCAL COLLECTOR]

9.1	How do you acquire reptiles & amphibians? (collect yourself, use other collectors, go direct to villages?)

9.2	*Do you have any agreements (formal or informal) with the people that supply reptiles & amphibians to you? How does the relationship operate?*	*Y / N*
9.2.1	*If YES, please specify*	

9.3	**Are there any formal procedures (licenses/taxes) required to collect and trade live reptiles & amphibians?**	**Y / N / Don't know**
9.3.1	**If YES, please explain**	
9.3.2	**Do you ever have any problems with these procedures?**	

9.4	How do you work out the price to pay to the people who supply you, e.g. do you pay a set price for each animal, do you pay for their time or do you pay them a fixed wage?
	fixed price per animal / wage according to their time / other *(please specify)*

9.5	Who establishes the price that you pay to the people who supply you with reptiles & amphibians?
	You (collector) / the exporters / the villager (other collector) / other *(please specify)*

9.6	Do you pay the people who supply you in advance or on receipt of reptiles & amphibians?
	Payment in advance / payment on receipt / in part / other *(please specify)*

9.7	Do you have to cover any costs (e.g. transport, accommodation, taxes) or provide equipment? (*Please specify)*

9.8	Are there any factors which affect the price you pay the people who supply you? E.g. how long it takes them to find the animal, the season, the type of animal or its size?	Y / N
9.8.1	If YES, please specify	

9.9	Do you collect reptiles & amphibians from the collection sites specified on the permit?	Always / often / sometimes / rarely / never
9.9.1	Do you ever have any problems finding reptiles & amphibians in the specified collection sites? *If so, what do you do?*	

9.10	**How many villages do you use to collect reptiles & amphibians?**	**in Madagascar:** **In the Moramanga** district:
9.10.1	**Can you give me the names and locations of the villages that you use to supply reptiles amphibians?** This information will be used to identify how many villages are used for collection in Madagascar and to locate villagers for interview should they be willing. PLEASE START WITH VILLAGES IN MORAMANGA DISTRICT	
9.11	**How many people in each village are involved in collecting reptiles & amphibians?**	

9.12	How many collectors are there	in Madagascar:	In the Moramanga district:
9.12.1	**Do you work with any other collectors to help you supply animals? If so, can you give me the names and locations of the collectors you work with?** *This information will be used to identify how many collectors are in operation in Madagascar and to understand the trade chain. Identifying information on collectors will not be published.*		

10. COLLECTION PRACTICES

10	What instructions do you give to trappers/local collectors regarding the following:	
10.1	Do you request specific **species or subspecies** to be collected? Always / often / sometimes / rarely / never	
10.2	Are trappers able to identify the species/subspecies that you request? Always / often / sometimes / rarely / never	
10.2.1	How do you deal with any instances where they cannot identify the species or subspecies?	
10.2.2	What percentage (%) do they collect that is wrongly identified?	
10.3	Do you specify the exact **quantity** of reptiles & amphibians to be collected? Always / often / sometimes / rarely / never	
10.3.1	Do you request the same quantity that has been ordered by the buyer/exporter, or do you request extra, or anticipate the quantity you can sell?	
10.4	Do you specify which **sex** to collect? Always / often / sometimes / rarely / never	
10.4.1	Are there any preferences for certain sexes of reptiles & amphibians in trade?	
10.5	Do you specify the **size or age** to be collected? Always / often / sometimes / rarely / never	
10.5.1	Are there any preferences for certain sizes of reptiles & amphibians in trade?	
10.6	Do you specify the **colour or pattern** to be collected? Always / often / sometimes / rarely / never	
10.6.1	Are there any preferences for certain colours or patterns of reptiles & amphibians in trade?	
10.7	Do you give instructions to trappers regarding **methods** used to trap reptiles & amphibians? Y / N	
10.7.1	If YES, please provide details	
10.8	Do you specify the **time period** in which reptiles & amphibians should be collected? Always / often / sometimes / rarely / never	
10.8.1	If so, what is the usual time period?	
10.9	Are there any other specific instructions you give to trappers/local collectors	Y / N
10.9.1	If YES, please provide details	

10.10	How do you care for reptiles & amphibians before sale/exchange?	
10.11	How do you transport reptiles & amphibians to the exporters?	
10.12	What % of reptiles that you obtain die before SALE/EXCHANGE?	
10.13	What % of amphibians that you obtain die before SALE/EXCHANGE?	

11. LEGISLATION/AWARENESS

11.1	What rules/legislation are you aware of concerning the trade and export of reptiles & amphibians in Madagascar? *Are you aware of CITES? Are you aware of export quotas?*

11.2	How have these rules/legislation affected your business?

11.3	Are there any penalties for breaking the rules or not abiding by the legislation?	Y / N / Don't know
11.3.1	If YES, please specify what the penalties are:	
11.3.2	How many collectors do you know who have received a penalty?	

11.4	**Do you think that reptiles & amphibians should be protected in the wild in Madagascar?**	Y / N / Don't know
11.4.1	If YES, for what reason do you think they should be protected?	

Thank you for your time. Is there any further information you wish to add?

This questionnaire is not self-complete and should be administered by a trained research assistant

Date:		**Interviewer:**	
Location:			

APPENDIX E

REPTILE QUESTIONNAIRE

DO YOU GIVE YOUR CONSENT TO PARTICIPATE IN THIS STUDY? *TICK BOX*	☐

1	**Have you acquired a reptile in the last five years? *please circle***	**Y / N**

If yes, continue with questionnaire

2	**What type of reptile keeper do you consider yourself to be?**	***Tick one option***
a	Private reptile keeper (those keeping reptiles for pleasure)	
b	Private reptile breeder (those keeping and breeding reptiles mainly for pleasure)	
c	Private reptile breeder (those keeping reptiles mainly for monetary gain)	
d	Commercial enterprise (those buying/selling/breeding as part of a business)	

If Q2 d was selected, ask question 3. Otherwise, continue to Q4

3	**Do you sell dry goods as well as animals? *please circle***	**Y / N**

4	**What do you understand the following terms to mean? *Please state***	
	Captive Bred	
	Long Term Captive	
	Captive Farmed	
	Ranched	
	Wild Caught	

The following questions relate to your experience keeping different reptile groups. Anything you know as 'Long Term Captive (LTC)' is included with the 'Wild' category for this questionnaire. I am going to ask you questions for each reptile group and then split it down, so it may seem like I am asking the same question twice in some cases.

	Have you acquired any _____in the last five years? This includes reptiles brought **into** collection, not births		5. **[RRT]** OF THE _____ THAT YOU ACQUIRED OVER THE LAST FIVE YEARS, HOW MANY DIED **WITHIN THE FIRST 12 MONTHS?**	6. What is the average amount of time you hold this group before rehoming/sale/ exchange, or do you not move them on?	7. How many years' experience do you have in keeping this reptile group?	**Based on your experience and not preconceived ideas about the group**		10. How many _____have you acquired in the last **5** years, excluding births? If you are unsure, please estimate.	**22. [Direct Q] To be asked at end.** Of the _____ that you acquired over the last 5 years, how many died within the first 12 months?
						8. How easy or difficult is this group to keep? *[scale card]*	9. How do you rate the survival of this group in captivity? *[scale card]*		
	SNAKES	all							
	Snakes	C		GO TO Q8					
		W							
		CF							
		U							
	Boas & pythons	all							
	Boas & pythons	C							
		W							
		CF							
		U							
	King & rat snakes	all							
	King snakes (Lampropeltis) & rat snakes (Elaphe)	C							
		W							
		CF							
		U							
	Other snakes	all							
	Other snakes	C							
		W							
		CF							
		U							

	Have you acquired any _____in the last five years? This includes reptiles brought **into** collection, not births		5. **[RRT]** OF THE _____ THAT YOU ACQUIRED OVER THE LAST FIVE YEARS, HOW MANY DIED **WITHIN THE FIRST 12 MONTHS?**	6. What is the average amount of time you hold this group before rehoming/sale/ exchange, or do you not move them on?	7. How many years' experience do you have in keeping this reptile group?	**Based on your experience and not preconceived ideas about the group**		10. How many _____have you acquired in the last **5** years, excluding births? If you are unsure, please estimate.	**22. [Direct Q] To be asked at end.** Of the _____ that you acquired over the last 5 years, how many died within the first 12 months?
						8. How easy or difficult is this group to keep? *[scale card]*	9. How do you rate the survival of this group in captivity? *[scale card]*		
	CHELONIANS (tortoises etc.)	all							
	Chelonians (tortoises, turtles & terrapins)	C							
		W							
		CF							
		U							
	Tortoises & box turtles	all							
	Tortoises (Testudo) & box turtles (terrapene)	C							
		W							
		CF							
		U							
	Terrapins & turtles	all							
	Terrapins & turtles	C							
		W							
		CF							
		U							

	Have you acquired any _____in the last five years? This includes reptiles brought **into** collection, not births		5. **[RRT]** OF THE _____ THAT YOU ACQUIRED OVER THE LAST FIVE YEARS, HOW MANY DIED **WITHIN THE FIRST 12 MONTHS?**	6. What is the average amount of time you hold this group before rehoming/sale/ exchange, or do you not move them on?	7. How many years' experience do you have in keeping this reptile group?	**Based on your experience and not preconceived ideas about the group.**		10. How many _____ have you acquired in the last **5** years, excluding births? If you are unsure, please estimate.	**22. [Direct Q] To be asked at end.** Of the animals that you acquired over the last 5 years, how many died within the first 12 months?
						8. How easy or difficult is this group to keep? *[scale card]*	9. How do you rate the survival of this group in captivity? *[scale card]*		
	LIZARDS	all							
	Lizards	C							
		W							
		CF							
		U							
	Chameleons	all							
	Chameleons	C							
		W							
		CF							
		U							
	Geckoes	all							
	Geckoes	C							
		W							
		CF							
		U							
	Skinks	all							
	Skinks	C							
		W							
		CF							
		U							
	Iguanas	all							

	Have you acquired any _____in the last five years? This includes reptiles brought **into** collection, not births		5. **[RRT]** OF THE _____ THAT YOU ACQUIRED OVER THE LAST FIVE YEARS, HOW MANY DIED **WITHIN THE FIRST 12 MONTHS?**	6. What is the average amount of time you hold this group before rehoming/sale/ exchange, or do you not move them on?	7. How many years' experience do you have in keeping this reptile group?	**Based on your experience and not preconceived ideas about the group.**		10. How many _____ have you acquired in the last **5** years, excluding births? If you are unsure, please estimate.	**22. [Direct Q] To be asked at end.** Of the animals that you acquired over the last 5 years, how many died within the first 12 months?
						8. How easy or difficult is this group to keep? *[scale card]*	9. How do you rate the survival of this group in captivity? *[scale card]*		
	Iguanas	C							
		W							
		CF							
		U							
	Tegus & monitors	all							
	Tegus & monitors (varanus)	C							
		W							
		CF							
		U							
	Agamids (dragons etc.)	all							
	Agamids (incl. water dragons & bearded dragons)	C							
		W							
		CF							
		U							
	Other lizards	all							
	Other lizards	C							
		W							
		CF							
		U							

General questions

11	**How many years have you been keeping reptiles?** ***please circle***				
	0-1 years	2-5 years	6-10 years	11-20 years	21+ years

12	**Are you a member of any of the following groups or societies?**	***Tick all that apply***
	British Herpetological Society (BHS)	
	International Herpetological Society (IHS)	
	Local or regional society i.e. Thames & Chiltern Herpetological Group etc.	
	Taxa specific society e.g. British Chelonia Group	
	Other herpetological or conservation society (including ARG UK)	
	I am not a member of any herpetological or conservation groups or societies	

13	**Do you have any specific training or qualifications relating to reptile biology or care (informal or formal) e.g. college course, worked in zoo or lab?** ***please***	**Y / N**
	Please specify	

14	**Gender** ***please circle***	**M / F**

15	**Country of residence** ***please state***	

16	**First part of post code** ***please state***	

17	**What is your year of birth?** ***please state***	

18	**What is your marital status?** ***Please circle***		
	Single, never married	Married or domestic partnership	Widowed, divorced or separated

19	**What is the highest level of education you have <u>completed</u>?**	***Tick one option***
	GCSE/O-Level/CSE	
	Vocational qualifications (NVQ1+2)	
	A-Level or equivalent (NVQ3)	
	Bachelor or degree or equivalent (NVQ4)	
	Masters/PhD or equivalent	
	Other *(please specify)*	
	No formal qualifications	

20	**Employment/activity**	***Tick one option***
	Working full time (more than 30 hours a week)	
	Working part-time (0-30 hours a week)	
	Self-employed	
	Student *(skip Q21)*	
	Retired *(skip Q21)*	
	Temporarily unemployed and seeking work *(skip Q21)*	
	Permanently unemployed (e.g. chronically sick, independent means) *(skip Q21)*	
	Not in paid work for other reason (e.g. house wife, carer) *(skip Q21)*	

21	**What personal annual income band do you fall into (before tax)? *please circle***				
	Under £20,000	£20,001 - 30,000	£30,001 - 50,000	£50,001 - 70,000	Over £70,000

Q 22 – DIRECT QUESTION

Evaluation questions

23	**How easy or difficult did you find the card method to use? *(please circle)***				
	Very easy	Easy	Neither easy nor difficult	Difficult	Very difficult

24	**When using the card method, how protected or unprotected did do you feel your answers were? (*please circle)***				
	Very protected	Somewhat protected	Neither protected nor unprotected	Not very protected	Not at all protected

25	**How sensitive do you consider the questions about the quantity of your reptiles that have died in the first year of you owning them? (*please circle)***				
	Very sensitive	Somewhat sensitive	Neither sensitive nor insensitive	Not very sensitive	Not at all sensitive

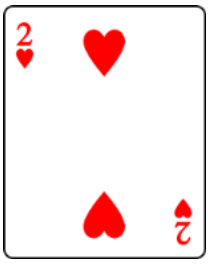
26	**When asked directly, how likely do you think people would be to tell the truth when asked about the quantity of reptiles that have died in the first year? (*please circle)***				
	Very likely	Likely	Neither likely nor unlikely	Unlikely	Very likely

Thank you for taking the time to complete this questionnaire.

APPENDIX F – aRRT INSTRUCTION CARDS

There is no way I can trace your answers back to you. You remain completely anonymous.

Example **INSTRUCTIONS**

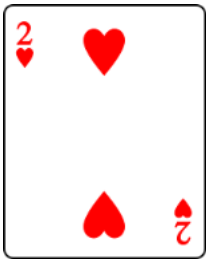


Please pick a card from the pack – do not let me see what card you have
Remember the rules:
Queen = answer the question truthfully
Number card = add the number on the card you have picked to your true response and report the total (Ace = 1)

QUESTION: **Of the _ _ _ _ _ _ _ _ _ _ _ that you acquired over the last five years, how many died within the first 12 months?**

There is no way I can trace your answers back to you. You remain completely anonymous.

Example **INSTRUCTIONS**



Please pick a card from the pack – do not let me see what card you have
Remember the rules:
Queen = answer the question truthfully
Number card = add the number on the card you have picked to your true response and report the total (Ace = 1)

QUESTION: **Of the _ _ _ _ _ _ _ _ _ _ _ that you acquired over the last five years, how many died within the first 12 months?**