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Nomenclature in the online reptile trade

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Abstract The internet has expanded opportunities for wildlife traders to conduct business globally, but monitoring this activity is often challenging. As monitoring techniques frequently employ language-based searches for particular words, it is important to understand the language traders use, particularly the nomenclature used to refer to traded species. We recorded advert data from four UK websites, focusing on reptiles, which constitute a large proportion of the international pet trade. We analysed whether the language types used by advertisers to refer to individual reptiles were associated with certain trader characteristics. We found English common names were the most frequent name type used to refer to species, regardless of the geographical location of the seller and the CITES Appendix listing of the species. However, scientific names were recorded in twice as many adverts for threatened and Near Threatened species as in adverts for non-threatened species, and only scientific names were used for three families: Anguidae, Pseudaspididae and Sphaerodactylidae. These findings could inform the creation of tailored keyword detection tools, which must account for the numerous language types in use within online wildlife trade communities. Future studies should examine the nuances of language used by other online wildlife trader communities in other contexts, such as different online platforms or different languages. The ultimate aim of these language detection tools will be to track in detail trends in the online reptile trade, offering a better understanding of potentially unsustainable trade patterns and helping authorities to enforce laws against illegal online reptile trade.

Keywords Common name, detection, language, nomenclature, online, reptile, scientific name, wildlife trade

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Introduction

The rise of e-commerce and social media has transformed how international wildlife trade networks operate. The global reach of the internet, where platforms are

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open constantly, has amplified the ability of wildlife traders to do business. The surface web, the part of the internet that consists of publicly viewable websites, is a space where traders advertise reptile species despite commitments by social media firms to eliminate wildlife trade on their platforms (Harrison et al., 2016). Online adverts for wildlife on the surface web are often the only online trace of a wildlife trade transaction, as further contact between buyer and seller often occurs in private messages, texts or emails. However, these online adverts can be used to monitor patterns of wildlife trade (Stringham et al., 2020). Because online adverts typically convey their messages using text (perhaps accompanied by uploaded photographs), these adverts can be detected using text-based search techniques. These techniques often involve manual keyword searches (Olmos-Lau & Mandujano, 2016) or automated text detection and classification systems that use natural language processing (Sonricker-Hansen et al., 2012; Lavorgna et al., 2020). Although manual keyword searches are time-consuming, automated search methods also require manual data cleaning (Stringham et al., 2020). An understanding of which keywords to search for is vital to these search methods. However, natural language is evolving continually (Crystal, 2006) and it is still unknown whether or how much the language that wildlife traders use changes in response to online regulations and improvements in language detection methods. Examples of this kind of language change are the use of code words for ivory (Alfino & Roberts, 2020), the recent increased use of pictographic emoji icons in social media posts for wildlife, and Facebook (Meta, Menlo Park, USA) posts containing circumlocutory phrases that, following the wildlife trade ban on this platform, imply that a pet is for sale but do not say so overtly (D. Clemens, pers. comm., 2021). Traders advertising illegal wildlife products such as ivory have been observed using code words in response to keyword detection techniques implemented to prevent ivory sales on e-commerce websites (Alfino & Roberts, 2020). Understanding the nomenclature with which wildlife traders refer to species in trade and building a lexicon of the words used in online wildlife trade adverts could help researchers and authorities monitor online wildlife trade using keyword searches or other language-based detection methods.

The global market for exotic pets is an important part of the international wildlife trade (UNODC, 2016). CITES enables the monitoring and regulation of a fraction of wild species exported for the pet market. However, the majority of species in the exotic pet trade are not included in the CITES Appendices. This situation can lead to opportunities

for the overexploitation of popular species in the international pet trade, which poses a considerable threat to global populations of numerous reptile species, as has been observed with decline of the earless monitor *Lanthanotus borneensis* and arboreal alligator lizards *Abronia* spp. (Böhm et al., 2013; Auliya et al., 2016; Janssen & Krishnasamy, 2018). Pet reptiles are highly sought-after, with reptiles being the second most abundant and species-rich vertebrate class reported in the global pet trade (Bush et al., 2014). Researchers, NGOs and website managers could track the trade demand for various reptile species by locating and recording online adverts offering reptiles for sale. This approach has been used previously to assess patterns of both legal and illegal wildlife trade (Olmos-Lau & Mandujano, 2016; Janssen & De Silva, 2019; Choquette et al., 2020).

The language used within the wildlife trade has been little studied, and, to our knowledge, no prior research has examined the language used in online adverts for pet reptiles. Here we consider the types of nomenclature ('name types') used online to refer to advertised live reptiles. Understanding the variation in this nomenclature could inform the development of language-based tools for tracking online wildlife trade. We consider whether certain name types are associated with particular groups of reptile traders, and categorize these groups based on variables such as the platform used by the trader, the stated location of the trader and the type of species being advertised. This study uses a snapshot approach focusing on adverts recorded from four UK websites.

Methods

We employed a covert observational approach using freely available online content posted by internet users for their own purposes. A covert observational approach was necessary because there are no practical means of obtaining free and prior informed consent for a study of this kind (Thompson et al., 2021).

To date, there has been little research into the identification of online communities of reptile traders in the UK. As such, no prior framework exists for the categorization of online traders into communities. We therefore grouped individuals advertising reptiles online (hereafter 'sellers') according to information pertaining to each seller as revealed in the adverts they posted online. We hypothesized about and grouped particular communities of sellers according to the following variables: (1) the platform that each seller used to post adverts, (2) the geographical region in which the seller stated they were based, (3) the IUCN Red List status of the species for sale (IUCN, 2021), (4) whether a species was listed under CITES (CITES, 2020), (5) the taxonomic status of the species advertised, (6) whether the same seller posted numerous adverts, and (7) whether a seller posted bulk adverts, defined as adverts offering three or more individuals for sale.

We gathered advert data from four online platforms: Reptile Forum UK (2021; hereafter 'Reptile Forum'), Reptiles for Sale UK (2021; hereafter 'Reptiles for Sale'), Pre-Loved (2021) and Instagram (2021). We chose these four websites because, at time of writing, each was a publicly accessible UK platform through which pet reptiles were offered for sale. Reptile Forum is an established hobbyist platform that has been operational for over a decade and has a classified advert section. Reptiles for Sale is a newer website hosting classified adverts for exotic pets. Pre-Loved is a general classified advert website with a pets classified advert section, which has a reptiles subsection. We also collected data from the social media platform Instagram. For data protection purposes we anonymized any personal details (e.g. seller usernames) and we removed other sensitive details when commencing the data analysis stage. We stored the dataset securely on a password-protected encrypted flash drive.

We conducted the data collection during 10 May–10 June 2021 by searching for adverts across the four websites. We used a systematic browsing approach to view adverts on each website. This approach consisted of a set number of steps to ensure consistency each time we browsed each website. We browsed adverts week by week in reverse chronological order, viewing the most recent adverts first and working back through progressively older adverts. On the classified websites (Reptiles for Sale, Reptile Forum and Pre-Loved) we defined as adverts any classified listing post that stated or implied the offer of a live reptile for sale. On Instagram we defined as adverts any individual post in which a photograph, video or free-text description (excluding hashtags) stated the offer of a live reptile for sale. We took as ambiguous any Instagram posts that did not state explicitly the offer of live reptiles for sale and excluded these from the dataset. We excluded from the dataset any advert that offered animals for free (including for no-fee re-homing/adoption), as a swap or as part of a competition or promotion. We did not record duplicates of adverts on the same website. We recorded the information for each advert based on its textual content and metadata (e.g. date, seller username). We recorded the following variables for each advert: (1) date, (2) relevant text, (3) username of the seller, (4) stated location of the seller, (5) specific word(s)/phrase(s) used, (6) category of language used to name the individual(s) for sale, (7) species advertised, (8) stated source of the individuals (e.g. captive-bred, wild-caught), (9) whether the advert was a bulk advert, and (10) number of individuals advertised. For each species identified in the adverts we recorded the IUCN Red List status and whether the species was listed in the CITES Appendices (accessed May–August 2021). We collected an equal number of adverts from the websites Pre-Loved and Reptile Forum (450 each). Large quantities of text were common within the free-text sections of the adverts. Consequently, for ease of analysis, we

recorded only relevant sentences of free text. We defined as relevant text from each advert those sentences naming the individual(s) for sale, using any kind of language category to name individuals.

During the data analysis stage we investigated the variability of names used for each species. We achieved this by counting the different names recorded for each species and using a simple scoring system to estimate the variability of the names used by sellers to refer to each species.

Veracity of adverts   Because of the anonymity facilitated by the internet, it is a challenge to verify information gleaned from online adverts. By necessity we took the information included in the adverts as genuine, whether about the source of the individuals for sale or the location of the seller, because there was no simple way to prove otherwise.

Variables recorded   The linguistic variables studied were the nouns used to refer to individuals for sale. We grouped these into six categories: English common name, scientific name, abbreviation, acronym, slang and morph name (see Supplementary Material 1 for definitions). We recorded variations on standard spelling and apparent misidentifications of species. We also recorded instances in which species were not named (i.e. described only with a generic term such as 'python' or 'tortoise'). When two different advertisers, on any platform, had the same username (e.g. if two sellers both had the username John), we appended numbers to the usernames to differentiate between them (e.g. John1, John2). We recorded the IUCN Red List status of each advertised species (IUCN, 2021). When adverts offered species listed under CITES, we recorded in which CITES Appendix the species was listed (CITES, 2020). We checked the taxonomic status of reptile species using the Reptile Database (Uetz et al., 2021). If adverts included photographs of the individuals for sale, we used this taxonomy to verify whether the species pictured in the photographs matched the species described in the text of the advert. Where adverts did not include photographs, it was not possible to verify whether sellers had correctly identified the advertised species, and in these instances we assumed species were correctly identified.

Data analysis   Royal pythons *Python regius* are extremely popular in the pet reptile trade. When analysing certain elements of the whole dataset, it was necessary to separate and exclude data for royal pythons, to analyse the effects of certain variables without the data being biased by the large number of adverts for this species. Any results that exclude royal pythons are accompanied by the corresponding data that include this species. To optimize the data, we excluded some advert data when analysing some variables. This occurred when comparing the name types used for species

assigned to different reptile families. We excluded adverts when the advertised species could not be identified or when adverts listed two or more species assigned to different families. Where we conducted χ^2 tests or Fisher's exact tests on multiple variables in the same data, we applied a Bonferroni correction. We conducted all statistical analyses in *R Studio 1.3.1093* (R Core Team, 2020).

Results

We recorded 231 reptile species and subspecies, allocated to 35 families, for sale in 1,094 individual adverts across the four platforms studied. The royal python was the most frequently advertised species, recorded in 175 adverts (16.0% of all adverts recorded). The family Pythonidae was represented in the highest number of adverts (appearing in 294 adverts, 26.9%), followed by Colubridae (172 adverts, 15.7%), Diplodactylidae (113 adverts, 10.3%), Agamidae (88 adverts, 8.0%), Boidae (87 adverts, 8.0%), Testudinidae (70 adverts, 6.4%) and Eublepharidae (59 adverts, 5.4%). We recorded 101 snake species and subspecies in the adverts. The second most commonly advertised snake species was the corn snake *Pantherophis guttatus*, recorded in 71 adverts (6.5%). We recorded reticulated pythons *Malayopython reticulatus* in 32 adverts (2.9%) and boa constrictors (listed to species level; i.e. *Boa constrictor*) in 32 adverts. The subspecies *B. constrictor imperator* appeared in 19 adverts (1.7%). We recorded 102 different lizard species in the adverts. The two most commonly advertised lizard species were crested geckos *Correlophus ciliatus*, which appeared in 66 adverts (6.0%), and bearded dragons *Pogona vitticeps*, which also appeared in 66 adverts. Leopard geckos *Eublepharis macularius* were the second most commonly advertised lizard, in 49 adverts (4.5%). We recorded 29 chelonian species in the adverts. The most commonly advertised were Hermann's tortoise *Testudo hermanni* and Horsfield's tortoise *Testudo horsfieldii*, which both appeared in 17 adverts (1.6%). We recorded no adverts for crocodilian species. See Supplementary Material 2 for a complete list of the species recorded.

We recorded species categorized on the IUCN Red List in a total of 922 adverts (84.3% of the total). Of these, we recorded threatened species (i.e. Vulnerable, Endangered or Critically Endangered) in 166 adverts (18.0%), with Vulnerable species in 135 adverts (14.6%). Least Concern was the most common IUCN category for advertised species, recorded in 716 adverts (77.7%). We recorded Near Threatened or Endangered species infrequently, and Critically Endangered and Data Deficient species appeared in the smallest number of adverts (Table 1).

A total of 408 adverts (37.3% of all adverts) offered CITES-listed species for sale, excluding adverts for royal pythons (a species included in CITES Appendix II); including

TABLE 1 Number of name types recorded in adverts for the sale of reptiles on four publicly accessible websites, grouped by the IUCN Red List category under which the species are listed (with per cent of adverts that contained each name type). More than one name type could appear in a single advert, so that across each row the per cents for each name type will not necessarily sum to 100%.

IUCN Red List category	Number of name types (%)							Total adverts per IUCN Red List category
	English common name	Morph name	Abbreviation	Scientific name	Acronym	Slang	Species not named	
Least Concern	537 (75.0)	363 (50.7)	97 (13.5)	74 (10.3)	13 (1.8)	12 (1.7)	8 (1.1)	716
Near Threatened	24 (75.0)	0 (0.0)	5 (15.6)	13 (40.6)	0 (0.0)	0 (0.0)	0 (0.0)	32
Vulnerable	113 (83.7)	54 (40.0)	21 (15.6)	16 (11.9)	1 (0.7)	13 (9.6)	1 (0.7)	135
Endangered	16 (76.2)	2 (9.5)	5 (23.8)	7 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	21
Critically Endangered	5 (50.0)	0 (0.0)	1 (10.0)	7 (70.0)	0 (0.0)	0 (0.0)	0 (0.0)	10
Data Deficient	8 (100.0)	0 (0.0)	0 (0.0)	5 (62.5)	0 (0.0)	0 (0.0)	0 (0.0)	8
Not listed	129 (80.6)	49 (30.6)	30 (18.8)	47 (29.4)	16 (10.0)	2 (1.3)	1 (0.6)	160

royal pythons, this was 582 adverts (53.2%). We recorded CITES Appendix I-listed species in 17 adverts (1.6%). Excluding adverts for royal pythons, we recorded Appendix II-listed species in 384 adverts (35.1%); including adverts for royal pythons, 558 adverts (51.0%). We recorded CITES Appendix III-listed species in seven adverts (0.6%). We recorded 107 CITES-listed species and subspecies for sale (46.3% of all species recorded in the adverts). Nine CITES-listed species (8.4%) were listed in Appendix I, 93 (86.9%) in Appendix II and five (4.7%) in Appendix III.

Analysis of language use

We recorded 450 adverts (41.1%) each from Pre-Loved and Reptile Forum, 99 adverts (9.0%) from Reptiles for Sale and 95 adverts (8.7%) from Instagram. It was not possible to collect an equal number of adverts from all four platforms because there was only a limited number of relevant adverts on Reptiles for Sale and Instagram. For these two platforms we collected all available relevant adverts. Across all four platforms, English common names were the most commonly used name category, instances of which we recorded in 838 adverts (76.6%). Morph names, such as 'pied' or 'axanthic', were the second most common name category, recorded in 447 adverts (40.9%). We recorded scientific names in 175 adverts (16.0%), abbreviations in 161 adverts (14.7%) and acronyms in 29 adverts (2.7%). The least common name type was slang names, used in 28 adverts (2.6%). In 16 adverts (1.5%) no species were named (e.g. adverts simply stated 'tortoise for sale'). See Table 2 for further details.

On Reptile Forum, Pre-Loved and Reptiles for Sale, English common names were the most frequently recorded name category in adverts, followed by morph names. On Instagram, morph names were the most common name category in adverts, followed by English common names. Fisher's exact test indicated a significant association between

the platform used and the use of certain name types ($P < 0.001$). Subsequent χ^2 tests (with a Bonferroni correction critical value $\alpha = 0.007$) revealed associations between the platform used and the usage of English common names ($\chi^2 = 416.4$, df = 3, $P < 0.0001$), morph names ($\chi^2 = 156.9$, df = 3, $P < 0.0001$), scientific names ($\chi^2 = 288.6$, df = 3, $P < 0.0001$), abbreviations ($\chi^2 = 102.2$, df = 3, $P < 0.0001$) and acronyms ($\chi^2 = 19.4$, df = 3, $P = 0.0002$). However, there was no association between the platform used and slang names ($\chi^2 = 8.0$, df = 3, $P = 0.046$) nor between the platform used and species not being named in adverts ($\chi^2 = 5.7$, df = 3, $P = 0.126$).

Where adverts included details of the location of the seller, the most common region stated was south-east England, in 232 adverts (21.2%), followed by the Midlands, in 172 adverts (15.7%), and south-west England, in 144 adverts (13.2%). The least frequently listed region was Northern Ireland, in two adverts (0.2%). In 147 adverts (13.4%) sellers did not state their location. English common names were the most frequently recorded name type for every region and for the Location Not Listed category. Fisher's exact test indicated there was no association between name type use and the stated geographical location of the seller ($P = 0.110$; see Supplementary Table 1 for further details).

In adverts for species listed under the majority of IUCN Red List categories, English common names were the most frequently used name type (Table 1). However, in adverts for species categorized as Critically Endangered (n = 10), scientific names were the most commonly recorded name type, used in seven adverts. For species categorized as Least Concern and threatened or Near Threatened, a similar per cent of adverts contained English common names (75.0 and 79.8% respectively), abbreviations (13.5 and 16.2%, respectively) or species that were not named or identified (1.1 and 0.5%, respectively). A total of 21.7% of adverts for threatened and Near Threatened species used scientific

T ABLE 2 Number of adverts for the sale of reptiles containing each name type on four publicly accessible websites (with per cent of adverts that contained each name type). More than one name type could appear in a single advert, so that across each row the per cents for each platform will not necessarily sum to 100%.

Platform	Number of adverts (%)							Total adverts per platform
	English common name	Morph name	Abbreviation	Scientific name	Acronym	Slang	Species not named	
Instagram	39 (41.1)	47 (49.5)	14 (14.7)	7 (7.4)	1 (1.1)	7 (7.4)	5 (5.3)	95
Pre-Loved	375 (83.3)	193 (42.9)	56 (12.4)	25 (5.6)	11 (2.4)	9 (2.0)	10 (2.2)	450
Reptile Forum	336 (74.7)	161 (35.8)	85 (18.9)	140 (31.1)	15 (3.3)	11 (2.4)	0 (0.0)	450
Reptiles for Sale	88 (88.9)	46 (46.5)	6 (6.1)	3 (3.0)	2 (2.0)	1 (1.0)	1 (1.0)	99
Total	838 (76.6)	447 (40.9)	161 (14.7)	175 (16.0)	29 (2.7)	28 (2.6)	16 (1.5)	

names, whereas this was 10.3% of adverts for Least Concern species. A total of 6.6% of adverts for threatened and Near Threatened species used slang, and this was 1.7% for Least Concern species (see Table 1 for full details). A Fisher's exact test indicated a significant association between the IUCN Red List category of an advertised species and the name type used to describe it ($P < 0.001$).

In adverts for species listed in CITES Appendix I ($n = 17$), English common names were the most commonly used name type, used in 12 adverts (70.6%), followed by scientific names in seven adverts (41.2%). For CITES Appendix II-listed species, English common names were the most common name type, in 409 of 558 adverts (73.3%), followed by morph names in 267 adverts (47.8%), and scientific names in 77 adverts (13.8%). Amongst adverts offering Appendix III species ($n = 7$), English common names were the most commonly recorded name type, used in all these adverts, and scientific names were used in three adverts (42.9%; see Supplementary Table 2 for further details). Fisher's exact test indicated that when royal pythons were excluded, there was no association between name type use and the CITES Appendix listing of a species ($P = 0.079$), but there was an association when adverts for royal pythons were included ($P < 0.005$).

For the majority of the reptile families found in adverts, English common names were the most frequently recorded name type (Supplementary Table 3), used for 27 of 35 reptile families (77.1%). However, for Pythonidae (the most commonly advertised reptile family), morph names such as 'pastel' or 'harlequin' were the commonest name type, appearing in 222 out of the 294 adverts (75.5%). Scientific names were the only recorded name type for three families (Anguidae, Pseudaspididae and Sphaerodactylidae), each of which was represented only once in the dataset. For the family Gerrhosauridae, scientific names were recorded three times and English common names twice. For the families Crotaphytidae, Phrynosomatidae and Phyllodactylidae, equal numbers of scientific and English common names were recorded. For the families Carphodactylidae, Dactyloidae, Emydidae and Lacertidae, scientific and English common names were recorded in similar numbers (Carphodactylidae: English common names = 4, scientific names = 3; Dactyloidae: English common names = 4, scientific names = 3; Emydidae: English common names = 9, scientific names = 8; Lacertidae: English common names = 5, scientific names = 4).

We classified 304 adverts (27.8% of the total number of adverts) as bulk adverts (i.e. offering three or more individuals). Of these, 137 (45.1%) used English common names, 73 (24.0%) morph names, 43 (14.1%) scientific names and 37 (12.2%) abbreviations. Few bulk adverts included slang names ($n = 11$, 3.6%) or acronyms ($n = 2$, 0.7%) and only one (0.3%) omitted species names (see Supplementary Table 2 for further details). A Fisher's exact test indicated there was a significant association between name type usage and whether a seller posted bulk adverts ($P = 0.001$).

The advertised species referred to with the largest number of name variants of any name type (excluding those classed as morph names: see Discussion) were the royal python (11 variants) and *B. constrictor imperator* (eight variants), Hermann's tortoises (eight variants), *B. constrictor* (seven variants), bearded dragons (seven variants) and Mexican black kingsnakes *Lampropeltis getula nigrita* (seven variants). These numbers could, however, be influenced by the popularity of trade in a species (i.e. a species could have a greater number of names because it is advertised more often). To account for this, we calculated a name variability score as the number of names used to refer to a species divided by the number of adverts in which that species appeared, multiplied by 100. Amongst the commonly advertised species (i.e. species appearing in eight adverts or more), the species with the highest name variability scores were the Mexican black kingsnake (100.0), Pueblan milksnake *Lampropeltis polyzona* (71.4), Yemen chameleon *Chamaeleo calyptratus* (62.5) and Argentine black and white tegu *Salvator merianae* (60.0). Amongst the less frequently advertised species (those appearing in six adverts or fewer), the species with the highest name variability scores were Jackson's chameleon *Trioceros jacksonii* (250.0), the mangrove snake *Boiga dendrophila* (250.0), red-tailed racer *Gonyosoma oxycephalum* (200.0), Bredl's python *Morelia bredli* (166.7), pygmy

python *Antaresia perthensis* (166.7), Mediterranean spur-thighed tortoise *Testudo graeca* (150.0), red-footed tortoise *Chelonoidis carbonarius* (125.0) and black-headed python *Aspidites melanocephalus* (125.0).

Discussion

Of the different name types recorded, English common names predominated in the language of UK online reptile traders, used to refer to individuals for the majority of trader groups, whether grouped by platform, Red List status, CITES listing, seller location or bulk seller status. This pattern suggests that, in the online trade in pet reptiles in the UK, the use of name types other than the English common name is less prevalent than in other areas of online wildlife trade such as the trades in ivory or rhinoceros horn. Online traders selling illicit ivory or rhinoceros horn products have been observed to use deceptive code language in online adverts in both European and Chinese markets, because such language disguises illicit adverts by evading keyword filters (Xiao & Wang, 2015; Alfino & Roberts, 2020). In our study deceptive language was observed rarely, as were examples of species being mislabelled as other species, even for species subject to CITES controls.

Our findings demonstrate that individual adverts often include more than one name type (e.g. an advert for a single individual could include three different name types to refer to that same individual). This pattern could indicate the need for traders to communicate their adverts to the largest possible number of website users, but could reflect the limited scope of our study. On other websites not included in our study, reptile adverts might display different language patterns; on websites such as Facebook, whose moderators employ keyword filtering techniques to remove wildlife sales activity, reptile trading groups might evade detection through greater usage of deceptive language or slang, although it has been noted that rates of enforcement differ between different languages (Paul et al., 2020).

We found certain variables to be associated with name categories other than the English common name. Scientific names were used in 21.7% of adverts for species categorized as threatened or Near Threatened on the IUCN Red List compared with 10.3% of adverts for Least Concern species. This could be because species categorized as Least Concern (e.g. bearded dragons or corn snakes) are often those that are captive-bred more easily, therefore making them more numerous in the trade. Equally, these species could be sold more frequently and are therefore more widely known, leading to English common names becoming well established in common parlance amongst reptile traders and buyers. Species categorized as threatened or Near Threatened might not be traded as commonly and may therefore be less likely to have an established English common name.

From the assessment of the variability of names for each species, we found that the species recorded rarely in adverts were often those with the highest name variability scores, and this variation was both between and within adverts. A number of these species had high variability scores because of between-advert variation in names, with different advertisers using different iterations of a single name type. For example, we recorded 'blackheaded python', 'blackhead python' and 'black head python' (three iterations of an English common name) in adverts for *A. melanocephalus*, and 'red-footed tortoise', 'redfoot' and '*Chelonoidis carbonarius*' (an English common name, an abbreviation and a scientific name, respectively) in adverts for *C. carbonarius*. Within-advert variation in name types for the same individual could increase the likelihood of one of the names being detected in keyword searches, facilitating the detection of the advert by customers. For the same reason, this language pattern could also facilitate the detection of these adverts by researchers, web managers and enforcement bodies.

The scope of our study only allowed the investigation of a limited snapshot of adverts taken from three publicly accessible classified advert websites and one social media platform. Further research needs to investigate the language used to refer to reptile species across different platform types, including public sales websites, closed social media groups and encrypted messenger apps. In websites using languages other than English and in countries other than the UK, vernacular names might not be the predominant name type in reptile adverts. Future research on this is required. This research could consider the role of name variability in advertising particular species and the relationship between within- and between-advert variability in different reptile trade communities.

Only a total of 95 relevant adverts were recorded on Instagram. This could suggest this platform is used infrequently to advertise reptiles in the UK or, alternatively, reptile advertisements on Instagram could be covert, omitting language referring overtly to sales of reptiles. We excluded numerous posts encountered on Instagram from the dataset because their ambiguity made it unclear whether these posts were adverts. These posts contained photographs displaying captive-held individuals but included no accompanying textual description to clarify whether the pictured individuals were for sale. Adverts for reptiles (and other wildlife) on social media have been found to omit the language of commerce (D. Clemens, pers. comm., 2021) because posts that would include such language (e.g. the words 'sale', 'buy' and 'price') are often detected by keyword filtering systems, increasing the likelihood of such content being removed. Traders have been observed using pictographic strategies to circumvent these filters such as when emojis, rather than words, accompany photographs of individuals, implying an advert but not communicating this outrightly (D.L. Roberts, pers. obs., 2021). Advertisers could also evade

detection by superimposing words on photographs so that these words go undetected by keyword detection tools. Further research is needed into the linguistic and pictographic strategies with which online reptile traders imply the offer of an individual without stating so overtly in searchable text.

A considerable part of the international pet reptile trade involves captive-bred morphs of certain species. The royal python, for example, is a popular species in the reptile trade, perhaps because it is easily captive-bred and has been bred selectively for a wide range of colour and pattern morphs (Tapley et al., 2011). This process has also been applied to other popular reptile species (e.g. the corn snake and boa constrictor). The linguistic field of morph names is complex; advertised individuals were often labelled with large numbers of combinations of different colour and pattern morph names, which meant measuring the variation in this language type was beyond the scope of this study. These morph names are often accompanied by breeding and genetics terminology, including various bloodline names and shorthand phrases alluding to genetics (e.g. 'het' and 'possible het'). Moreover, adverts often include locality names referring to a particular subspecies or population of a species originating from distinct geographical areas (e.g. Ambilobe panther chameleon as distinct from Nosy Bé panther chameleon; both names refer to locations in Madagascar, where this species originates). It was beyond the scope of this study to analyse how traders use morph, locality and breeding terminology, and this is an area requiring further research.

Our study serves as a preliminary investigation into the language used in English-language wildlife trade adverts. Although English common names are used widely, our findings also indicate that the language of wildlife trade adverts is not homogeneous. English common names are used alongside various other types of name, such as scientific and morph names, abbreviations and acronyms. They also indicate that these other name types, notably scientific and morph names, are used frequently to refer to particular types of reptile or to species that are categorized as Critically Endangered on the IUCN Red List. Such a finding could offer help in the use of tailored keyword filters or the creation of other language detection tools, which need to take account of the broad range of language types that are used to refer to wildlife for sale. Our methods could serve as a template for further studies of the language patterns used in trade adverts for other taxa and for adverts in other languages. Future studies could benefit from using a sociolinguistic framework to understand the patterns of language use by different trading communities, and could also consider the language used by traders within the context of ethnobiology, as examining the language employed by wildlife traders online could offer insights into the nature and drivers of wildlife trade. There is therefore a need for interdisciplinary studies drawing on anthropology and linguistics to examine the relationships between communities of traders and patterns of language used in the online wildlife trade, to help construct targeted language-based online search and monitoring tools.

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