ROYAL SOCIETY OPEN SCIENCE

royalsocietypublishing.org/journal/rsos

Research

Cite this article: Bielby J, Rendle M, Impey K, Atkins D. 2026 Ball python trade dynamics on UK online classified advertisement sites. *R. Soc. Open Sci.* **13**: 251216.
https://doi.org/10.1098/rsos.251216

Received: 27 June 2025
Accepted: 15 January 2026

Subject Category:
Ecology, conservation, and global change biology

Subject Areas:
ecology, behaviour

Keywords:
ball python, colour morphs, exotic pets, legislation, online trade, animal welfare

Author for correspondence:
Jon Bielby
e-mail: J.N.Bielby@ljmu.ac.uk

Supplementary material is available online at https://doi.org/10.6084/m9.figshare.c.8317492.

THE ROYAL SOCIETY PUBLISHING

Ball python trade dynamics on UK online classified advertisement sites

Jon Bielby[1], Matthew Rendle[2], Kirsty Impey[1] and Daisy Atkins[1]

[1]School of Biological and Environmental Sciences, Liverpool John Moores University, Liverpool, UK
[2]Association of Exotic and Zoo Veterinary Nurses, Market Harborough, UK

JB, 0000-0003-4586-0429

The trade in the ball python (*Python regius*) has reduced wild populations significantly, but many of the animals traded and kept as pets are now selectively bred colour and pattern morphs (hereafter just 'morph'). This switch from wild caught to captive-bred morphs is not cost-free, however: some morphs experience significant welfare issues, and not all individuals within a clutch exhibit the desired phenotype, resulting in excess stock. We used online classified advertisements to investigate the trade dynamics of ball pythons within the UK. Specifically, we compared advertisement content of morphs and those of wild-types with a focus on price, whether equipment was included, and whether they represented single or multiple animals. Further, for morphs we looked at website and temporal variation in the most common morph terms. Significant variation was observed with wild-types exhibiting lower prices, being more commonly advertised alone, with equipment, illustrating different sales dynamics compared with morphs. The most common morphs were consistent over time and between sites. In the absence of transparent data from other sale routes, these patterns represent an insight into the dynamics and challenges in the breeding, trade and regulation of one of the most kept pet species in the UK.

1. Introduction

Ball pythons (*Python regius*) are a broadly distributed snake species whose global population has declined by almost 30% in the past two decades, resulting in a Red List status of Near Threatened [1]. A major driver of this decline has been the overexploitation of the species for the pet trade [1,2], with over

2.7 million global imports of the species between the years of 1996 and 2012 [3]. The source of the animals being imported appears to have changed over time, with a move towards ranched, farmed and captive-bred stock [2,3]. While it appears that global imports have reduced considerably in recent years, evidence on the sustainability of alternative sources remains equivocal [4,5], and welfare concerns exist at both source and sink [6].

One reason for the reduction in ball python imports sourced from wild populations is the selective breeding of animals to achieve a great variety of phenotypically diverse morphs [7] (hereafter 'morphs'). Over 7000 morphs have been informally catalogued in the past 30 years [8], but we are only just scratching the surface of the genetic basis and mechanisms underpinning this great variety [9–14]. The range of morphs available is matched by the diversity in demand for and price of these animals: although little research is available at present, the highest prices of individuals on popular morph-specific websites commonly exceeds $10 000 (e.g. [15]).

The trade in morphs is lucrative and popular, but concerns have been raised in relation to its impact on the welfare of the animals being bred [16]. Selective breeding for particular phenotypes has been associated with considerable welfare issues in a wide range of taxa, with the effects being most acute in domesticated animals, including dogs [17,18], chickens [19] and pigs [20]. Negative welfare implications of selective breeding for morphs of different reptile species are now being observed, recorded and factored into policy and legislation discussions [21]. For example, leopard geckos (*Eublepharis macularius*) of the Lemon Frost morph may exhibit trait-associated tumour-like skin lesions, or iridophoroma [22], while Enigma morphs of the same species can suffer from a neurological issue, termed Enigma syndrome, which is manifest in a range of symptoms from head-bobbing to, at its most severe, seizures [23]. Similarly, certain ball python morphs are associated with welfare issues, although given the diversity of morphs available we know relatively little about the prevalence or severity of such issues. The most well documented welfare concern is within a group of Spider morphs, which suffer from a neurological disorder known as 'wobble syndrome' [16], caused by morphological differences of the inner ear in Spider morph ball pythons [24]. While these obvious and severe health issues are clearly related to selective breeding for aesthetics, we have a very poor understanding on the existence of more subtle negative effects in other morphs. Further, at present, there are no policies or certified guidelines of best practice related to their breeding, husbandry or sale. The welfare implications of this lack of guidance or evidence may be considerable, although several forums for the sale of these animals have autonomously banned certain morphs that exhibit the most severe neurological syndromes [25,26].

While we know relatively little about the genetic basis of colour morphs or associated syndromes, in both wild and domestic animals, variation in colour patterns and intensity have been linked to differences in morphology, physiology and behaviour [27]. Our knowledge of these associations provides some insight into the mechanisms by which extreme selective breeding for colour could feasibly affect the welfare of the resulting animals. Pleiotropic effects of genes related to the melanocortin system, a major function of which is melanogenesis (i.e. pigmentation), have been linked to several key physiological functions. These include aggression levels, cardiovascular behaviour, energy homeostasis, hypothalamus– pituitary–adrenal (HPA) axis activity, immune status and sexual behaviours, in addition to variation in skin tone [27,28]. Most of the evidence in hand exists within wild species in a range of taxa (including snakes [29]) and often suggests an adaptive relationship between the melanocortin system and the linked suite of phenotypic traits. There also appears to be significant intra-specific variation in how this suite of traits are affected by changes to the melanocortin system via selective breeding of domestic animals for colouration. However, differences within a species seem to be highly context dependent, depending on a range of factors [30]. These high degree of plasticity of effects underlines both the potential importance of the melanocortin system in other aspects of an individual's biology, and the complexities of how selective breeding for a particular colour or pattern may be manifest in other, unexpected, ways relative to in wild animals. It is therefore possible that extreme selective breeding for specific colour patterns could result, in some circumstances, in an increase in frequency of occurrence and expression of maladaptive genotypes pleiotropically associated to the melanocortin system.

Selective breeding for the most desirable morphs could also have indirect negative broader impacts on welfare within the captive population. As the important aspects of morph phenotype (colour and pattern) exhibit Mendelian modes of inheritance [7], the production of desirable traits will lead to both the target morph and other variations within the same clutch, the latter perhaps being less desirable and economically valuable. The relative proportion of these non-target morphs could be high and could constitute a considerable number of individuals given the popularity of keeping and breeding

the species [31]. We currently have little data on the relative occurrence of different morphs within the pet trade and hobby, or current relative price differences between morphs and wild-type phenotypes. Historically, physical shops have increasingly sold morphs rather than wild-type ball pythons, and for a much greater price (over the period 1993–2005 [32]). More recent data from online platforms support this pattern, with ball pythons being the most listed species on a number of classified advertisement websites, and morph names being more commonly used that scientific terminology and even common species names on some platforms [33]. However, the trade may be highly dynamic with significant changes in supply and demand for reptiles being possible within relatively short time frames [32,34]. Quantifying the relative frequency of morph and wild-type availability, how these qualities change over time, and the price differences between them is an important step in understanding the complex dynamics of supply and demand in the breeding and sale in this popular species.

Quantifying and describing the dynamics of the pet hobby and trade generally is challenging [35], but it is especially so when many animals within the trade may be bred by non-registered sellers and hobbyists [36]. The online trade in animals has increased greatly in the past decade, with the market for some animals now being almost entirely based online (e.g. puppies [36]). Additionally, in some taxa online classified advertisements may be a useful metric of the size and diversity of the market in the absence of other robust data. For example, Bielby *et al*. [37] found that the most commonly sold turtles and tortoises on UK online platforms were representative of the most commonly kept overall in the UK based on surveys by herpetological societies [31]. For these reasons—the size of the online trade, and the suitability of online advertisements as a metric of the market—online classified advertisement platforms may provide useful data on the general size and diversity of the trade of taxon such as ball pythons, for which other detailed data are unavailable.

Here, we examine the trade of ball python and their constituent morphs with a focus on their relative frequency over time and their price differences. Given current welfare concerns around the subject of selective breeding in domestic animals, and popular reptile pets, we aimed to investigate the volume and composition of ball pythons offered for sale on widely used classified advertisement websites. Based on previous research [32,33] we predict that advertisements would more frequently feature morph names than not, and those containing morph names would be more expensive than those representing wild phenotypes. We also predicted variation in the frequency of morph name use, with some being more common in advertisements than others. We held no prior hypotheses as to which morph names would be the most used in advertisements, but we specifically investigated the presence of Spider morphs within online classified adverts. We did so to identify the relative frequency in the online trade of a morph known to be associated with a measurable welfare concern (such as wobble syndrome). Finally, we expected there to be temporal variation in the most advertised morphs because of changes in market demand and supply. To meet our aims, we used data from two widely used classified sales advertisement websites, incorporating data from 2020 to 2024.

2. Methods

A widely used dedicated website for animal classified advertisements (hereafter Site A), was sampled over three time periods to investigate temporal trends in ball python advertisement volume, composition and price. These time periods were July and August 2020 and 2021 and 1 December 2023–6 June 2024 inclusive. Additionally, for comparison between websites we also tracked advertisements on another more general classified advertisement site (hereafter Site B), from 17 April to 26 June 2024. For analyses, we removed all duplicate advertisements and excluded placeholder prices (e.g. £12 345, £100 000) from analyses related to cost. For each sampling period, we collected data daily on posts advertising ball pythons for sale, and for each post, we collected several pieces of information that characterized the advertisement. For each, we noted any terms related to morph phenotypes (hereafter 'morph terms') included in the title and description, the price of the listing, whether the advertisement description clearly referred to a single or multiple individuals, and whether any equipment was included in the advertisement or not. We use the phrase 'morph term' rather than simply 'morph' because a single snake can exhibit multiple phenotypic morph characteristics. The presence of a given morph term could result therefore represent different observed phenotypes (morphs) depending on the combinations of genes that are present. It is also possible that the mention of a morph term relates to the presence of a recessive gene in that snake. Further, some incomplete dominant morphs have a viable super version, which occurs when the gene's allele is paired. These morphs are called Super versions, and examples include Pastel, Mojave and Lesser. The Super often looks very different from

the morphs it originated from, in some cases making it difficult to determine which morph(s) is/was bred from, but in this case, we noted the presence of the morph term Super. The Site A 2024 data formed the basis of our analyses of price, whether snakes were sold with equipment, and whether they were advertised individually or in batches.

Morph terms were cross-checked with a popular website focusing on ball python morphs (www.worldofballpythons.com), and a list of 94 were compiled that covered all the adverts posted in the 2023/2024 sampling period (electronic supplementary material, table S1). Although the nature of the trade means that new morphs are frequently produced, we are confident that the most frequently advertised morphs on these websites were included in this list. If a morph term appeared in both the advertisement title and longer description within an advertisement, it was only included once in our tally. Because morph terms are not exclusive of each other within an individual snake when we report proportions they may sum to over 100%. We also assumed that no explicit mention of a morph term meant that the advertisement in question related to a wild-type phenotype (although these individuals could have held recessive morph genes). For further information on morphs generally, we also compiled a larger set of information of known morphs, their year of first production, their Mendelian inheritance tendency (recessive, dominant, incomplete dominant), and whether any issues had been recorded for the morph. These data were collated from www.morphmarket.com (electronic supplementary material, table S2).

We investigated associations between phenotype (any morph versus wild-type) and two other variables that are indicative of animals being resold rather than bred specifically for sales. First, we looked at whether there were associations between phenotype and multiple animals being advertised, with the logic that breeders may be more likely to advertise multiple animals, whereas individual animals may be more likely to represent a resale. Second, we looked for associations between phenotype and the presence of equipment being included in the advertisement to test whether phenotype was linked to resales of the python along with the equipment in which it was kept. These analyses were chi-square analyses of count data of the number of adverts in each combination of phenotype × number of snakes being advertised, and phenotype × equipment included respectively. In the presence of a significant association, we took the standardized residuals as being a measure of which combinations were driving this association, with an absolute value >2 being taken as a strong driver of any observed associations [38].

For Site A data, we statistically compared the frequency of the top 10 most commonly occurring morph terms with each other. We calculated the proportion each morph term represented of the total mentions of morph terms within all adverts and then compared them with each other using the pairwise prop.test function from base R [39], adjusting *p*-values for multiple testing using the Holm method. To investigate the stability of morph term relative frequency over time and between websites, this measure of morph term frequency of occurrence was compared between the two websites (Site A and Site B) in 2024, and for Site A across years (2020 versus 2021; 2020 versus 2024; 2021 versus 2024) using Pearson's correlation. We also tallied the frequency of the morph term 'Spider' on Site A in 2020 and 2024 to identify whether the knowledge of 'wobble syndrome' had affected their frequency over time.

To compare prices of advertisements for morphs combined and those for wild-types we included only those advertisements that explicitly included a single individual for sale and came free of extra equipment. Using this approach, we aimed to ensure that what we were characterizing was the perceived monetary value of morphs versus wild-type phenotypes. We compared the two phenotypes on Site A in the 2020 dataset and the 2024 dataset to determine whether any price differences were temporally consistent. Due to the non-normal nature of the data, the relationship between phenotype (morph versus wild-type) and price was analysed using a Mann–Whitney test. Ideally, we would have liked to have compared prices among morph phenotypes, but the nature of the text within advertisement descriptions and the complexities of Mendelian genetics meant that it was not feasible to identify exactly which phenotypes were being advertised.

All online data were collected using a covert observational approach from the public domain, which, as with similar studies previously, was necessary because no means of getting prior consent exists for a study of this kind. As outlined above the nature and type of data collected, and scale of analyses conducted meant that no potentially identifiable human images or data were presented or collected in this study, and no individuals were recognizable throughout the data collection or analysis process.

All data wrangling and analyses were conducted in the software package R using the tidyverse package [40]. Specifically, data extraction used the rvest [41], stringr [42], tidyr [43] and dplyr [44]

libraries, and plots were made using ggplot2 [45] and Sankey charts produced using the highcharter package [46].

3. Results

Our data collection process resulted in 320 advertisements from Site A in 2020, 471 from Site A in 2021, 602 from Site A in 2024 and 391 from Site B in 2024. The 2024 Site A data were categorized further into phenotype (wild-type or morph), whether there were single or multiple snakes in the advertisement, and whether equipment was included or not (figure 1). Of the 602 advertisements included in this analysis, 450 (75%) advertised morphs containing 93 morph terms (electronic supplementary material, data S1), 152 (25%) advertised wild-types. Of the former, 267 of 450 (59%) were single snakes, 118 (44%) of which were advertised with equipment, 149 (56%) were without. This means that 183 (41%) adverts of morphs included multiple snakes, of which 46 (25%) had equipment included and 137 (75%) did not. Of the 152 wild-type advertisements, 130 (85%) were for single snakes and 22 (15%) for multiples. Of the 130 singletons, 107 (82%) were advertised with equipment included while 23 (18%) had no equipment. For the 22 postings advertising multiple snakes, 9 (41%) included equipment and 13 (59%) did not.

Based on these figures there was a significant association between phenotype and whether a post advertised a single or multiple snakes ($\chi^2 = 33.56$, d.f. = 1, p-value < 0.001) with more morph multiples than expected by chance (std residual = 2.40) and more wild-type singles (std residual = 2.97). The strongest effect, as highlighted by the very low standardized residual (−4.14), indicated that there were far fewer posts advertising multiple wild-types than we would expect by chance.

There was also a significant association between the phenotype in an advertisement and whether equipment included in the sale ($\chi^2 = 71.01$, d.f. = 1, p-value < 0.001). This association seems to have been driven most strongly by the high number of wild-type snakes being sold with equipment (std residual = 5.39) and the very low number of wild-types without equipment (std residual = −5.02).

There was also a significant difference in the price of postings advertising morphs relative to those of wild-type ball pythons on Site A in the 2024 sampling period. Of those advertisements included in the analysis (single snakes without equipment) the former were significantly more expensive (W = 2270.5, p-value < 0.001). The median price of a morph advertisement was £150 (IQR = 110) compared with £60 (IQR = 60) for a wild-type snake (figure 2). In 2020, the price difference between morphs and wild-types was also significant with morphs being significantly more expensive than wild-types (figure 3; W = 2159.5, p-value < 0.001; morph median price = £150, IQR = 170, wild-type median price= £50, IQR = 60; data in electronic supplementary material, data S2).

There were significant differences among morphs in the proportion of total morph term mentions in the 2024 Site A advertisement data (figure 4). Pairwise proportion tests, adjusting for multiple testing using the Holm method suggested that the most commonly mention morph terms, 'Pastel' and 'Pied', occurred significantly more frequently than others. The third and fourth most common, 'Clown' and 'Banana', were significantly more common than those below them in the top 10 most frequent (table 1). All pairwise comparisons between the top 10 from Site A 2024 are included in electronic supplementary material, table S3.

There was a strong significant correlation between morph term frequency in advertisements between Site A and Site B in 2024 (t = 40.16; d.f. = 92, p < 0.001, correlation coefficient = 0.973; figure 5), and although there was some variation in the constituent top 10 morphs mentioned between Site A and Site B 2024 (figure 6; electronic supplementary material, table S4), the top 10 morphs were relatively similar, particularly those in the top five.

There were also temporal correlations in advertisement morph term frequency on Site A among the years 2020, 2021 and 2024 and Site B in 2024, with similar morph terms being more common (electronic supplementary material, figures S1–S3) and strong significant pairwise correlations between each of the years (2020 versus 2021, t = 24.678, d.f. = 92, p-value < 0.001 correlation coefficient = 0.932; 2020 versus 2024, t = 17.331, d.f. = 92, p-value < 0.001 correlation coefficient = 0.875; 2021 versus 2024, t = 20.255, d.f. = 92, p-value < 0.001 correlation coefficient = 0.904; electronic supplementary material, figures S4–S6). Visual inspection of the most common morph terms highlights some changes in the top 10 most frequently mentioned between years on Site A, but the proportion of total morph mentions remains relatively stable over time (figure 6; electronic supplementary material, table S4).

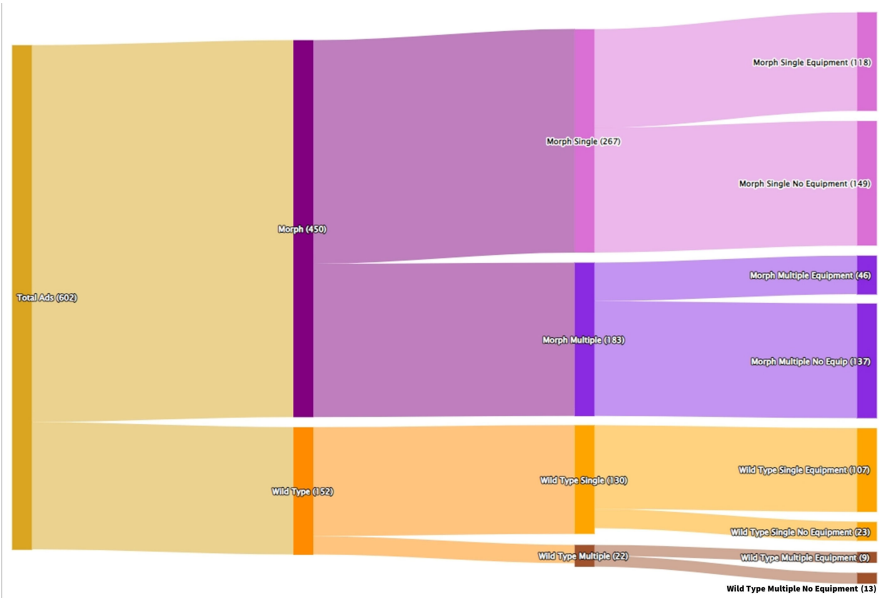

Figure 1. Sankey plot illustrating the number of Site A 2024 advertisements in each nested combination of phenotype, single/multiple, equipment/no equipment. Numbers in brackets represent the number of advertisements at that node.

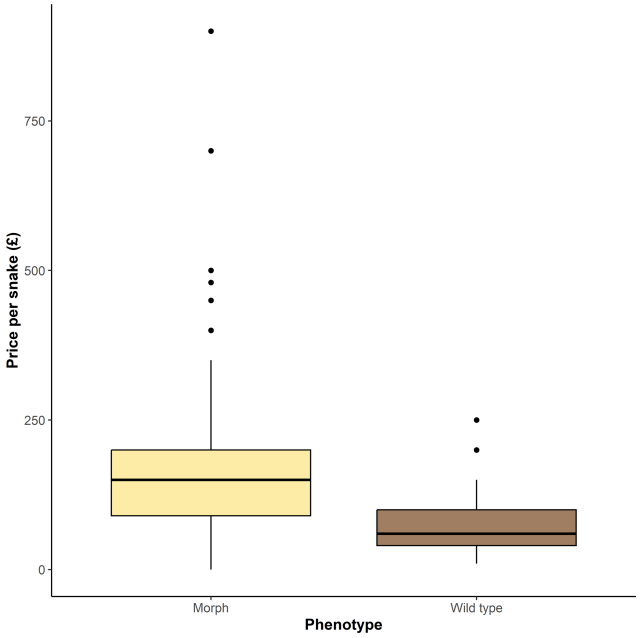

Figure 2. Prices on Site A 2024 advertisements of listings containing a morph-related term compared with those listing mentioning no such term, and therefore assumed to refer to a wild phenotype python. There was a significant difference between the prices ($W = 2270.5$, p-value < 0.001). The median price of a morph advertisement was £150 (IQR = 110) compared with £60 (IQR = 60) for a wild-type snake.

The text of advertisements on Site A in 2020 contained references to the Spider morph on 35 occasions, making it the sixth most used morph term. In 2024, it was named in 55 advertisements—the 17th most frequently mentioned morph term.

4. Discussion

Although the market for ball pythons is large and economically important, the size and scope of this trade in the UK is poorly understood, as is the stability of demand over time and with respect to popular morphs. Our results suggest that online advertisements exhibit a suite of characteristics

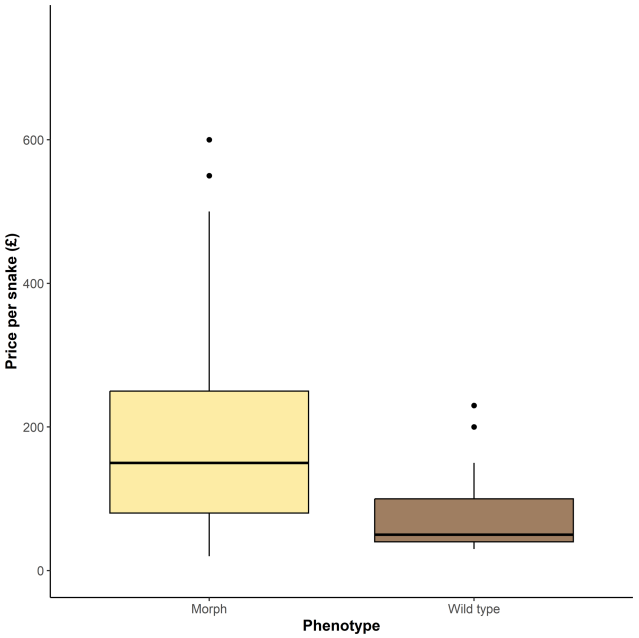

Figure 3. Prices on Site A 2020 advertisements of listings containing a morph-related term compared with those listing mentioning no such term, and therefore assumed to refer to a wild phenotype python. There was a significant difference between the advertisement types ($W = 2159.5$, p-value < 0.001) with adverts containing morph-related terms having a median price of £150 (IQR = 170) and wild-type phenotypes median price equal to £50 (IQR = 60).

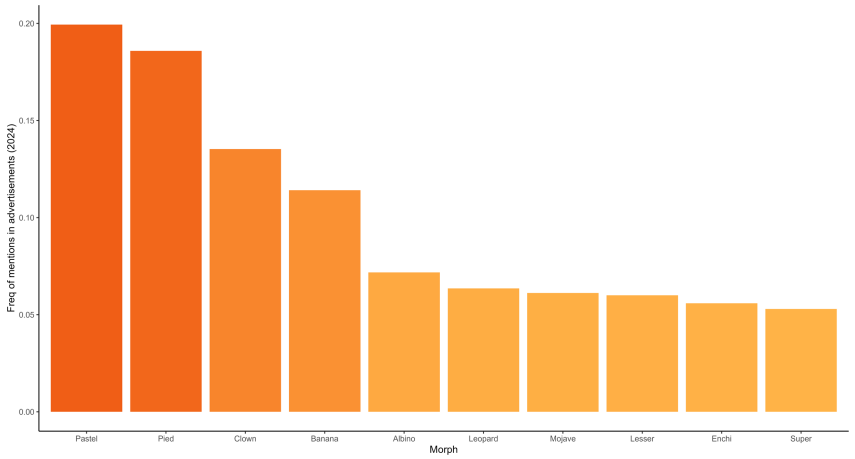

Figure 4. Relative frequency of 10 most common morph-related terms in Site A advertisements in 2024. Relative frequency represents the proportion of all advertisements in which that morph term occurs.

that are consistent with morphs being more in demand than wild phenotypes, with the most popular morph terms exhibiting consistency of advertisement frequency across advertising platforms and, within a website, over time. These results are consistent with the UK's trade in ball pythons exhibiting two very different sets of dynamics, one for morphs, and one for wild-type phenotypes, the latter of which could be a resultant byproduct of the demand for selectively bred lines and traits. The temporal consistency in which morph terms are advertised could provide an evidence base for targeted efforts to identify and deal with any morph-specific welfare issues. However, the continued presence of Spider morphs in the data suggests that current approaches to the online trade (and perhaps the broader trade) in morphs are insufficient to effectively monitor and control the advertisement of particular morphs and issues.

Our data are consistent with the prediction that morphs are advertised most by breeders, rather than casual owners wishing for a cessation of their ownership of their pet. Advertisements containing morph terms consistently referred to multiple animals, and those animals were being advertised at a higher price per individual than those of a single wild phenotype. Further, morph advertisements less

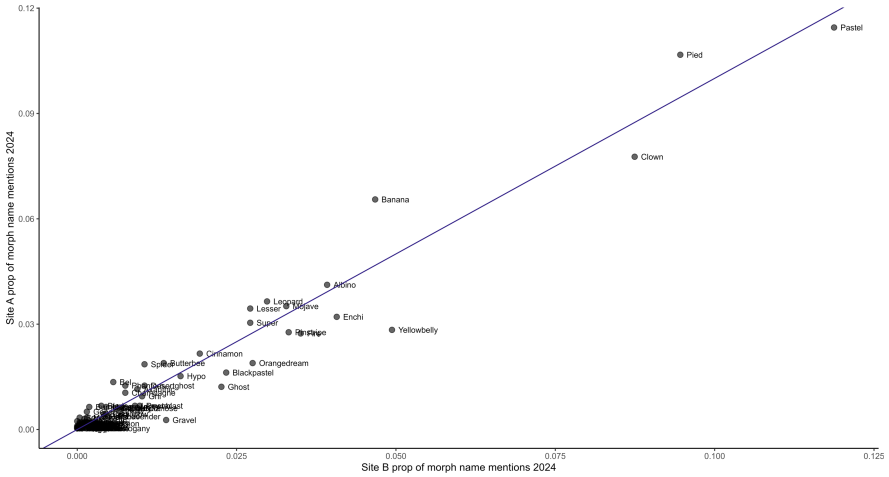

Figure 5. Relationship between relative frequency of morph term mentions in advertisements listed on Site A and Site B in 2024.

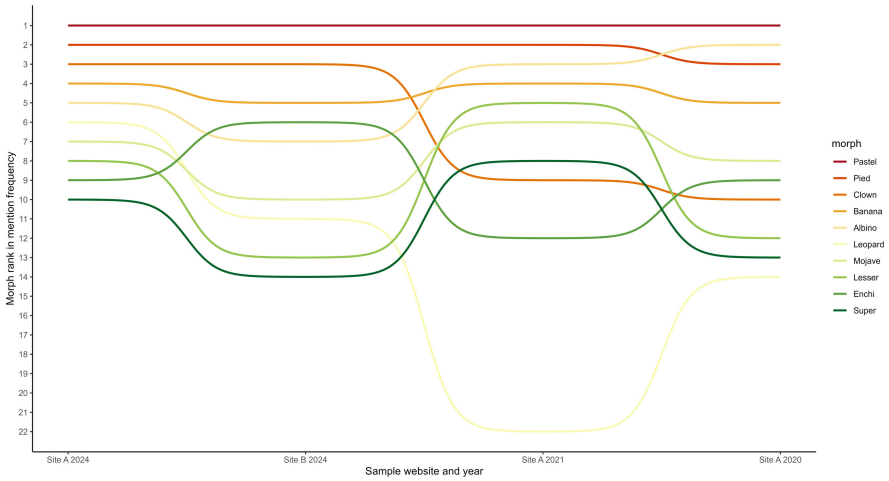

Figure 6. Relative ranking of each of the top 10 most commonly mentioned morph terms on Site A in 2024 compared with Site A 2020 and 2021 and Site B 2024.

Table 1. Ten most common morph terms ordered by the number of advertisements in which they are mentioned in Site A advertisements in 2024. Group membership represents the results of pairwise proportion test comparisons between each morph term—different letters represent statistical differences between those morph terms.

morph name	mentions	group membership
Pastel	339	A
Pied	316	A
Clown	230	B
Banana	194	B
Albino	122	C
Leopard	108	C
Mojave	104	C
Lesser	102	C
Enchi	95	C
Super	90	C

frequently contained equipment as part of the deal, which is again consistent with animals being bred purposely for sale or as surplus stock from existing breeding operations. By contrast wild phenotypes

were most advertised as singletons, for a lower price, and often with equipment, which is an advertisement profile consistent with owners advertising animals they no longer want or can keep. The way that these characteristics consistently cluster together on advertisements of morphs (multiple individuals, higher price, no equipment) and wild-types (single individuals, lower price, equipment included) suggests the existence of two distinct subsets of ball pythons within the UK online market, each of which will likely have different dynamics, advertisers, target audiences and concerns.

While the popularity and diversity of morph reptiles has grown rapidly in size over recent decades, our knowledge of the specific-welfare concerns related to their selective breeding has not. Our current knowledge of deleterious morph-specific tendencies in reptiles is limited at present, with only those most visible conditions being recorded [24]. However, it seems possible that other less obvious problems may exist and would only become apparently upon further research into the physiology, behaviour and life history of selectively bred morphs. One obvious starting point would be to focus on morphs that are most genetically like those known to experience welfare problems (e.g. Spider morphs [16,24]), or to approach expanding our welfare knowledge by first understanding more thoroughly those morphs that are most common within the market. A problem with the former point is our poor knowledge of the genes responsible for existing colours, patterns [7] or neurological problems [24], whereas in the latter case the lack of transparency in the breeding and sales of morphs may be a larger issue. In the USA, most ball python keepers who breed animals do so as a hobby rather than for profit [47], although they may keep hundreds of animals. In the UK, present legislation surrounding the sale of animals [48] does not require a licence if an advertiser is 'selling a small number of surplus offspring or excess stock from animals bred as a hobby, for pleasure … and for low value species that may produce large numbers of excess stock'. If the keeping and breeding of ball pythons in the UK is largely a hobby, as is the case in the USA, this UK legislation makes it unfeasible to easily develop a comprehensive understanding of the current UK market for ball pythons or to further guide the breeding and sale of certain morphs. The temporal stability of the most frequently advertised morphs provides us hope in this regard, however. Our data suggest that the most advertised morph terms have not changed significantly over the past 5 years and that, at least in general classified advertisement websites, they remain consistent between websites. These two points suggest that targeted research could identify any behavioural, physiological or neurological issues that exist within the most common morphs, and appropriate policies regarding their welfare could be implemented. However, the continued presence of Spider morphs within our dataset despite known welfare issues suggest that new approaches to monitoring and guiding the sale of these animals may be necessary.

It is also possible that the most advertised morphs are surplus stock resulting from breeders' efforts to produce rarer, more lucrative morphs. A more detailed investigation into the demand and price of different morphs, as well as studies into the heritability of different phenotypic traits could yield important information on the supply, demand and relative number of different morphs within the market. In turn, this could help us to better manage the breeding of these animals to reduce surplus individuals. A prime example of this may be more wild-type animals which, according to our data, are advertised at lower prices which likely represents the lower demand for them in the market. As multiple factors converge to increase the number of UK pet carers needing or wanting to relinquish their animals, any measures that help reduce pressure within the system must be considered.

There are some obvious extensions to this research that would further develop our knowledge of the UK trade in ball pythons. The data presented here were based on descriptive identification of the animals being advertised and therefore may not always accurately identify the morph phenotype or genes within that animal. For example, some recessive genes may not be expressed and would not be obvious to the advertiser. This would mean that our estimates of the relative frequency of morphs within the trade is not 100% accurate. Perhaps the most important example of this would be in the category of wild-type phenotype animals. We used this category as a default setting, in that if no other morph genes or phenotypes were explicitly mentioned, we assumed wild phenotype. However, some advertisers may simply have not mentioned the morph of their animal or, alternatively, that animals may have a wild phenotype but could still carry recessive genes that were simply not expressed. More detailed investigation of the relative scale of morphs within the supply chain could involve third party identification of morphs being sold either via photographs on the advertisement websites or in person at trade shows and breeders' meetings.

Reptiles are generally perceived poorly by the public and media [49], and recent surveys suggest that only 50% of the UK public think that snakes are sentient (i.e. can have physical and emotional experiences and can feel pain) [50]. These negative perceptions are important because if they represent

the thoughts, attitudes, beliefs and actions of individuals, they will likely feed into societal values [51]. In turn, these values may feed into the form and efficacy of policies and legislation that are developed to support the welfare of these animals. In fact, the evidence base for advanced cognitive capabilities and sentience in reptiles generally, and specifically in snakes, is growing. There is evidence of advanced cognitive functioning and sentience [52,53] and even self-recognition [54] in snakes. In terms of human–animal interactions there is a body of evidence that reptile keepers form strong bonds with their animals [55–57], and that people who keep reptiles have a more accurate estimation of their animals' cognitive capabilities [58]. The existence of strong, positive human–snake interactions, allied with their advanced cognitive capabilities, suggests that the taxon deserves more careful consideration when developing interventions to make the trade and hobby more welfare-based and ethically sound.

The selective breeding of reptile morphs is a popular section of the reptile-keeping market, and it has considerable economic worth [31,32]. Associated with its popularity some concerns have been raised, but research into the market has until now been limited. These concerns are based around issues faced in other taxa, as well as some acute neurological issues exhibited by certain breeds in a small number of species [16] and have led to high-profile campaigns to implement further legislation within the selective breeding sector of the morph market [21]. The results presented here suggest that differences exist in advertiser and buyer preference with respect to snake phenotype, that the profile of the popular morphs is stable over time and website, but that morphs known to experience significant welfare issues are still advertised. Combined, these data suggest that novel, tailored interventions may be beneficial when assessing and identifying issues related to specific morphs, developing best practice breeding guidelines, and ethically managing the economically important ball python market in the UK.

Ethics. This work did not require ethical approval from a human subject or animal welfare committee.

Data accessibility. The data and supplementary information are available online [59].

Declaration of AI use. We have not used AI-assisted technologies in creating this article.

Authors' contributions. J.B.: conceptualization, formal analysis, investigation, methodology, supervision, visualization, writing—original draft, writing—review and editing; M.R.: conceptualization, supervision, writing—review and editing; K.I.: conceptualization, data curation, methodology, writing—review and editing; D.A.: conceptualization, data curation, methodology, writing—review and editing.

All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

Conflict of interest declaration. At the time of writing, J.B. is a Board Member of Royal Society Open Science, but had no involvement in the review or assessment of the paper.

Funding. No funding has been received for this article.

References

1. D'Cruze N, Wilms T, Penner J, Luiselli L, Jallow M, Segniagbeto G, Niagate B, Schmitz A. 2022 *Python regius (amended version of 2021 assessment)*. The IUCN Red List of Threatened Species 2022: e.T177562A220378972. (doi:10.2305/IUCN.UK.2022-2.RLTS.T177562A220378972.en)
2. Harrington LA, Green J, Muinde P, Macdonald DW, Auliya M, D'Cruze N. 2020 Snakes and ladders: a review of ball python production in West Africa for the global pet market. *Nat. Conserv*. **41**, 1–24. (doi:10.3897/natureconservation.41.51270)
3. Robinson JE, Griffiths RA, John FAS, Roberts DL. 2015 Dynamics of the global trade in live reptiles: shifting trends in production and consequences for sustainability. *Biol. Conserv*. **184**, 42–50. (doi:10.1016/j.biocon.2014.12.019)
4. D'Cruze N, Harrington LA, Assou D, Green J, Macdonald DW, Ronfot D, Segniagbeto GH, Auliya M. 2020 Betting the farm: a review of ball python and other reptile trade from Togo, West Africa. *Nat. Conserv*. **40**, 65–91. (doi:10.3897/natureconservation.40.48046)
5. Toudonou C *et al*. 2022 Seeking serpents: ball python trade in Benin, West Africa. *Nat. Conserv*. **50**, 85–114. (doi:10.3897/natureconservation.50.86352)
6. D'Cruze N, Paterson S, Green J, Megson D, Warwick C, Coulthard E, Norrey J, Auliya M, Carder G. 2020 Dropping the ball? The welfare of ball pythons traded in the EU and North America. *Animals* **10**, 413. (doi:10.3390/ani10030413)
7. Irizarry KJ, Bryden RL. 2016 *In silico* analysis of gene expression network components underlying pigmentation phenotypes in the python identified evolutionarily conserved clusters of transcription factor binding sites. *Adv. Bioinform*. **2016**, 1286510. (doi:10.1155/2016/1286510)
8. World of Ball Pythons. 2024 *The big morph list*. See https://www.worldofballpythons.com/morphs (accessed 3 July 2024).
9. Brown AR, Comai K, Mannino D, McCullough H, Donekal Y, Meyers HC, Graves CW, Seidel HS, BIO306W Consortium. 2022 A community-science approach identifies genetic variants associated with three color morphs in ball pythons (*Python regius*). *PLoS One* **17**, e0276376. (doi:10.1371/journal.pone.0276376)

10. Dao UM, Lederer I, Tabor RL, Shahid B, Graves CW, Seidel HS. 2023 Stripes and loss of color in ball pythons (*Python regius*) are associated with variants affecting endothelin signaling. *G3* **13**, jkad063. (doi:10.1093/g3journal/jkad063)
11. Garcia-Elfring A *et al*. 2023 Piebaldism and chromatophore development in reptiles are linked to the tfec gene. *Curr. Biol*. **33**, 755–763. (doi:10.1016/j.cub.2023.01.004)
12. Lederer I *et al*. 2023 A frameshift variant in the melanophilin gene is associated with loss of pigment from shed skin in ball pythons (*Python regius*). *MicroPubl. Biol*. **2023**. (doi:10.17912/micropub.biology.000896)
13. Garcia-Elfring A, Roffey HL, Abergas JM, Hendry AP, Barrett RD. 2024 GTP cyclohydrolase 1 and axanthism in ball pythons: a new vertebrate model for pterin-based pigmentation. *bioRxiv*.
14. Garcia-Elfring A, Roffey HL, Abergas JM, Wuyts J, Hendry AP, Tzika AC, Barrett RD. 2025 A ball python colour morph implicates *MC1R* in melanophore–xanthophore distribution and pattern formation. *Pigment Cell Melanoma Res*. **38**, e13215. (doi:10.1111/pcmr.13215)
15. Morph Market. 2024 *Animals for sale*. See https://www.morphmarket.com/all/c/all?ordering=-price (accessed 3 July 2024).
16. Rose MP, Williams DL. 2014 Neurological dysfunction in a ball python (*Python regius*) colour morph and implications for welfare. *J. Exot. Pet Med*. **23**, 234–239. (doi:10.1053/j.jepm.2014.06.002)
17. Packer RM, Hendricks A, Tivers MS, Burn CC. 2015 Impact of facial conformation on canine health: brachycephalic obstructive airway syndrome. *PLoS One* **10**, e0137496. (doi:10.1371/journal.pone.0137496)
18. McMillan KM, Bielby J, Williams CL, Upjohn MM, Casey RA, Christley RM. 2024 Longevity of companion dog breeds: those at risk from early death. *Sci. Rep*. **14**, 531. (doi:10.1038/s41598-023-50458-w)
19. Hartcher KM, Lum HK. 2020 Genetic selection of broilers and welfare consequences: a review. *Worlds. Poult. Sci. J*. **76**, 154–167. (doi:10.1080/00439339.2019.1680025)
20. Turner SP, Camerlink I, Baxter EM, D'Eath RB, Desire S, Roehe R. 2024 Breeding for pig welfare: opportunities and challenges. *Adv. Pig Welf* **1**, 429–447. (doi:10.1016/B978-0-323-85676-8.00003-1)
21. British Veterinary Association. 2023 Policy position on non-traditional companion animals. See https://www.bva.co.uk/take-action/our-policies/exotic-pets-non-traditionalcompanion-animals/ (accessed 11 December 2024).
22. Szydłowski P, Madej JP, Duda M, Madej JA, Sikorska-Kopyłowicz A, Chełmońska-Soyta A, Ilnicka L, Duda P. 2020 Iridophoroma associated with the lemon frost colour morph of the leopard gecko (*Eublepharis macularius*). *Sci. Rep*. **10**, 1–6. (doi:10.1038/s41598-020-62828-9)
23. Kubiak M. 2020 Geckos. In *Handbook of exotic pet medicine* (ed. M Kubiak), pp. 241–262. Chichester, UK: John Wiley. (doi:10.1002/9781119389934)
24. Schrenk F, Starck JM, Flegel T, Kiefer I, Tebrün W, Pees M. 2022 Comparative assessment of computed tomography and magnetic resonance imaging of spider morph and wild type ball pythons (*Python regius*) for evaluation of the morphological correlate of wobble syndrome. *J. Comp. Pathol*. **196**, 26–40. (doi:10.1016/j.jcpa.2022.05.003)
25. International Herpetological Society. 2025 *Importance notice—banned morphs*. See https://www.ihs-web.org.uk/news/show-news/important-notice-banned-species/ (accessed 21 May 2025).
26. Pets4Homes. 2025 *Terms and conditions*. See https://www.pets4homes.co.uk/terms/.
27. Roulin A, Ducrest AL. 2011 Association between melanism, physiology and behaviour: a role for the melanocortin system. *Eur. J. Pharmacol*. **660**, 226–233. (doi:10.1016/j.ejphar.2011.01.036)
28. Ducrest AL, Keller L, Roulin A. 2008 Pleiotropy in the melanocortin system, coloration and behavioural syndromes. *Trends Ecol. Evol*. **23**, 502–510. (doi:10.1016/j.tree.2008.06.001)
29. Castella B, Golay J, Monney JC, Golay P, Mebert K, Dubey S. 2013 Melanism, body condition and elevational distribution in the asp viper. *J. Zool*. **290**, 273–280. (doi:10.1111/jzo.12037)
30. Venkatesh KMV, Roulin A. 2025 The function of melanin-based colour polymorphism in cattle, sheep and goats. *Pigment Cell Melanoma Res*. **38**, e70024. (doi:10.1111/pcmr.70024)
31. Pet Food Manufacturers Association and Federation of British Herpetologists. 2021 Reptile and Amphibian Keepers' Survey. See https://www.thefbh.org/ (accessed 11 December 2024).
32. Tapley B, Griffiths RA, Bride I. 2011 Dynamics of the trade in reptiles and amphibians within the United Kingdom over a ten-year period. *Herpetol. J*. **21**, 27–34.
33. Lynn VJ, Roberts DL. 2023 Nomenclature in the online reptile trade. *Oryx* **57**, 15–22. (doi:10.1017/S0030605322000552)
34. Valdez JW. 2021 Using google trends to determine current, past, and future trends in the reptile pet trade. *Animals* **11**, 676. (doi:10.3390/ani11030676)
35. McMillan KM, Harrison XA, Upjohn MM, Christley RM, Casey RA. 2024 Estimation of the size, density, and demographic distribution of the UK pet dog population. *Sci. Rep.* **14**, 31746. (doi:10.1038/s41598-024-82358-y)
36. Ross KE, Langford F, Pearce D, McMillan KM. 2023 What patterns in online classified puppy advertisements can tell us about the current UK puppy trade. *Animals* **13**, 1682. (doi:10.3390/ani13101682)
37. Bielby J, Ferguson A, Rendle M, McMillan KM. 2023 Online classified adverts reflect the broader United Kingdom trade in turtles and tortoises rather than drive it. *PLoS One* **18**, e0288725. (doi:10.1371/journal.pone.0288725)
38. Agresti A. 2012 *Categorical data analysis*. Hoboken, NJ: John Wiley & Sons.
39. R Core Team. 2022 R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. See https://www.R-project.org/.

40. Wickham H *et al*. 2019 Welcome to the Tidyverse. *J. Open Source Softw*. **4**, 1686. (doi:10.21105/joss.01686)
41. Wickham H. 2024 rvest: Easily Harvest (Scrape) Web Pages. R package version 1.0.4. See https://rvest.tidyverse.org/.
42. Wickham H. 2022 _stringr: Simple, Consistent Wrappers for Common String Operations_. R package version 1.5.0. See https://CRAN.R-project.org/package=stringr.
43. Wickham H, Vaughan D, Girlich M. 2024 tidyr: Tidy Messy Data. R package version 1.3.1. See https://github.com/tidyverse/tidyr.
44. Wickham H, François R, Henry L, Müller K, Vaughan D. 2023 dplyr: A Grammar of Data Manipulation. R package version 1.1.4. See https://dplyr.tidyverse.org.
45. Wickham H. 2016 Ggplot2: elegant graphics for data analysis. New York, NY: Springer. See https://ggplot2.tidyverse.org.
46. Kunst J. 2022 Highcharter: A Wrapper for the 'Highcharts' Library. See https://github.com/jbkunst/highcharter.
47. Cacioppo JA, Perry SM, Rockwell K, Mitchell MA. 2020 A survey of husbandry and breeding techniques in the ball python (*Python regius*) pet trade. *J. Herpetol. Med. Surg*. **31**, 25–35. (doi:10.5818/JHMS-05-2020)
48. National Archives. 2018 *The Animal Welfare (Licensing of Activities Involving Animals) (England) Regulations 2018*. See https://www.legislation.gov.uk/uksi/2018/486/schedule/4/made.
49. Bielby J, McMillan K, Davies G. 2025 It's not fur: newspaper article reporting of abandonment and relinquishment of pets exhibit taxonomic biases in framing and language use. *R. Soc. Open Sci*. In print.
50. RSPCA. 2024 Kindness Index. See https://www.rspca.org.uk/whatwedo/latest/kindessindex/annual/report2024#top (accessed 19 December 2024).
51. Fish RD, Austen GE, Bentley JW, Dallimer M, Fisher JC, Irvine KN, Bentley PR, Nawrath M, Davies ZG. 2024 Language matters for biodiversity. *Bioscience* **74**, 333–339. (doi:10.1093/biosci/biae014)
52. Matsubara S, Deeming DC, Wilkinson A. 2017 Cold-blooded cognition: new directions in reptile cognition. *Curr. Opin. Behav. Sci*. **16**, 126–130. (doi:10.1016/j.cobeha.2017.06.006)
53. Nagabaskaran G, Burman OH, Hoehfurtner T, Wilkinson A. 2021 Environmental enrichment impacts discrimination between familiar and unfamiliar human odours in snakes (*Pantherophis guttata*). *Appl. Anim. Behav. Sci*. **237**, 105278. (doi:10.1016/j.applanim.2021.105278)
54. Freiburger T, Miller N, Skinner M. 2024 Olfactory self-recognition in two species of snake. *Proc. R. Soc. B* **291**, 20240125. (doi:10.1098/rspb.2024.0125)
55. Haddon C, Burman OH, Assheton P, Wilkinson A. 2021 Love in cold blood: are reptile owners emotionally attached to their pets? *Anthrozoös* **34**, 739–749. (doi:10.1080/08927936.2021.1926711)
56. Azevedo A, Guimarães L, Ferraz J, Whiting M, Magalhães-Sant'Ana M. 2022 Understanding the human–reptile bond: an exploratory mixed-methods study. *Anthrozoös* **35**, 755–772. (doi:10.1080/08927936.2022.2051934)
57. De la Fuente MF, de Araújo BMC, da Silva Policarpo I, Pereira HM, Borges AKM, Vieira WLS, Pereira Filho GA, Alves RRN. 2023 Keeping reptiles as pets in Brazil: keepers' motivations and husbandry practices. *J. Ethnobiol. Ethnomed*. **19**, 46. (doi:10.1186/s13002-023-00618-z)
58. Crisante A, Burman OH, Wilkinson A. 2023 Does ownership impact perception of reptile cognitive abilities and welfare needs? *Appl. Anim. Behav. Sci*. **268**, 106067. (doi:10.1016/j.applanim.2023.106067)
59. Bielby J, Rendle M, Impey K, Atkins D. 2026 Supplementary material from: Ball python trade dynamics on UK online classified advertisement sites. FigShare (doi:10.6084/m9.figshare.c.8317492)