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Reptile expos: an analysis and recommendations for control

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Reptile expos are typically itinerant events at which live wild-caught and/or captive-bred turtles, tortoises, crocodiles, lizards, and snakes are displayed, sold, or exchanged for pet keeping purposes. We conducted a literature review and analysis of reports regarding animal welfare and public health issues of concern associated with the display and sale of reptiles at expos in Europe and North America. We also conducted a limited survey of several relevant government authorities to briefly appraise existing situations regarding governance and law internationally, and performed a further limited examination of online advertisements in order to estimate the number of events. In addition, we conducted an analysis comparing husbandry standards for reptile expos versus other animal display or sale situations using UK formal legal guidance, which adopts the Five Welfare Needs as a basis. Finally, we also conducted a SWOT (strengths, weaknesses, opportunities, and threats) analysis of key features associated with reptile expos. We identified at least 10 animal welfare and 5 public health and safety problems as occurring and endemic to the typical operation of reptile expos. Comparisons between the ways in which animal welfare and public health issues are regarded or managed for reptile expos in relation to, for example, traditional zoos, mobile zoos, and pet sales are stark and concerning, with expos constituting the least protective and potentially most harmful situations out of all captive reptile-keeping scenarios. The lack of monitoring and control of reptile expos, combined with their frequent occurrence, strongly indicates the requirement to urgently control and prohibit these events. We recommend that where reptile expos are already essentially prohibited such bans should be immutable and not subject to any weakening provisions. Where reptile expos are permitted and/or subject to limiting conditions, or where reptile expos are not subject to limiting conditions, then our recommended 40 stipulations and overarching control principles should be applied as interim mitigating measures pending the introduction of prohibitions or 'bans'. Governments should aim to ensure that enforcement of such measures is robust.

KEYWORDS

reptile expo, reptile show, exotic pet market, animal welfare, zoonoses, public health, government control, government legislation

1 Introduction

Reptile expos (also referred to as shows, markets, breeders' meetings, or fairs) are typically itinerant events at which live wild-caught and/or captive-bred turtles, tortoises, crocodiles, lizards and snakes are displayed, sold, or exchanged for pet keeping purposes (Arena et al., 2012; Altherr, 2014; Schoonover, 2019; D'Cruze et al., 2020; Warwick and Steedman, 2021). Whilst some entirely non-trade-related events may occasionally occur, reptile expos are frequently and largely commercial, although often portrayed as 'hobbyist' gatherings by some organisers in order to avoid trade-relevant laws (Arena et al., 2012; Altherr, 2014; D'Cruze et al., 2020). There can be some similarity between reptile expos as characteristically observed in Europe and North America and wildlife markets that occur in, notably, Asia and South America. In particular, European and North American reptile expos almost exclusively sell animals for pets, whereas in Asia and South America, animals may be offered or acquired for purposes including human food, traditional local medicines, curio products, or pets (Warwick and Steedman, 2021). Some expo events involve animal classes other than reptiles (e.g., invertebrates, fishes, amphibians, and mammals) and may be broadly described as featuring exotic animals (Arena et al., 2012).

Reptile expos have raised several major and recurring concerns as expressed by non-governmental organisations as well as the scientific community, notably regarding poor animal welfare (Arena et al., 2012; Altherr, 2014; D'Cruze et al., 2020), threats to public health and safety, from zoonotic infections (Arena et al., 2012; Warwick et al., 2012b; Warwick and Steedman, 2021), propagation of emergent disease spill overs (Warwick and Steedman, 2021; Vora et al., 2023), introduction of invasive alien species (Arena et al., 2012; Altherr, 2014; Warwick and Steedman, 2021), trading of threatened or endangered species (Arena et al., 2012; Altherr, 2014; Nijman and Stoner, 2014; Auliya et al., 2016; Hruby, 2019; Altherr and Lameter, 2020; Das and Auliya, 2021), selling of wild-caught animals (Arena et al., 2012; Altherr, 2014; Auliya et al., 2016; Altherr and Lameter, 2020), and misrepresentation of operational status to avoid legal controls (Arena et al., 2012; Auliya et al., 2016). Relatedly, the overall ethics of trading and keeping of reptiles generally has also been challenged (Warwick, 2014).

Reptiles are accepted to possess sentience, as well as the abilities to sense pain and stress (Lambert et al., 2019; Learmonth, 2020; Arena et al., 2023; Font et al., 2023; Lillywhite, 2023); thus, as for other animals, they warrant concern for their welfare and life quality. Moreover, contrary to some perceptions, many if not most reptilian lifestyles manifest complex behavioural repertoires and psychological performances, including sociality, play, environmental awareness, self-awareness, sensory perception, and mental abilities to problem-solve and numerically count that frequently competes with or exceeds birds and mammals [e.g (Burghardt, 1998; Manrod et al., 2008; Wilkinson and Huber, 2012; Burghardt, 2013; Szabo et al., 2021; Arena et al., 2023; Burghardt and Layne-Colon, 2023; Doody, 2023; Font et al., 2023; Gillingham and Clark, 2023)]. However, although there is some overlap with other animal classes, reptilian biology and welfare is also strongly dominated by certain highly specialised features, notably ectothermy and thermoregulation, metabolic and energetic rate, innateness and ancestral traits, and nocturnality. Reptile expos involve environments that are notably deprived in respect of, for example, positive stimulation and habitat diversity, and also overly represented by negative stimulation, for example, severe spatial restriction and disturbances. These issues imply significant impacts on welfare and disfavourably weigh against any perceived strengths promoted for reptile expos, as further indicated in our SWOT analysis.

Reptilian life under natural conditions is complex, and whilst little is known regarding biological histories in the wild for most reptile species, no information is comprehensive for any reptile species (Warwick et al., 2023a). Importantly, as objective data regarding reptile biology in the wild is increasing, this knowledge confirms that these animals are highly evolved in terms of environmental, physiological, behavioural, and psychological developments and requirements (Warwick et al., 2023a). Below, we present very brief summary comparisons between selected features of natural biology for two reptile species that are commonly kept as pets, and which offers insight into some marked differences between wild *versus* captive lifestyles.

For example, bearded dragons (*Pogona vitticeps*) are members of the Agamid lizard family native to eastern and central Australia, and are one of the most commonly sold and kept pet reptiles, and frequently occur at reptile expos. Free-living bearded dragons occupy large home ranges of up to 45,000 m^2, which involves diverse habitat types including desert, scrubland, and dry forest (Craig et al., 2007). These lizards, which may reach approximately 60 cm in length, are opportunistic omnivores consuming a wide variety of invertebrates and vegetable matter, and occasional small mammals or reptiles (Kubiak, 2020). Although not highly social, their behaviour is significantly hierarchical and territorial (Oonincx et al., 2015; Kubiak, 2020). Formal government guidance for pet selling establishments in the UK advises spatial provisions of 4 x snout-to-vent length by 2.5 x snout-to-vent length as being suitable to house 2-3 adult lizards (DEFRA, 2023b). The formal guidance also stipulates suitability of environment, enrichment accessories to stimulate natural behaviour appropriate to the species, substrate, temperatures, humidity, light, water quality, ability to hide, and ability to bathe.

Corn snakes (*Pantherophis guttatus*) are members of the Colubrid family native to North America, and are one of the most commonly sold and kept pet reptiles. Free-living corn snakes occupy large home ranges of up to approximately 79,000 m^2, which involve diverse habitat types including fields, trees, open habitat, and dry forest, and a range of altitudes to 1800 m (Conant and Collins, 1991; Hedley and Eatwell, 2018). These snakes, which may reach approximately 150 – 180 cm in length, are carnivorous and ovivorous, feeding on a variety of herpetofauna, mammals and birds as well as birds' eggs (Conant and Collins, 1991; Rush et al., 2014). The snakes are largely solitary and crepuscular or nocturnal (Conant and Collins, 1991). Formal government guidance for pet selling establishments in the UK advises spatial provisions of 2/3 x 1/3 snake length as being suitable housing (DEFRA, 2023b). The formal guidance also stipulates suitability of environment,

enrichment accessories to stimulate natural behaviour appropriate to the species, substrate, temperatures, humidity, light, water quality, ability to hide, ability to bathe.

The examples above only minimally summarise factors relevant to life in the wild; thus far greater complexity can be assumed. Indeed, life under natural conditions may be regarded as being incalculably more complex than currently understood by science, which raises major questions regarding the extent to which the biological requirements of animals may be significantly under-appreciated and unmet at reptile expos.

Public health and safety issues associated with reptile keeping generally, which is relevant to expos, include risks of injury (such as bites, scratches, envenomations, associated infections and allergic reactions) (de Haro and Pommier, 2003; Schaper et al., 2009; Warwick and Steedman, 2012). However, for this report we will focus on the public health issues of zoonoses, which are infections transmissible from animals (here reptiles) to humans, because little information appears to be available regarding injuries from animals to people. Approximately 200 zoonoses are known, and involve bacterial, viral, fungal, and parasitic pathogens (Warwick et al., 2012a). Despite the diversity of zoonotic agents linked to reptiles, *Salmonella* spp. constitute the most commonly reported infections (Mermin et al., 2004; Zając et al., 2021), with approximately 70,000 occurring in the United States, and 6,000 in the United Kingdom annually (Woodward et al., 1997; Mermin et al., 2004; Toland et al., 2012). Among more than 1,400 surveyed human diseases, over 60% have been identified as being of potentially zoonotic origin (Karesh et al., 2005), and at least 40 are associated with reptiles (Warwick et al., 2012a). Also, among global emerging human diseases, 75% have a wild animal link (Brown, 2004). Accordingly, based on the diversity of species involved and the accessibility of the public to these animals, their environments, and the probability of widespread contamination, reptile expos can be considered significant hubs of potential zoonotic infection.

The probable presence of atypical or exotic pathogens at reptile expos has been highlighted as an important concern (Warwick et al., 2012a, b; Zając et al., 2013). A recent large-scale study sampled 731 reptiles and their environments at exhibitions to determine the presence or otherwise of *Salmonella* (Zając et al., 2021), and found *Salmonella* to be present in 92% of snakes, 84% of lizards, and 60% of turtles. *Salmonella* was also found in 82% of swabs from table and floor surfaced post reptile exhibition. In total, the study found 918 strains of *Salmonella* belonging to 207 serovars and serological variants, including types of high public health significance. Whilst there are relatively few case reports [e.g (Weiss et al., 2011)] of infection directly attributable to attendance at reptile expos, this situation is likely symptomatic of classic under-reporting due to habitual disassociation – infections occurring without determining a causal link, which is exacerbated by inadequate investigation of patients by health care professionals (Warwick and Corning, 2013).

The global numbers of reptile expos are unknown. The number of reptiles presented at each event is variable, but it has been estimated that tens of thousands of animals may be displayed or sold at a single venue (Hruby, 2019). A considerable diversity of animals is frequently available at reptile expos, and one study identified at least 148 species at three individual events across Spain, The Netherlands, and United Kingdom (Arena et al., 2012). In some countries or regions, reptile expos that include a commercial nature are effectively prohibited (e.g., in UK), whereas in others they are either legally permitted (e.g., regions of Canada, the United States, Belgium, Germany, Spain, The Netherlands), or otherwise continue to manifest regardless of intended controls (e.g., UK, regions of the USA) (Arena et al., 2012; Altherr, 2014; Auliya et al., 2016; Altherr and Lameter, 2020).

This report focuses on animal welfare, including relevant key biological factors, and public health and safety issues pertinent to expos in Europe (Belgium, Germany, Spain, The Netherlands, United Kingdom), and North America (Canada and the United States), which are known to host many examples, as well as some relevant management concerns. We also present examples of legislation and/or regulations and their ability or otherwise to control relevant problems associated with these events. In addition, we also present a SWOT (strengths, weaknesses, opportunities, and threats) analysis of key features associated with reptile expos. We aim to summarise the key characteristics of reptile expos as well as the concerns and problems associated with their operation. Finally, given the lack of objective guidance or controls pertaining to reptile expos, this report also aims to produce recommendations and stipulations that may be widely applied to the range of problematic issues using existing frameworks or where regulation is absent.

2 Methods

We conducted a literature search using the engines Scopus and Google Scholar (Box 1) for peer-reviewed reports published between 2010 and present, with a view to collating, in particular but not exclusively, reported information and concerns regarding animal welfare, public health and safety, general management issues, and governance and law internationally. A number of reports were unavailable due to inaccessibility or irrelevant due to their peripheral nature as indicated by their titles or abstracts. Google Scholar also includes non-peer reviewed material and secondary sources, which contributed to the requirement for removal. Google Scholar searches for words that are contained anywhere in an article, which leads to identification of significant numbers of both relevant and irrelevant reports. Numerous reports were captured that constituted duplicates held within the authors' own libraries and are effectively contained under the 'removal of duplicates' in Box 1. Relevant reports were analysed by comprehensive examination to identify any cited concerns arising from reptile expos. Each concern was listed sequentially in a table, such as "lack of water" or "barren environment" along with its reference or source. When all papers had been analysed, similar concerns were grouped together and tabulated. Our literature review followed the guidelines for rapid reviews (Khangura et al., 2012; Dobbins, 2017). From the literature review we identified and categorised reports regarding animal welfare and public health issues of concern associated with the display and sale of reptiles at expos.

Also, to briefly appraise existing regulations, we conducted (via email) a limited survey of several relevant government authorities in

BOX 1 Search results from Scopus and Google Scholar for reptile expos.

Search terms: "reptile show" OR "reptile expo" OR "reptile breeders meeting" OR "reptile fair" OR "reptile market" from 2010 to the present day. Total retrieved from search SCOPUS: 228 Total retrieved from Scholar: 223 Total retrieved: 451	
Results	
Removed as unavailable, irrelevant or not in English*	365
Downloaded for further examination	86
Remaining after removal of irrelevancies or duplicates	13
Removal of irrelevancies or duplicates	73
Added from authors' libraries	27
Total used in review	40

*Due to the search algorithm in Google Scholar, the search identified many papers not all of which were relevant.

Europe (Belgium, Germany, Spain, The Netherlands, United Kingdom) (some regional data was further obtained from Germany and Spain on reference from national departments) and provincial/state government departments in North America (Canada and the United States). We sought information from relevant departments by describing the nature of reptile expos as: *"Events of interest are those typically named or referred to as: reptile shows, reptile expos, reptile markets, reptile trade fairs, reptile fairs, reptile breeders' meetings. These events characteristically include the display and sale of reptiles (whether wild-caught of captive-bred) by commercial or non-commercial entities. Events are usually itinerant, occur over one or two days, and may occur infrequently or regularly at venues accessible to the public"* and asked the following questions: "*1. How many, if any, of these events do you experience in your jurisdiction annually? 2. What, if any, formal or informal regulations do you have to manage animal welfare and public health and safety at these events?*" We contacted 88 government authorities and received 43 responses. The survey was emailed to at least one relevant government authority in each country or region with a request to either supply contact information for, or forward the email to, a contact most able to answer the questions. Responses were summarised by documenting the numbers of events as estimated or known by each relevant authority, and whether or not an authority operated particular legislation, or issued guidance. We also performed a limited examination of online advertisements in order to estimate the number of events using Google (for Europe and Canada) and Opera (for US) search engines. The name of the region followed by 'reptile expo' was used to make each search and the number of relevant expos advertised collated from the first page-scroll, which included approximately 50-60 entries after which results were found to be of low relevance or repetitious. We also used the Five Welfare Needs model (RSPCA, 2006) to analyse key comparisons regarding legal stipulations for animal husbandry, as well as public health and safety, at four display and sale situations. Finally, we also conducted a SWOT (strengths, weaknesses, opportunities, and threats) analysis of key features associated with reptile expos. Each key feature was itemised by reading all relevant reports and including any or all issues that were clearly identifiable within the remits of the four SWOT criteria. Strengths imply areas that work well or function, although these relate to factors that benefit organisers and attendees of expos. Manifestly, many people obtain some benefits, for example, financial or enjoyment. Weaknesses imply areas of under-performance or failure and that require change. Because weaknesses imply problems, they are also indirectly related to threats. Opportunities imply areas where improvements or changes can or should be made in order to ameliorate or resolve weaknesses and threats. Threats imply areas of actual or potential problems of concern, which in some respects also relates to weaknesses.

3 Results

3.1 Animal welfare

Table 1 provides information from the published literature regarding animal welfare issues of concern associated with the display and sale of reptiles at expos. The body of evidence in the table presents both hazards and welfare consequences, and relates to

TABLE 1 Documented concerns regarding reptile expos: animal welfare.

Concern	References
Unenriched, barren, or deprived environments	(Arena et al., 2012; Sollund, 2017; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023)
Absence of food or water	(Arena et al., 2012; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023)
Severe spatial restriction	(Arena et al., 2012; Sollund, 2017; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023)
Crypto-overcrowding (inability for all animals to	(Arena et al., 2012; Warwick and Steedman, 2021; Warwick, 2023)

(Continued)

TABLE 1 Continued

Concern	References
use any single provision at one time)	
Held in accommodation designed as temporary, for prolonged periods of time	(Arena et al., 2012; Sollund, 2017; D'Cruze et al., 2020)
Invasive disturbances: transportation, handling, sound, noise, vibration, light, and observation stress	(Arena et al., 2012; Sollund, 2017; D'Cruze et al., 2020; Warwick and Steedman, 2021)
Psychological stress and abnormal behaviour	(Arena et al., 2012; D'Cruze et al., 2020; Warwick and Steedman, 2021)
Injury and disease	(Arena et al., 2012; Borza et al., 2012; Schoonover, 2019; Hellebuyck et al., 2021; Warwick and Steedman, 2021; Vetere et al., 2022; Eurogroup for Animals, 2023)
Miseducation, deficient knowledge-bases, and impulse purchases	(Arena et al., 2012; Schoonover, 2019; D'Cruze et al., 2020)
Encouragement of impulse purchases	(Arena et al., 2012; Schoonover, 2019; D'Cruze et al., 2020; Warwick and Steedman, 2021)

housing, management, and behaviour, as well as health parameters of the animals.

3.2 Public health and safety

Table 2 provides information regarding reported health and safety issues of concern associated with the display and sale of reptiles at expos. The table presents issues relevant to pathogens, contagious diseases, resistance to (veterinary/human) drugs/medicines, disease threats, and control measures.

TABLE 2 Documented concerns regarding reptile expos: public health.

Concern	References
Contact with animals and their environments, and dispersal of pathogens	(Arena et al., 2012; Warwick et al., 2012b; D'Cruze et al., 2020)
Poor or no hygiene control	(Arena et al., 2012; Warwick et al., 2012b; D'Cruze et al., 2020)
Presence of antimicrobial-resistant pathogens	(Zając et al., 2013)
Probable presence of atypical/exotic zoonotic pathogens	(Arena et al., 2012)
Pandemic threats	(Arena et al., 2012; Warwick, 2020a, b; Warwick and Steedman, 2021)

3.3 Governance, law and number of events

In respect of our survey of government authorities, minimal responses were received from agencies. Most countries and regions have generalised animal protection regulations under which, theoretically, most or all captive situations fall, although these may not specifically relate to reptile expos but retain relevance. General legislation also applies to the movement, sale, and keeping of listed threatened, injurious, invasive, and, sometimes, native species in Europe and North America. Specific regional responses regarding number of events and applicable legislation are provided in Appendix 1.

Amongst the responding governments the estimated numbers of reptile expos per region were up to: Europe $n = 56$, and North America $n = 196$ (Canada $n = 15$, US $n = 181$). Survey responses were received from 29 of 50 US States, 6 of 13 Canadian Provinces and Territories and 6 of 7 European countries. However, various government departments in any region may be involved in the regulation of expo type events depending on, for example, the individual species involved (e.g., native or non-native, invasive or not), importation regulations, or public health risks (e.g., large or venomous reptiles or zoonotic risks). Not all relevant departments were contactable via the email survey because some regions and/or government departments either do not have publicly accessible emails or block emails from out-of-country sources, leading to incomplete data. However, due to the incomplete responses received, variability of type of information provided by respondents, and challenges to standardisation, the information summarised below and in Appendix 1 should be regarded as offering only very approximate examples of legislative approaches or their absence regarding reptile expos, as well as the number of events occurring.

From limited examination of events advertised online, we identified that at least 61 reptile expos occur annually in Europe (Belgium $n = 6$, Germany $n = 33$, Spain $n = 5$, The Netherlands $n = 15$, United Kingdom (England) $n = 2$), and 163 reptile expos in North America (Canada $n = 21$, United States $n = 142$).

We also compared husbandry standards for reptile expos versus other animal display or sale situations using UK formal guidance (DEFRA, 2023a; DEFRA, 2023b; UK Government, 2023c) in relation to the Five Welfare Needs model (Appendices 2A–E). Our analysis identified no specific governmental guidance provisions for the welfare or management of reptiles at expos. In addition, we used English Government legal provisions (DEFRA, 2023a; DEFRA, 2023b; UK Government, 2023c) to provide comparative examples concerning legal stipulations for public health and safety regarding four different animal

display or sale situations: static zoos; mobile zoos; pet retail or wholesale sellers; and reptile expos (Appendices 3A–E). Our analysis identified no specific governmental guidance provisions pertaining to public health and safety at expos.

3.4 SWOT analysis

Our SWOT (strengths, weaknesses, opportunities, and threats) analysis of reptile expos is provided in Box 2 below.

BOX 2 SWOT (strengths, weaknesses, opportunities, and threats) analysis of reptile expos (no particular order).

Strengths (Areas that 'work well' for these events.)	Sources	Weaknesses (Areas of under-performance ['Threats' can constitute an implicit extension of this category].)	Sources
Commercial financial income for sellers.	Arena et al., 2012; Hruby, 2019; Altherr and Lameter, 2020; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023	No governmental regulation.	Arena et al., 2012; Hruby, 2019; Warwick and Steedman, 2021
Private financial income for sellers.	Arena et al., 2012; Hruby, 2019; Altherr and Lameter, 2020; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023	Limited governmental regulation.	Arena et al., 2012; Warwick et al., 2012a; Hruby, 2019; Warwick and Steedman, 2021
Abilities to obtain animals commercially.	Arena et al., 2012; Hruby, 2019; Altherr and Lameter, 2020; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023	Non-specific governmental regulation	Arena et al., 2012; Hruby, 2019; Warwick and Steedman, 2021
Abilities to obtain animals privately.	Arena et al., 2012; Hruby, 2019; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023	Minimal and/or erroneous local governmental managemental guidance for animal welfare.	Arena et al., 2012; Warwick and Steedman, 2021
Enjoyment by reptile breeders and sellers.	Arena et al., 2012; Eurogroup for Animals, 2023	No mandatory independent objective managemental guidance.	Arena et al., 2012; Warwick et al., 2012b; Warwick and Steedman, 2021
Public entertainment.	Arena et al., 2012; Eurogroup for Animals, 2023	Poor or no hygiene control.	Arena et al., 2012; Warwick et al., 2012b; Warwick and Steedman, 2021
Social interaction.	Eurogroup for Animals, 2023	Financial transactions often unrecorded.	Arena et al., 2012; Hruby, 2019
		Lack of ethical oversight.	Arena et al., 2012; Hruby, 2019; Eurogroup for Animals, 2023
Opportunities (Areas offering improvement or resolution.)	**Sources**	**Threats (Areas of actual or potential problems of concern.)**	**Sources**
Introduction of immediate or future bans.	Arena et al., 2012; Warwick and Steedman, 2021	Animal welfare.	Arena et al., 2012; Warwick, 2014; Hruby, 2019; Warwick et al., 2019; D'Cruze et al., 2020; Warwick and Steedman, 2021; Eurogroup for Animals, 2023
Introduction of interim specific governmental regulation pending bans.	Arena et al., 2012; Warwick and Steedman, 2021		
Introduction of ethical oversight.	Arena et al., 2012; D'Cruze et al., 2020	Public health (epidemic or pandemic).	Arena et al., 2012; Warwick et al., 2012a, b; Warwick and Steedman, 2021; Eurogroup for Animals, 2023
Development and introduction of mandatory independent objective managemental recommendations and stipulations.	Altherr and Lameter, 2020; D'Cruze et al., 2020; Warwick and Steedman, 2021; Jessop et al., 2023	Animal health (epidemic or pandemic).	Arena et al., 2012; Warwick and Steedman, 2021; Eurogroup for Animals, 2023

(Continued)

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Opportunities (Areas offering improvement or resolution.)	Sources	Threats (Areas of actual or potential problems of concern.)	Sources
Monitoring of all financial transactions.	Arena et al., 2012; D'Cruze et al., 2020	Promotion of anti-microbial resistant pathogens.	Warwick et al., 2012a; Warwick and Steedman, 2021
		Public safety.	Arena et al., 2012; Warwick et al., 2012a; Warwick and Steedman, 2021; Eurogroup for Animals, 2023
		Release of invasive species and threats to biodiversity.	Arena et al., 2012; Warwick and Steedman, 2021; Eurogroup for Animals, 2023
		Miseducation.	Arena et al., 2012; Warwick et al., 2012b; Jessop et al., 2023
		Encouragement of impulse purchases Illegal trading of wildlife.	Arena et al., 2012; Warwick and Steedman, 2021
		Illegal trading of threatened and endangered species.	Arena et al., 2012; Altherr, 2014; Hruby, 2019; Altherr and Lameter, 2020; Warwick and Steedman, 2021
		Promotion of activities with threats to habitat ecology, biodiversity, and species conservation.	Arena et al., 2012; Altherr, 2014; Hruby, 2019; Altherr and Lameter, 2020; Warwick and Steedman, 2021

4 Discussion

Animal welfare and public health issues are increasingly recognised as importantly integrated under the 'one-health' umbrella, which summarises a paradigm in which environment, animals, and people are interconnected (Rabozzi et al., 2012; Cantas and Suer, 2014; Garciá Pinillos, 2021; Broom, 2022; CDC, 2022). For example, chronically stressed animals may be more likely to shed potentially zoonotic and other cross-species infections that may negatively and diversely affect animals, people and ecologies. Relatedly, collection of wild animals for the pet trade can involve major disturbances to habitat ecologies and contribute to emergent diseases and pandemics (García-Moreno, 2023). Therefore, reptile expos encompass a range of issues that collectively come under the one-health paradigm. Our investigation identified numerous specific animal welfare and public health and safety concerns, as well as general management concerns, associated with reptile expos. For our SWOT analysis (Box 2) we drew together key aspects mentioned in the literature and categorised these according to strengths, weaknesses, opportunites, or threats, as implied in the test. Evidently, overall, far more areas were associated with problems than with benefits. Below, we further examine each of these concerns.

4.1 Animal welfare

The animal welfare concerns that we identified were, in particular: unenriched, barren, or deprived environments; absence of food or water; severe spatial restriction; crypto-overcrowding (inability for all animals to use any single provision at one time); animals held in accommodation designed as temporary, for prolonged periods of time; invasive disturbances: transportation, handling, sound, noise, vibration, light, and observation stress; psychological stress and abnormal behaviour; and injury and disease (Table 1). Animal welfare issues also featured negatively within our SWOT analysis (Box 2).

4.1.1 Unenriched, barren or deprived environments; absence of food or water; severe spatial restriction, crypto-overcrowding

Unenriched, depauperate and deprived environments are commonly present at reptile expos, for both solitary or multiple occupant situations, including inadequate or no provision or management for climate control within enclosures or opportunities for basking, severe restrictions regarding mobility, inadequate shelter, lack or absence of water and food, lighting, and humidity needs, insufficient or absent substrate, inadequate burrowing facilities, and poor hygiene (Arena et al., 2012; D'Cruze et al., 2020), all of which are likely to cause stress (Burghardt, 2013).

Figures 1–4 provide examples of typical husbandry conditions for a variety of reptiles at expos.

The extremely restrictive spatial conditions affect most animals, in particular snakes, which are prevented from extending their bodies or engage in any locomotor movement (Arena et al., 2012; D'Cruze et al., 2020). The overwhelming objective scientific research and guidance stipulates that snakes must be able to fully stretch in their enclosures as part of essential normal behaviour and health maintenance [e.g (Warwick et al., 2018, 2019; Spain et al., 2020; Hollandt et al., 2021; Warwick et al., 2021; Cargill et al., 2022)]. A recent UK Government scientific review concluded that snakes should be able to fully stretch in all enclosures (AWC, 2023). Relatedly, at least 20 problematic clinical and 24 behavioural issues

FIGURE 1
Tortoises in display/sale containers at Hamm, Germany. (Credit: Phillip Arena).

FIGURE 3
Juvenile snakes in display/sale containers at Hamm, Germany. (Credit: Phillip Arena).

have been identified with the use of such diminutive enclosures for snakes, which is also relevant to conditions typical at reptile expos (Warwick et al., 2019; Arena and Warwick, 2023). Many other species, notably lizards, are also subject to severe spatial limitations at reptile expos, in which animals are incapable of fully extending their bodies (tip of snout to tip of tail) and freely moving around within their enclosures (Arena et al., 2012). Indeed, most animals are effectively forcibly coiled within diminutive plastic tubs or boxes. Accordingly, spatially overly-restrictive containers and major restriction of movement are a considerable concern (Arena et al., 2012, 2023).

Long periods without food, water, or exercise (e.g., including inter-state or international travel to and from venues) (Arena et al., 2012) are considered to constitute significant stressors, which may also become cumulative factors that negatively affect health (Arena et al., 2012, 2023; Mancera and Phillips, 2023; Warwick, 2023). Relatedly, crypto-overcrowding refers to situations where, regardless of available space, all animals cannot use any single provision at the same time (Warwick et al., 2018; Warwick, 2023). For example, any enclosure that contains a water vessel or basking area that all animals cannot fully utilise together and simultaneously infers crypto-overcrowding. Thus, whilst spatial factors may superficially appear adequate, closer inspection can reveal an overcrowded situation. The inherent use of diminutive enclosures and minimalist provisions at reptile expos directly promotes crypto-overcrowding.

Relatedly, reptiles, being ectothermic, are highly dependent on precise environmental conditions to control their body temperature to within fractions of a degree Celsius using behavioural thermoregulation in order maintain homeostasis and the maintenance of normal physiological states, digestion, metabolism, physical activities, immunological condition, and other factors (Frye, 1991; Arena et al., 2023; Gillingham and Clark, 2023; Lillywhite, 2023). Accordingly, highly complex captive conditions regarding artificial climate as well as habitat diversity are vital to promoting good health and welfare and avoiding harm in captive reptiles (Burghardt and Layne-Colon,

FIGURE 2
Gecko lizards in display/sale containers at Doncaster, UK. (Credit: Animal Protection Agency).

FIGURE 4
Adult pythons in display/sale containers at Sabadell, Spain. (Credit: Phillip Arena).

2023; Greenberg, 2023; Mancera and Phillips, 2023; Mendyk and Augustine, 2023; Warwick and Steedman, 2023).

4.1.2 Prolonged and problematic 'temporary' accommodation; animals held in accommodation designed as temporary, for prolonged periods of time

The captive conditions referred to previously, may be argued to constitute temporary arrangements, and thus may not involve enduring stresses for animals. However, such situations, even in the course of a single day, are capable of causing significant and major stress in reptiles, with potentially lasting consequences, such as behavioural frustration, immunological compromise, opportunistic disease, and death (Arena et al., 2012; Warwick, 2023; Warwick et al., 2023c). Moreover, as discussed further below, allied to stressful conditions during the day(s) of display and/or sale, reptiles also frequently face extensive pre- or post-event stressors related to intensive breeding, transportation, handling (direct or indirect within containers or sacks), storage, and other issues (Arena et al., 2012; D'Cruze et al., 2020; Warwick et al., 2023c). Such cumulative stresses reasonably justify the need for even greater than normal relief than other situations; thus, the case can be clearly made that reptile expos have greater than normal obligations to provide enhanced conditions for rest and recovery for animals (Gangloff and Greenberg, 2023; Warwick, 2023). Accordingly, a maximum period of 24 hours has been proposed to define short-term housing (Warwick et al., 2023c). While reptiles may experience captivity-stress under longer-term housing, such as general pet and hobby keeping and zoos, acute disturbances are particularly associated with expos.

4.1.3 Invasive disturbances; transportation, handling, sound, noise, vibration, light, and observation stress

The itinerant nature of reptile expos inherently involves the transportation of animals from holding sites to venues, encompassing handling, sound, noise, vibration, light, and observation stress (Arena et al., 2012; Sollund, 2017; D'Cruze et al., 2020; Mancera and Phillips, 2023). Transportation is typically achieved by confining animals to diminutive containers or sacks, and travel periods can measure hours to days (Arena et al., 2012). Such diminutive containers also frequently act as accommodation for the duration of expos, and then also for the return journey if unsold or onwards after sale, or to another venue, which may involve substantial transnational travel (Arena et al., 2012; Sollund, 2017). Accordingly, reptiles may be confined to such conditions for several days, and static/supply base facilities can also be similarly minimalistic (Arena et al., 2012; Sollund, 2017). Several welfare concerns regarding reptile expos relate to the issues of transportation conditions, the handling of animals and their containers by sellers as well as by many attendees (Arena et al., 2012).

Consequently, reptiles may harbour significant stress burdens preceding, during, and after an expo, as have been identified through established specific behavioural indicators (Martínez-Silvestre, 2014; Benn et al., 2019; Mancera and Phillips, 2023; Warwick et al., 2013a; Warwick, 2023). These probable stress burdens infer that providing as comfortable conditions as possible for reptiles at expos warrant particular attention. In other transport and disturbance situations, following major confinement and transportation stresses, animals may be able to gain some degree of rest and recovery where promptly relocated to better conditions. However, for reptiles at expos, such potential respite is typically not available, which raises particularly serious welfare concerns.

Another issue associated with expos, disturbances and welfare monitoring is the matter of nocturnality among reptiles, which has implications for both invasive disturbances, as well as opportunities to assess the condition of animals. Many species of reptile are nocturnal, and thus are typically active during the night, morning, or evening. Nocturnality strongly conflicts with normal human activity patterns. This conflict implies that human disturbances to animals (caused by noise, vibration, light, and general movement within the environment), may significantly and negatively impact the normal resting periods of reptiles (Mancera and Phillips, 2023; Warwick, 2023). Also, observation of animals, especially, during their normal activity periods, is important in order for caretakers to assess emergent welfare issues (Warwick et al., 2018; Arena and Warwick, 2023; Warwick, 2023). It is probable that caretakers do not sufficiently observe nocturnal reptiles for potential welfare issues (Warwick et al., 2018; Arena and Warwick, 2023).

4.1.4 Psychological stress and abnormal behaviour

Psychological stress and abnormal behaviour are well documented for captive reptiles, including at expos (Arena et al., 2012; Warwick et al., 2013a; Grant et al., 2017; Benn et al., 2019; Warwick, 2023). A study of 1,533 amphibians and reptiles displayed and sold at pet expos in Spain, The Netherlands, and the United Kingdom found that the prevalence of stress-related behaviour was as follows: interaction with transparent boundary 27.5%; hyperactivity 11%; hyper alertness 1.8%; rapid body movement 2.1%; flattened body posture 2.4%; head-hiding 4.6%; inflation of the body 0.5%; other significant signs (e.g., rostral lesion) 1.0% (Arena et al., 2012). Given that observation periods for behaviour during the study were set at one minute, these findings indicate that stress-related behaviour is highly prevalent at reptile expos. Innateness is a significant factor related to aetiology of psychological stress and abnormal behaviour in reptiles. Innateness infers the presence of evolved ancestral, hard-wired, traits and drives that involve genetically programmed behavioural and psychological needs, such as long-distance and complex exploratory locomotor and transient activity, spatial and habitat expectations, prey acquisition, elective social interactions, and other factors (Gillingham and Clark, 2023; Warwick, 2023). Accordingly, reptilian life is adapted to involve these highly programmed features (i.e., to behave and mentally function in natural contexts), which means that in captivity, without their provision, a raft of stress-related behavioural and mental problems occurs due to inherent inabilities to adapt (Warwick, 2023). Within captive conditions numerous stress-related behavioural and mental problems are

linked to conflicts between innate drives and depauperate environments (Arena et al., 2023; Warwick, 2023). Accordingly, causes of psychological stress and abnormal behaviour can be multifactorial, and include inappropriate habitats, inadequate space, imbalanced social structures, and extraneous disturbances.

The above issues are diverse in nature and frequently associated with reptile expos in the literature. However, within our SWOT analysis (Box 2) all these issues can be considered to fall within the criterion of 'Animal welfare' as presented under 'Threats'.

4.1.5 Injury and disease

Injuries and disease among animals at reptile expos raise important concerns. Overly restrictive and inappropriate habitats, overcrowding, crypto-overcrowding, invasive disturbances, and behavioural drivers can each promote exploratory and escape activities in reptiles, which are typically frustrated due to confinement. However, such exploratory and escape activities can lead to physical injuries such as rostral abrasions, injured digits and tails, and aggression, all of which may further invite infection (Frye, 1991; Warwick et al., 2013a). Captivity-stress generally can also increase risks of succumbing to opportunistic infection (Frye, 1991). Reptiles generally have relatively low metabolic and energetic rates; for example, energy expenditure may be approximately 2 - 5% of that compared to similar sized birds and mammals (Nagy, 2005; Donoghue, 2006). Such low rates can have special significance regarding welfare in that the delayed onset of disease and the associated lag-phases regarding signs may obscure identifiable illnesses and their original causes, and complicate health assessment or remediation (Frye, 1991). Water and food are often not provided for animals at reptile expos. While the energy and nutritional requirements for reptiles may be relatively low compared with, for example, many birds and mammals, and thus a lower required frequency of sustenance, small reptiles (whether juveniles or diminutive species) may still require frequent nutrition (Lillywhite, 2023). Thus, reptiles may misleadingly appear normal at observation, yet also be experiencing degeneration, latent disease and poor welfare (Frye, 1991). Thus, under-reporting of disease prevalence associated with reptile expos may be assumed. However, some cases of morbidity and mortality in reptiles have been linked to their acquisition at expos. For example, stress-related mortality was reported for a veiled chameleon (*Chamaeleo calyptratus*) (Borza et al., 2012), fatal mycobacteriosis was recorded in a sand boa (*Eryx colubrinus loveridgei*) recently acquired at a reptile show (Vetere et al., 2022), and pentastome infestation in a banded water snake (*Nerodia fasciata*) recently acquired at a reptile show (Farrell et al., 2023).

4.2 Public health and safety

The public health and safety concerns that we identified, association with reptile expos were, in particular: probable presence of atypical/exotic zoonotic pathogens; probable presence of antimicrobial-resistant pathogens; contact with animals and their environments, dispersal of pathogens; poor or no hygiene control; and potential pandemic threats (Table 2). As with other subjects examined during our SWOT analysis (Box 2), public health and safety concerns dominated the weaknesses and threats elements of the text and appear to outweigh the potential human benefits offered by reptile expos.

4.2.1 Contact with animals and their environments, and pathogen dispersal

Handling of animals and contact with their environments are routine features of reptile expos (Arena et al., 2012; Warwick et al., 2012a, b; D'Cruze et al., 2020). The high prevalence of pathogens (notably, but not exclusively, *Salmonella* spp.) in reptiles implies strong risks regarding the presence of contamination in animals and their environments (e.g., enclosures, sellers, table surfaces, display paraphernalia), and thence to humans and their own items (e.g., clothes, carried items). Such prevalent contamination risks microbial transfer and disease in handlers, and also implies probable dispersal of contaminants to others and the wider environment (Warwick et al., 2012a, b; Zając et al., 2021). For example, an observational study of 813 attendees at three reptile expos found that 3.6% had direct contact with an animal and 27.3% had indirect contact with a presumed contaminated source, (Warwick et al., 2012b) within 5 minutes. Also, 18.7% of people made contact in respect of hand-to-mouth, 52.2% hand-to-body, and 19.9% person-to-person (Warwick et al., 2012b). Accordingly, behaviour at reptile expos frequently involves potential or probable contaminated contact episodes to own mouth, hair, clothes, and pockets; person-to-person contact.

4.2.2 Poor or no hygiene control; antimicrobial resistance; probable presence of atypical/exotic zoonotic pathogens

Reptile expos involve inherent challenges to control microbial transfer associated with direct contacts and subsequent re-contamination (Warwick et al., 2012a, b; Zając et al., 2021). Regular cleaning of surfaces is not typically practiced; thus, there is little or no control of fomites (Warwick et al., 2012a, b). Information provided (if any) regarding hygiene control at venues and at point of sale or hand over is also poor, minimalist, or absent (Warwick et al., 2012a, b; Zając et al., 2021). When provided, hygiene advice is typically limited to very low-key guidance regarding voluntary hand-washing (Warwick et al., 2012a, b; Zając et al., 2021), which may be offered to avoid dissuading people from acquiring animals. Hand-washing, whilst recommended, has limited benefits for prevention and control of infections such as salmonellosis (Warwick et al., 2012a, b). Also, the fact that many people touch, for example, their own hair, clothes, or pockets (thus transferring and storing microbes into those areas), implies that even if such measures as hand hygiene were practiced, occult recontamination is likely, and difficult to control (Warwick et al., 2012a, b).

Antimicrobial resistance is a major and growing global concern (WHO, 2016). A study of reptile faecal samples conducted at pet

stores, and private homes, as well as via fomite swabs at reptile exhibitions post-event in Poland identified contamination with atypical and drug-resistant Salmonella lineages (*S. kentucky*), and concluded that potential horizontal transfer of microbes may be facilitated by trade and exhibition practices (Zając et al., 2013). Accordingly, the authors cautioned that in particular carnivorous reptiles (which consume diverse animal-based microbiomes) should be regarded as vectors for multi-drug-resistant infections (Zając et al., 2013, 2021).

4.2.3 Potential pandemic threats

Since 1919 there have been at least 19 major global pandemics associated with wildlife resulting in over 600 million human (excluding Covid-19) and countless animal deaths worldwide (Warwick and Steedman, 2021). Wildlife markets are frequently implicated in these data, and generally are regarded to constitute significant risks as sources of emergent pandemic diseases (Can et al., 2019; Kolby, 2020; Vora et al., 2023), and reptile expos have been categorised alongside these sources (Arena et al., 2012; Warwick, 2020a; Warwick and Steedman, 2021). In addition to being carriers of many bacterial and other pathogens, reptiles are also potentially capable of acting as incidental vectors for important viral agents via ingested prey (Warwick and Steedman, 2021). Few or no quarantine or other importation control are imposed on reptiles because, as ectotherms, they do not transmit certain notifiable pathogens, such as rabies and some agricultural diseases (Warwick and Steedman, 2021). The nature of trading in and keeping of reptiles can frequently involve the wild capture, transport and delivery of animals into commercial hubs and private homes within periods as minimal as approximately 24 hrs (Warwick and Steedman, 2021).

4.3 General management concerns

The general management concerns that we identified in association with reptile expos were lack of veterinary supervision; miseducation, deficient knowledge-bases and impulse purchases; and threats to biodiversity conservation (Table 1). Within our SWOT analysis (Box 2), several problematic weaknesses and threats relate to general management at reptile expos. Individually and cumulatively, these concerns strongly account for the weaknesses and threats identified during our SWOT analysis.

4.3.1 Lack of veterinary supervision

Veterinary supervision to ascertain the health and welfare of animals kept in a variety of situations is widely integral to whether or not they (individual animals or entire collections) can be displayed or sold (Warwick et al., 2013b, 2018). Broadly, veterinarians hold an overriding duty of care to safeguarding welfare and, accordingly, to assessing the state of each animal as well as reporting honestly regarding its condition (Warwick et al., 2013b). However, significant issues are inherent to reptile expos that severely complicate or negate the ability of veterinarians to perform normal inspection duties. To be effective, normal veterinary inspections require detailed examination of individual animals, or at least allow inspectors reasonable assessment enabled by accessibility and ease of observation. Reptile expos frequently involve thousands of animals and the inspecting veterinary team may be very small or even a single individual. Relatedly, many animals are confined in containers with highly limited access, meaning that normal conditions of veterinary inspection are greatly inhibited or impossible. In order to perform reliable and honest examinations and welfare assessments of animals, a high ratio of inspectors to animals would be required so that the health state of all animals could be ascertained prior to the commencement of any reptile expo. Veterinarians declaring animals fit for display and failing to conduct proper health and welfare assessments may constitute false declarations according to relevant codes of conduct, and potentially involve serious repercussions for attending inspectors.

4.3.2 Miseducation, deficient knowledge-bases and impulse purchases

Reptile expos are known to be associated with poor knowledge among exhibitors and sellers of animals, misleading education, poor husbandry, and encouragement of impulse purchases (Arena et al., 2012; D'Cruze et al., 2020). Lack of knowledge and the perpetuation of false or misleading information handed down from keeper to keeper (so-called 'folklore husbandry') among those displaying or selling and keeping animals is an increasingly reported concern, with major welfare implications [e.g (Arbuckle, 2013; Williams and Jackson, 2016; Arena et al., 2023; Jessop et al., 2023; Mendyk and Warwick, 2023)]. Poor husbandry information prior to sale may encourage impulse purchases, and at point of sale or hand over lead to problematic care, animal welfare issues, and unwanted animals (Warwick et al., 2014). Poor information, combined with evolved biological requirements and adaptive limitations, has resulted in widespread recognition that reptiles frequently experience poor care. For example, a six-year study of reptile mortality in the home in the UK found that 75% of reptiles do not survive one year (Toland et al., 2012). Another study of snakes in the home found a mortality rate of 52% in 2 years (Cargill et al., 2022). A study at a commercial seller warehouse in the USA found a mortality rate of 42% in 10 days (testudines, lacertilians, serpents) (Ashley et al., 2014). Whilst tools are available to help would-be keepers make informed decisions regarding whether or not to undertake a pet reptile [e.g (Warwick et al., 2014; Jessop et al., 2023)], uptake of (notably scientific) guidance is also frequently lacking or poor (Howell et al., 2020; Azevedo et al., 2021; Howell et al., 2022; Mendyk and Warwick, 2023).

Another factor that must be considered, is what care the animals will receive in their new homes. Reptile expos encourage impulse buys, sellers may not discriminate to whom they sell, and present examples of poor husbandry that may then be followed, along with the misconception that these are low maintenance pets (Warwick et al., 2014). In addition, inadequate or misleading information is frequently contained in husbandry 'care sheets' that are offered (Arena et al., 2012). Accordingly, the question of the welfare of the animals going forward is worthy of consideration. Although Crisante et al. (2023) found that owners of reptiles were more aware of their cognitive complexity and specialised

requirements than non-owners, welfare problems in captivity persist, as documented, and can be caused in part by a lack of information and knowledge of how to meet these specialised needs. Research into how reptile expos encourage impulse buys by inexperienced owners and the extent to which they bear responsibility for providing accurate information on the complex needs of reptiles would be an interesting area for future research.

4.3.3 Threats to biodiversity conservation

Many reptiles sold by a variety of sellers are harvested from the wild (Böhm et al., 2013). The lack of regulation of the global reptile trade has caused significant declines and threats to very many species (Böhm et al., 2013). Despite regulatory mechanisms, such as the Convention on International Trade in Endangered Species (CITES) and other mechanisms, the illicit trade in reptiles is one of the largest illegal businesses in the world, with traders frequently ignoring regulations (Marshall et al., 2020). The effects of this issue are twofold – depletion of species in the wild, possibly leading to them becoming critically endangered or extinct (Marshall et al., 2020), and other species becoming invasive (for example the red-eared slider (*Trachemys scripta elegans*) has become globally invasive as a result of the pet trade (Espindola et al., 2022)). Reptile expos certainly contribute to this illegal trade and its associated issues, being a minimally regulated way for smugglers to sell reptiles (Arena et al., 2012).

4.4 Governance, law and number of events

Based on the minimal responses to our survey of governments in Europe and North America (Appendix 1), incomplete data and very few controls were identified for reptile expos. Accordingly, from the survey, it was not possible to offer precise figures of scale for reptile expos in Europe or North America. However, the estimates provided by responding governments for the numbers of reptile expos (Europe $n = 56$, North America $n = 196$) were not widely different from the numbers of events identified via our limited online survey of advertisements (for Europe and 61 for North America $n = 163$). In the US alone, it has been estimated that at least 300 itinerant animal events of various configurations, including reptile expos, occur annually (Collis and Fenili, 2011). Our survey of government authorities was limited to selected regions and countries where reptile expos are popular, although many other countries also host these events (Warwick and Steedman, 2021); thus, the reach of this survey was incomplete. Several regional US governments (Alaska, Arizona, Iowa, Mississippi) were unaware of events within relevant jurisdictions, despite their occurrence. Therefore, it appears that there is some disconnect between formal knowledge of reptile expos and actual occurrence of these events. This disconnect emphasises the need for recognition and control of reptile expos in all relevant regions. During our SWOT analysis, problematic weaknesses as well as several opportunities regarding control were identified. Later, we provide detailed protocols for the control of reptile expos.

4.4.1 Comparing husbandry standards for reptile expos versus other animal display or sale situations

Comparing formal stipulations for husbandry between different animal use sectors provides insight into the proposed standards of animal care, which has implications for welfare. The information provided in Appendices 2A–E and Appendices 3A–E includes English Government legal provisions (slightly edited for conciseness) to provide comparative examples concerning legal stipulations for animal husbandry regarding four different animal display or sale situations. These situations were static zoos; mobile zoos (categorised in England as animals for exhibition); retail or wholesale sellers; and reptile expos. In the UK all relevant animals are protected under the provisions of the Animal Welfare Act (2006) (UK Government, 2023a), which adopts the principles of the Five Welfare Needs, and relevantly relates to the Pet Animals Act 1951 (UK Government, 2023b).

Combined, these comparisons show that there is a dearth or absence of regulation or guidance for reptile expos compared with other animal activities. Essentially, beyond the elementary provisions of the UK Animal Welfare Act (2006) (UK Government, 2023a), there are no stipulations or other guidance specific to reptile expos. Sanctuaries or rescue centres would also add comparison to this discussion; however, there are currently no specific relevant legal guidance provisions in England, although a dedicated Bill may be under consideration (UK Parliament, 2001). Furthermore, the operating practices that are typically associated with reptile expos (and that result in the welfare concerns presented in Table 1) are inferior to and incapable of meeting husbandry provisions that are normally required for the display or sale of animals in other situations or the primary provisions of, for example, the Animal Welfare Act (2006) in England and Wales. Relatedly, because of the itinerant operational nature of expos as well as the large volumes of animals and people involved, extraordinary additional measures are required in order to mitigate relevant risks to animal welfare and public health and safety.

Current practices endemic to reptile expos may be most likened to wholesale or retail pet sellers in that they typically display and sell animals (albeit from market table tops rather than static stores) and to mobile zoos and related itinerant exhibitions in that they exhibit animals and allow their casual observation and handling. Whilst reptile expos fail to even approximately meet the relatively detailed provisions designed for retail pet sellers, expos also grossly fail to meet the broad guidance designed for mobile zoos and related itinerant exhibitions. Guidance provisions for static zoos have some peripheral relevance, in that zoos are generally required to adopt foundational scientific principles and provisions rather than itemised guidance (EAZA, 2022). However, in the UK, more specific husbandry guidance for zoos is currently in preparation and anticipated for publication in 2024. In the UK, current guidance for sanctuaries is relevant only to Scotland. Guidance for England and Wales is still being formally developed, thus comparisons cannot at this stage be made.

4.4.2 Development of new recommendations and stipulations

In Table 3 we provide evidence-based safety-net recommendations for managing reptiles at expos in situations where such events are either currently permitted or where immediate controls are necessary to mitigate inherent animal welfare and public health problems, pending stricter measures. Included are key provisions derived from established legislative requirements set out for static zoos, mobile zoos, and wholesale and retail centres, which are conveyed elsewhere (i.e., in Appendices 2A–E). However, below we highlight some general points that provide context to recommendations contained in Table 3. As indicated previously, husbandry conditions at reptile expos typically fall substantially below those of the general pet selling community, which has in itself been highly criticised for poor practices [e.g (Ashley et al., 2014; Warwick, 2014; Mendyk, 2018; Whitehead, 2018)]. Given the considerable risks to welfare and public health associated with reptile expos, selling or displaying animals in this way should not be allowed. However, this table can provide guidance on how to minimise risks wherever possible. Stipulations for control of reptile expos could be implemented in various ways, for example, via national, regional, or local governmental provisions or specific conditions attached to private venues by individual managers.

TABLE 3 Stipulations for control of reptile expos based on published scientific guidance.

Stipulation	Rationale
General	
1. Animals must appear healthy and be free of obvious injury, disease or other signs of poor health.	To avoid animals experiencing negative states from enduring increased stress or suffering. To avoid spread of animal-to-animal and zoonotic infections.
2. Impulse purchasing of animals to be discouraged, e.g., not promoted at reduced costs or part of special offers or product sales such as starter kits complete with animals.	To avoid animals being acquired by people with inadequate knowledge of their needs. To avoid people taking on an animal without fully considering the long-term care implications.
3. Handling of animals to be discouraged.	To avoid causing unnecessary stress to animals. To avoid spread of animal-to-animal and zoonotic infections.
4. Purchased animals must not be carried around the venue, but collected just prior to leaving.	To avoid causing unnecessary stress to animals from movement, vibration or other disturbances.
Animal welfare: foundational	
5. When on view for sale at the venue, animals must not remain in or be displayed in travel containers, e.g., Tupperware, other plastic containers/boxes.	To avoid causing unnecessary stress to animals from cramped and uncomfortable conditions, and to avoid visitors perceiving such conditions to constitute acceptable housing conditions for animals.
6. Within 24 hours all animals for display or sale must be transferred to conditions consistent with best practice standards, or be placed in transit to such conditions.	To avoid causing unnecessary stress to animals from cramped and uncomfortable conditions.
7. Clean drinking water must at all times be available and presented in an appropriate form, e.g., bowls, shallow depressions, misters to create water droplets suitable for the species.	To avoid causing unnecessary stress to animals from thirst or dehydration.
8. Where provided, food must be appropriate for the species. In general, food must be available, notably for herbivorous species. Insectivorous species should not be fed during exhibit time, but would be expected to be fed within 8 hours of transfer to the display enclosure. Carnivorous species should not be fed during exhibit time, but would be expected to be fed if contained in the display enclosure for longer than their usual feed interval.	Continued stable nutritional intake must follow the needs of the individual animal. When varied feeding should be guided by veterinary advice; e.g., feeding close to transportation may be detrimental to an animal's welfare.
9. Animal enclosures must not be situated too low down within an environment, e.g., at or near the floor. Enclosures must not be able to be touched, moved or handled by visitors or passers-by. Enclosures must not be positioned in narrow walkways or near doorways where they can be easily impacted or otherwise disturbed. Enclosures must not be situated where they may be subject to direct sunlight through windows or in the vicinity of heating elements. Enclosures must not be situated where they may be subject to door drafts.	To avoid causing unnecessary stress to animals through being viewed via multiple sides where animals may experience discomfort or fear from visitors or passers-by or from situations where they can be easily contacted or inadvertently knocked or kicked by visitors or passers-by or

TABLE 3 Continued

Stipulation	Rationale
Animal welfare: temperature, humidity, and lighting	
17. Animals must be provided with thermal range levels consistent with an active lifestyle and the generalised climate 'safety-net' zone the species originates from.	To avoid causing unnecessary stress to animals from restrictions related to thermoregulatory behaviour and needs.
18. Animals must not be subject to constant uniform temperatures, but must be provided with a reasonable variation of temperature, i.e., temperature gradient, within their enclosure.	To avoid causing unnecessary stress to animals from restrictions related to thermoregulatory behaviour and needs.
19. Diurnal basking animals must be able to warm their bodies across their entire length.	To avoid causing unnecessary stress to animals from restrictions related to thermoregulatory behaviour and needs.
20. Light management should be full spectrum and allow the choice of exposure or seclusion from the light source.	To avoid causing unnecessary stress to animals from restrictions related to light-interactive behaviour and needs.
21. Animals must be provided with humidity levels consistent with the generalised climate zone the species originates from.	To avoid causing unnecessary stress to animals from poor humidity.
22. Aquatic of semi aquatic species must have access to suitable, clean and tested swimming areas.	To better accommodate the health and welfare of these species, which are dependent on access to swimming water.
23. A record of origin (date or hatching) or date acquired and from where must be provided for each animal. Each animal must have a weight, body condition assessment and body length record. For snakes body length infers the total body length from tip of snout to tip of tail. For lizards and crocodylians body length infers the both total body length and tip of snout to vent length. For chelonians body length infers the straight-line carapace length.	To ensure compliance with regular health checks and ensure enclosure size is suitable.
Animal welfare: habitat	
24. Furnishings and other features must reflect the habitat and behavioural needs of animals, e.g., terrestrial, arboreal, climbing, hiding in crevices, burrowing, and encourage species-typical movements and behaviours.	To avoid causing unnecessary stress to animals from restrictions on essential behaviours.

(Continued)

TABLE 3 Continued

Stipulation	Rationale
Animal welfare: foundational	
	from light disturbance or overheating or from sudden bursts of cold air or rapid temperature changes, especially when holding species that have thermal and/or humidity sensitivities. To avoid spread of animal-to-animal and zoonotic infections.
10. Invasive disturbances, e.g., such as noise, vibrations, and light, must be mitigated to the maximum extent possible, e.g., creation of a general low level of ambient sound in venue quiet zone, and careful positioning of animals to avoid strong light.	To avoid causing unnecessary stress to animals from disturbances.
11. Enclosures with transparent sides should be masked wherever possible so that the boundary appears real and visible to the animal.	To avoid causing unnecessary stress to animals from abnormal interaction with transparent boundaries.
12. Enclosures must be kept at an appropriate level of hygiene, e.g., absence of foul or atypical odours, overt debris on walls and furnishings, old and soiled substrata, pest invertebrates, dirty or contaminated water.	To avoid poor hygiene and infection or disease.
Animal welfare: space	
13. Animals must not be displayed or otherwise held in overcrowded or crypto-overcrowded conditions - i.e., all animals must have access to sufficient space and to all resources in enclosure at any one time.	To avoid causing unnecessary stress to animals from cramped, and uncomfortable and deprived conditions.
14. Animals must have sufficient space (terrestrial, fossorial, arboreal, aquatic) to achieve normal positional-postural adjustments and be able to move, e.g., walk, run, climb, swim, burrow, fully stretch, and move in all directions.	To avoid causing unnecessary stress to animals from deprived conditions.
15. Animal enclosures must be at least 10 times body mass diameter lengths of largest animal; with no enclosure less being than 100cm X 40 cm X 40cm.	To avoid causing unnecessary stress to animals from cramped, and uncomfortable and deprived conditions.
16. No enclosures (including housing very small animals) to be under 100 cm in length, 40 cm in width and 40 cm in height.	To avoid causing unnecessary stress to animals from cramped, and uncomfortable and deprived conditions.

(Continued)

TABLE 3 Continued

Stipulation	Rationale
Animal welfare: habitat	
25. All animals must have opportunities for seclusion to remove themselves from public view as well as co-occupant activity, extraneous movement, handling through the provision of species-appropriate hiding places.	To avoid causing unnecessary stress to animals from restrictions on essential behaviours.
26. Animals must have species-appropriate substrate/bedding materials that are safe.	To avoid causing unnecessary stress or to animals from toxic items, or items likely to be injurious if ingested.
27. Substrate and/or bedding materials must be in and of sufficient quality and quantity so that it is not incidentally disarranged or dispersed by animal activities, e.g., attempts to escape or other movement within the cage, so as to leave the animal on bare floor surfaces.	To avoid causing unnecessary stress to animals from loss of locomotor traction, soiling of non-absorbent floor, deprivation of digging or borrowing.
Animal welfare: biology/behaviour	
28. Nocturnal species not permitted for display or sale.	To avoid causing unnecessary stress to animals. To avoid carers missing opportunities to assess welfare among sleeping animals.
29. Fossorial (subterranean dwelling) not permitted for display or sale.	To avoid causing unnecessary stress to animals. To avoid carers missing opportunities to assess welfare among sleeping animals.
30. Species that may present an invasive risk not permitted for display or sale.	To avoid animals being incidentally released into unsuitable habitats for species. To avoid incidental release of alien species into regional habitat.
Animal welfare: veterinary supervision	
31. An adequate number of veterinarians familiar with exotic species should be onsite and be sufficiently informed to immediately assess all animals prior to public display: assess clinical illness, injury, and problematic and stress-related behaviour for all animals; honestly declare animals as being fit to be displayed or sold; and provide directions or relief regarding the resolution of problematic situations. An adequate number of veterinarians infers an inspectorate that is	To avoid under-assessment of animal health and welfare.

(Continued)

TABLE 3 Continued

Stipulation	Rationale
Animal welfare: veterinary supervision	
sufficient to confidently declare all animals fit/unfit for display based on the inspectors' actual abilities to assess each individual animal's physical and behavioural states.	
Public health and safety	
32. Food for human consumption is not to be present or eaten at the event.	To avoid infection from transfer of potential pathogens between animals and people.
33. Animal sellers and relevant employees or volunteers must be required to cleanse/sanitise hands when moving between animal enclosures, other seller/display stations, or other areas of the venue, to reduce risk of human infections, and cross-contamination of potential pathogens among animals, enclosures and the wider environment	To avoid spread of animal-to-animal and zoonotic infections.
34. Animal displayers or sellers must regularly clean with a designated disinfectant surfaces that are potentially accessible to the public.	To avoid spread of animal-to-animal and zoonotic infections.
35. Any hand contact with a seller, animal or its surrounds must be followed by hand cleaning.	To avoid spread of animal-to-animal and zoonotic infections.
36. Independent hygiene information throughout venue. Signage must be in place at entrances to the event and throughout the venue cautioning the public with regard to zoonotic infections and the heightened risk to persons designated by health agencies as particularly vulnerable e.g.: a. children five years of age and under, pregnant women, the elderly, immune-compromised individuals, individuals on cancer drug therapies, developmentally challenged persons. b. Not to consume food or drink whilst on the premises. c. Clean hands regularly with designated disinfectant. d. Not to touch display facilities, including tables sellers, animals, or animal enclosures.	To avoid spread of animal-to-animal and zoonotic infections.
37. Hygiene information at point of animal sale or hand over to be passed to acquirer of animal. Information to state at minimum: a. Households should not keep, have on the premises or be in contact with people of the following groups: children five years of age and under, pregnant women, the elderly, immune-compromised individuals, individuals on cancer drug therapies, developmentally challenged persons. b. Hand washing, whilst helpful in reducing infection risk, not guarantee protection, e.g., clothes, pockets, hair, and general items may harbour or transfer contaminants.	To avoid spread of animal-to-animal and zoonotic infections.
38. First aid or other medic onsite and available at all times.	To avoid or address emergent health and safety issues.
General safety and contingency planning	
39. Event organisers must demonstrate written and practical protocols prior to the expo to the satisfaction of the local formal fire services.	To avoid or address emergent fire, smoke, or other issues and to ensure that all

(Continued)

TABLE 3 Continued

Stipulation	Rationale
General safety and contingency planning	
	animals and people can be safely evacuated in a timely manner.
40. Event organisers must have written contingency plans for significant events. These must to include: Animal caused injury. Exhibit Escapes. Electrical failures such that the animal environmental control is lost. Isolation of sick animals and potential contacts.	To risk assess the health and welfare of the animals and general public.

Derived from: Warwick et al., 2012a; Burghardt, 2013; Warwick et al., 2013a; Martínez-Silvestre, 2014; Alligood and Leighty, 2015; Frye, 2015; Bashaw et al., 2016; Grant et al., 2017; Moszuti et al., 2017; Oonincx and van Leeuwen, 2017; Mendyk, 2018; Tetzlaff et al., 2018; Warwick et al., 2018; Whitehead, 2018; Benn et al., 2019; Warwick et al., 2019; Spain et al., 2020; Warwick et al., 2021; Cargill et al., 2022; Arena and Warwick, 2023; Arena et al., 2023; Burghardt and Layne-Colon, 2023; Gangloff and Greenberg, 2023; Greenberg, 2023; Jessop et al., 2023; Mancera and Phillips, 2023; Maslanka et al., 2023; Mendyk and Augustine, 2023; Mendyk and Warwick, 2023; Warwick and Steedman, 2023; DEFRA, 2023b; Warwick et al., 2023b, c. This Table also includes key provisions derived from established legislative requirements set out for static zoos, mobile zoos, and wholesale and retail centres, which are specified elsewhere (i.e., in Appendices 2A–E and Appendices 2A–E).

4.4.3 Best practice standards

The term 'best practice' is widely used for animal husbandry recommendations and stipulations, but its meaning is highly contextualised. For example, within the high-level zoo community, best practice may infer large and complex habitats [e.g (EAZA, 2022; UK Government, 2023c)]. In contrast, within the context of pet selling and keeping, the term is used more restrictively to infer substantially smaller and less complex environments [e.g (DEFRA, 2023b)]. However, such differences should not be taken to imply that the lower standard best practice conditions for pets are scientifically or ethically acceptable; rather that for sellers and private keepers of reptiles, an overall lower standard of husbandry is typically expected. Accordingly, here, best practice implies conditions for animals that are also consistent within the context of selling and privately keeping pet reptiles.

Best practice standards infer the requirement that at all times caretakers of reptiles for expos significantly exceed the conditions stipulated below for absolute minimum standards in order to conform to legally and ethically defensible husbandry. Significantly exceeding absolute minimum standard conditions implies, for example: spatial provisions that enable snakes to freely move rectilinearly (fully stretched posture) in all dimensions within an enclosure; to bask and warm their bodies whilst in this posture under a broad heat source; for startled lizards to be able to accelerate, decelerate and stop without impacting confining barriers or to be able to drop from a height onto deep substrate or water; for turtles to be able to swim freely without having to contact co-occupants; and to burrow entirely within substrates. At its least, best practice should infer husbandry conditions similar to those expected for reptiles within the private home environment.

5 Conclusions

Reptiles are sentient animals with the abilities to sense pain and stress. Accordingly, welfare needs at reptile expos can be reliably presumed to be notably unmet. Despite highly incomplete formal information regarding the prevalence of reptile expos, these events occur regularly and widely within Europe, North America, and elsewhere. No government reported maintaining accurate records of reptile expos and their activities. There is very little specific monitoring or control of reptile expos, which is concerning given the breadth of significantly problematic issues endemic to their operation.

Exotic pet trading and keeping, which is a component of the wildlife trade in general, is increasingly scrutinised and criticised in scientific, legal, and ethical literature, for reasons of animal welfare, species conservation, protection of indigenous ecologies, and public health and safety. Reptile expos arguably represent one of the most problematic and uncontrolled sectors of the wildlife industry, with implications for all the aforementioned issues, which emboldens our rationalisation for regulation by way of bans.

This study identified numerous persistent and major animal welfare and public health and safety problems as occurring and endemic to the typical operation of reptile expos. Comparisons between the ways in which animal welfare and public health issues are regarded or managed for reptile expos in relation to, for example, traditional zoos, mobile zoos, and pet sales in the UK are stark and concerning, with expos constituting the least protective and potentially most harmful situations.

In order to alleviate historical and growing concerns regarding both animal welfare and public health and safety issues associated with reptile expos, we have developed two general recommendations based on our assessment of current control deficiencies, as well as 40 specific stipulations and overarching control principles derived from existing evidence-based guidance literature that are all designed to operate in unison and without selectivity. The underlying concepts and principles for these recommendations are that reptile expos currently cannot be assured to meet accepted best practice (and many lower) stipulations that are in place for other relevant events, and, thus prohibitions on their occurrence should be imposed where feasible. However, whilst prohibitions remain the key target, we adopt the pragmatic position that mitigating measures may be rapidly applied as interim measures pending pursuit of stronger legislative controls to protect animal welfare, public health, and other factors. Moreover, the recommendations we provide are all consistent with conventional minimum requirements established for the display or sale of reptiles; thus, they do not represent unreasonable provisions.

6 Recommendations

1. In situations where reptile expos are already essentially prohibited such bans should be immutable and not subject to any weakening provisions. Such actions are necessary because even robust permissive control measures will be unlikely to resolve the areas of concern raised in this report. In prohibiting reptile expos governments should aim to ensure that enforcement of such bans is robust. This recommendation is to ensure that the various risks associated with reptile expos are acted on comprehensively and preventatively.

2. In situations where reptile expos are subject to permissions and/or limiting conditions, or where reptile expos are not subject to permissions and/or limiting conditions, then the recommended 40 safety-net stipulations and overarching control principles that we provide in Table 3 should be applied as interim mitigating measures pending the introduction of prohibitions or 'bans'. The 40 safety-net stipulations and overarching control principles are designed to operate in unison and without selectivity. In applying interim mitigating measures to reptile expos governments should aim to ensure that enforcement of all stipulations is robust. This recommendation is to ensure that absolute minimal 'safety net' conditions are met pending greater controls.

Author contributions

CW: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. CS: Investigation, Writing – review & editing. MJ: Writing – review & editing. RG: Conceptualization, Investigation, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

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