Current Clinical Microbiology Reports (2024) 11:88–98
https://doi.org/10.1007/s40588-024-00221-0

REVIEW

Zoonotic Parasites in Reptiles, with Particular Emphasis on Potential Zoonoses in Australian Reptiles

Tommy L. F. Leung[1]

Accepted: 21 February 2024 / Published online: 20 March 2024

Abstract

Purpose of Review Zoonotic infections are a major public health issue, but reptiles are generally overlooked as sources of zoonoses compared with other classes of vertebrate animals. This paper provides an overview of the biology and ecologies of zoonotic parasites, including helminths, arthropods and protozoans from reptiles.

Recent Findings Reptile zoonoses include parasites from a wide range of taxa, and a variety of different infection routes. In particular, Australia's diverse reptile fauna may be harbouring a range of parasites with varying degrees of zoonotic potential, but the basic biology and ecology of many of those parasites are poorly known.

Summary While some reptile parasites are foodborne zoonoses, many others may be acquired from exposure to infective stages which have been shed into the environment, especially among captive reptiles. Within Australia, consumption of reptile meat is rare in comparison to other parts of the world, but the increasing popularity of reptiles as pets means that captive pets and the reptile trade may become a key source of emerging zoonoses in the future.

Keywords Zoonoses · Parasites · Reptiles · Emerging infectious diseases · Helminths

Introduction

Zoonotic infections are a major global public health issue [1, 2]. The majority of human infections have originated from non-human animals [3], and it is recognised that many emerging infectious diseases come from various animals including wildlife and livestock [4, 5]. Most studies on emerging zoonotic infections have focused on mammals as potential sources of zoonoses [6, 7] for two key reasons: (1) Since humans are also mammals, the phylogenetic affinities and thus physiological similarities to other mammals mean that there is greater likelihood of successful host-jump event from such animals [8]. And (2) since many domestic pets and livestock are also mammals, there are more opportunities for humans to come into contact with them and their parasites [9].

In contrast, the phylogenetic distance and physiological dissimilarity between reptiles and humans would seemingly mean that there are less overlaps in their respective parasite communities. However, because many reptiles predate upon mammals, some of their parasites also use mammals as intermediate hosts. Thus, such parasites may present some element of infection risk to humans. Compared with mammals, humans interact less frequently with reptiles, as they are considered to be of relatively low economic or veterinary importance, and accordingly, there has been comparatively less research interest in the parasite communities of reptiles. Though, this may change in the future with increasing popularity of reptiles as companion animals [10, 11],

Living (non-avian) reptiles are an extremely diverse and species-rich class with over 11,000 known living species [12]. They play important ecological roles in a wide variety of habitats [13–15], and this diversity in terms of sheer number of species as well as ecological breadth means they are host to a wide variety of parasites. The parasite communities of reptiles were traditionally considered to be relatively depauperate [16], and the parasite fauna of reptiles is not as well-studied as those of other vertebrate classes such as mammals, birds, and fishes. While studies on the parasite communities of reptiles have increased over the last few decades, the life cycles and ecology of many of those reptile parasites, along with their zoonotic potential, remains unknown.

✉ Tommy L. F. Leung
tleung6@une.edu.au

1 Zoology, School of Environmental and Rural Science, University of New England, Armidale, NSW, Australia

While zoonoses from reptiles are not as common as those from mammals, there are still some very notable examples [17••] which are of public health concern. Reptiles are known to be host to various serotypes of *Salmonella* bacteria, which are common among captive reptiles [18, 19], as well as a range of other lesser-known zoonotic bacteria [20]. Reptiles can also serve as potential reservoirs for a range of zoonotic arboviruses [21–23]. But this review will be focusing on groups which fall under the traditional definition of "parasites"—helminths, arthropods and "protozoans" (unicellular eukaryotes excluding fungi). The review will be providing an overview of zoonotic and potentially zoonotic parasites found in reptiles, and then it will be turning its focus on the diverse reptile fauna of Australia to discuss the potential zoonoses which may be found in their parasite communities.

Zoonotic Parasites of Reptiles

Reptiles are host to a range of potentially zoonotic parasites from many different taxa [17••] which can be broadly divided into three categories: helminths, arthropods, and protozoans.

Helminths

Trematodes

Of the many taxa of trematodes known from reptiles, the main group of zoonotic concern is species in the genus *Alaria*, which commonly uses snakes as paratenic hosts [24]. These flukes have a three-host life cycle, with carnivorous mammals serving as the definitive host, aquatic snails as the first intermediate host and a wide range of different animals as the second intermediate and paratenic hosts including frogs, snakes, rodents and boars [25]. Inside the second intermediate or paratenic host, the fluke develops into the mesocercaria stage, and humans can become infected through eating raw or undercooked intermediate or paratenic hosts [25]. The mesocercariae can cause high pathogenicity as they migrate into various different organs and tissues, causing lesions and haemorrhages, anaphylaxis or even fatality in the case of heavy infections [25].

Cestodes

Reptiles are host to a wide range of cestodes both as intermediate/paratenic hosts and as definitive hosts. However, the species of reptile-borne cestodes which are of zoonotic and public health significance are those in the genus *Spirometra*. *Spirometra* is a genus of cestodes which has a worldwide distribution [26]. There are four recognised species of *Spirometra*, and their plerocercoid stages are associated with the larva migrans disease sparganosis [27]. This parasite's life cycle involves three hosts, with cats or canids serving as the definitive hosts for the adult tapeworm, copepods as the first intermediate host, and a wide range of vertebrate animals can act as the second intermediate host including fish, amphibians, reptiles, various mammals and birds [26]. In the second intermediate host, *Spirometra* develops into a plerocercoid, which is the stage commonly associated with sparganosis [28].

Inside a human host, the plerocercoid invades various parts of the body including subcutaneous tissue, the central nervous system and visceral organs and in some cases starts budding and proliferating progeny plerocercoids [28]. Sparganosis has been reported from many parts of the world, though most cases are from mainland China and East Asia [29, 30]. The most common infection route is through eating raw or undercooked frogs or snakes [31, 32], or drinking water contaminated with infected copepods [29]. *Spirometra* plerocercoids are particularly prevalent in snakes [33] and have been found to be common in snakes sold at markets for food [32] or the exotic pet trade [34].

Nematodes

A wide variety of nematode parasites are found in reptiles, but only a handful of reptile-borne nematodes are known to be potential zoonoses. It must be noted that this is not necessarily reflective of the actual zoonotic potential of nematodes from reptiles, but rather the current state of scientific knowledge as there have been relatively few studies on the zoonotic potential of reptile nematodes, especially when compared with nematodes from other vertebrate classes. Of those reptile-borne nematodes, three genera stand out as particularly notable zoonotic parasites: *Angiostrongylus*, *Gnathostoma* and *Trichinella*.

Angiostrongylus is a genus of nematode with 21 recognised species around the world [35]. The species most commonly associated with disease in humans is *Angiostrongylus cantonensis*. Its definitive host are rats, with snails serving as intermediate hosts, while a wide variety of other invertebrates and vertebrates can function as paratenic hosts [36]. When humans become accidentally infected, usually through ingestion of infected intermediate or paratenic hosts, the nematode migrates to the central nervous system where it can cause an inflammatory reaction that manifests as eosinophilic meningitis, which can lead to paralysis, coma or death [36]. *Angiostrongylus cantonensis* has been reported to use lizards as paratenic hosts [37, 38•] and there have been recorded cases of *Angiostrongylus* infections resulting from consumption of raw or undercooked monitor lizard (*Varanus* spp.) meat [38•, 39].

Gnathostoma is also a foodborne zoonosis; there are 12 species in the genus, and five are known to be zoonotic [40]. Since humans are accidental hosts, the pathologies induced by *Gnathostoma* results from the mechanical damage caused to tissues and internal organs by the larvae's migratory tracks through the body, as well as inflammatory and immunological reactions induced by the larvae's presence and secretions [41]. The primary route of zoonotic infection is through ingesting infected intermediate or paratenic hosts such as fish, snakes, frogs, and poultry [40]. *Gnathostoma* larvae have been reported from various species of snakes [42–44], and while usually associated with consumption of raw or undercooked fish [41], there is a recorded case of gnathostomiasis resulting from consumption of raw snake [45], and there are likely other unreported cases in areas where consumption of snakes is more common.

Trichinella is another genus of concern which has some rather unique aspects to its biology as it uses the same host individual as both the definitive and intermediate host in its life cycle. Hosts become infected via ingesting muscle cells containing *Trichinella* larvae; these worms then grow to sexual maturity in the intestinal mucosa and produce larvae that are carried by the lymphatic and circulatory systems to striated muscle cells which they infect and encyst, awaiting ingestion by the next host [46].

There are two species which are known to infect reptiles, *T. papuae* and *T. zimbabwensis*, both of which are also capable of infecting and circulating in mammalian hosts [47, 48]. *Trichinella papuae* has been found in farmed crocodiles [48], while among wild reptiles, *T. zimbabwensis* has mostly been found in crocodiles and monitor lizards [49]. Experimental infections have shown that both *T. papuae* and *T. zimbabwensis* are also capable of infecting other reptiles including pythons and turtles [50]. As the consumption of crocodile meat becomes more popular in various parts of the world, those *Trichinella* species could present a significant public health risk [48]. Furthermore, there has been a documented case of *T. papuae* infection resulting from eating raw soft-shelled turtles [51], showing that crocodilian meat is not the only reptilian source of *Trichinella* infection.

There are also other reptile-borne nematodes which are not usually known to be zoonotic, but may potentially become zoonotic under certain circumstances. Nematodes from the Ascaridida order are of particular concern due to aspects of their life cycles and life histories. Many of them have complex life cycles that involve vertebrate intermediate hosts [52] and can potentially be zoonotic when humans become accidental intermediate or paratenic hosts. For example, experimental infection has shown that *Hexametra* larvae can successfully infect primates, which indicates it may potentially infect humans [53]. Furthermore, a recent case of an *Ophidascaris robertsi* larva causing human visceral and neural larva migrans [54•] raises further questions about the zoonotic potential of these reptile ascarids and the pathologies they may cause.

Arthropods

Pentastomida

Pentastomids are highly derived parasitic crustaceans [55], and they have a complex life cycle with the adult living in the respiratory system of their tetrapod vertebrate definitive hosts (mostly reptiles) and can infect a variety of both invertebrates and vertebrate animals as intermediate and paratenic hosts [56]. For reptile pentastomids, humans usually serve as accidental paratenic hosts, in which the larval stage (nymphs) migrates to various parts of the body, causing visceral pentastomiasis [57]. While the infection can often be asymptomatic, ocular pentastomiasis, where the nymphs migrate into the eyes [58], can cause permanent vision loss, and on rare occasions, high-intensity infection may result in death [59].

Of the reptile pentastomids, species from the genus *Armillifer* are most commonly associated with zoonoses. *Armillifer* has been reported in snakes sold for human consumption [60, 61], and human pentastomiasis is most common in parts of West Africa, Central Africa, and Malaysia [57] where consumption of undercooked snakes is relatively common. In those cases, infection can result from consumption of meat which has been contaminated with the eggs of pentastomes during the butchering process [61], or the incidental consumption of the gravid adult pentastome itself [59]. *Armillifer* and other pentastomids have also been found in captive reptiles that are kept as pets [62] which can present a zoonotic risk, as accidental ingestion of pentastome eggs in secretion or faeces from infected reptile may also be a potential infection route [63].

Ticks

There are a number of tick species that can feed across different vertebrate classes, parasitising both reptiles and mammals at various stages of their life cycles [64, 65]. Additionally, some tick species that predominately parasitise reptiles have also been documented to occasionally bite humans [e.g. 66, 67]. While the impact of each individual tick feeding is negligible, they can act as vectors for a variety of infectious agents which circulate in reptiles and other animals that they bite. For example, *Rickettsia* has been detected from *Amblyomma dissimile* [68], and the tortoise tick *Hyalomma aegyptium* can carry the pathogens that cause granulocytic anaplasmosis and Q fever [69], as well as Crimean-Congo haemorrhagic fever virus [70•]. Considering that a wide range of ticks are commonly found on reptiles in the international reptile trade [65, 71], reptile ticks and the infectious agents they carry should be a key zoonotic concern.

Mites

Reptiles are host to a wide range of mites [72], some of which can potentially infect humans [17••, 23]. For example, the snake mite *Ophionyssus natricis* is commonly found in captive reptiles [73], and it has been recorded to infest humans, causing pruritic dermatitis [74, 75]. More recently, *Hirstiella*, a genus of lizard mite, has also been recorded to cause papular dermatitis in the owner of a captive green iguana (*Iguana iguana*) which was heavily infested with mites [76]. And much like ticks, those mites can also serve as potential vectors for various pathogens such as *Rickettsia* [77]. It is notable those recorded cases usually involve captive reptiles, kept either privately or in a zoo, showing that frequent contacts with captive reptiles can lead to infestation by reptile mites.

Protozoans

Reptiles are host to a variety of blood-borne pathogens, some of which may have zoonotic significance. Lizards have been found to be reservoirs for a variety of *Trypanosoma* [78] including human-infecting species such as *T. brucei* [79] and *T. cruzi* [80]. Reptiles are also host to a range of enteric protozoans that can potentially be zoonotic. *Sarcocystis* is a genus of intracellular parasite with a two-host life cycle—a prey intermediate host and a predatory definitive host, and two species, *S. hominis* and *S. suihominis*, are known to infect humans as the definitive host [81]. However, *S. nesbitti*, a species which uses snake as its definitive host, has been found to infect humans as intermediate host, causing relapsing fever and myalgia [82, 83]. Additionally, *Cryptosporidium* and *Giardia* have also been reported from pet reptiles [84]. While reptiles seem to have their own specific species of *Giardia* [e.g. 85], the zoonotic species *Giardia duodenalis* has also been detected in free-living lizards [86]. *Cryptosporidium* has also been reported from many different species of reptiles, and while reptile-specific species of *Cryptosporidium* are usually not considered to be infectious to mammals [87], human-infecting species of *Cryptosporidium* such as *C. parvum* have also been detected from captive reptiles [88–90], possibly due to captive conditions with humans exposing them to *C. parvum* via their food and surroundings.

Zoonotic Parasites in Australian Reptiles

Australia is home to about 14% of the world's total reptile diversity with over 1100 known reptile species, composing of all major groups of living non-avian reptiles aside from Rhynchocephalia (more commonly known as Tuatara) [91]. While many aspects of these reptiles have been extensively studied [91], knowledge about their parasite communities has lagged behind in comparison. In a summary of helminth parasites in Australian reptiles by Pichelin, Thomas, and Hutchinson [92], they listed about 230 helminth taxa from 180 host taxa. Since then, a handful of dedicated workers have added more taxa to that list (see [93] for details), but the sum knowledge of sampled host taxa represents only a small fraction of Australia's reptile fauna.

The zoonotic reptile parasites of Australia consist of a mix of both invasive and native species. While some of the invasive parasites are well-known as zoonoses elsewhere in the world, the zoonotic potential of many Australian native reptile parasites is poorly understood.

Cestodes

The sole species of *Spirometra* recorded in Australia is *S. erinacei* [94]. Also known as "zipperworms", *S. erinacei* is the most commonly found helminth in feral cats along eastern Australia [95], which play a crucial role in the dissemination and transmission of *S. erinacei* in Australia. *Spirometra* plerocercoids have been recorded from various snakes in Australia [94, 96], with Stephanson [96] finding between 12 and 28% prevalence in Australian snakes, but very little is known about the prevalence and abundance of plerocercoids in other Australian reptiles. The first case of human sparganosis in Australia was reported in 1905 [97], and while human infection by *Spirometra* is relatively rare in Australia when compared to other parts of the world, they are possibly under-recognised as these parasites have a long incubation period and presents a diagnostic challenge [97].

Nematodes

While both *Angiostrongylus* and *Gnathostoma* are commonly present as potential foodborne reptile zoonoses in other parts of the world, zoonotic cases involving those parasites are rare in Australia, and the prevalence of those nematodes in Australian reptiles is unknown. While *Angiostrongylus* is well-established in Australia, cases of human infection have been rare and sporadic, and are usually associated with incidental ingestion of infected snails or contaminated vegetables [98]. *Gnathostoma* is considered to be an uncommon zoonotic infection in Australia associated with consuming raw or undercooked fish [99], though some diagnosis of gnathostomiasis attributed to *Gnathostoma* in Australia may in fact be caused by a different genus of gnathostomatid nematode, *Echinocephalus* [100].

In contrast to those introduced species, there are a number of native reptile-borne nematodes which may have greater zoonotic significance in the Australian environment. As mentioned in the previous section, reptile ascarids can be potentially zoonotic, and they are found among many species of Australian reptiles, mostly in large snakes [92]. The health risk they pose can be seen with a recent case of *Ophidascaris robertsi* causing visceral and neural larva migrans, in a patient who may have accidentally ingested *O. robertsi* eggs via contaminated vegetation or kitchen equipment [54•]. The eggs of *O. robertsi* are resistant to desiccation [101], and the larvae have been recorded to use many different species of native Australian mammals as their intermediate hosts [102–104]. While *O. robertsi* larvae have been found to develop poorly in introduced mammals such as guinea pigs and rabbits, and not at all in cats, dogs or sheep [102], the case reported by Hossain et al. [54•] shows that a larva can develop into a full-size L3 inside a human host. The potential for *Ophidascaris* zoonoses has previously been raised [e.g. 105], but usually in the context of bush meat and direct human consumption of the snake definitive host. The findings by Hossain et al. [54•] highlight the need to consider other routes of infection which are less direct and not as immediately apparent.

In addition to ascarid nematodes, Australian reptiles are also host to a range of physalopterid nematodes [106], some of which may present an infection risk for humans [107]. While human infections with physalopterid nematodes have been in dramatic decline throughout modern time [108], there has been a reported case in Australia of an infant suffering from gangrene in the small bowel due to being infected with physalopterid nematodes [109]. Studies on the life cycles of physalopterids from Australian reptiles found that the larvae parasitise arthropod intermediate hosts [107], which means human infection may result from accidental ingestion of infected insects. Given the ubiquity of physalopterids in Australian reptiles [106], it would be worthwhile to investigate their zoonotic potential.

Pentastomids

Pentastomids are common among Australian snakes [110], but the life cycle of most pentastomids in Australia is poorly known. The nymphs of *Alofia merki*, a crocodile pentastomid, have been found in two species of marine and brackish water fish [111], which may present a potential risk as a foodborne zoonosis. However, the genus most usually associated with visceral pentastomiasis in human infection is *Armillifer* [112], and there are two species of *Armillifer* which have been described from Australian snakes—*A. australis* and *A. arborealis* [112], but the zoonotic potentials of these Australian species are unknown.

Ticks

There are 12 species of ticks in Australia which are considered as reptile ticks [113], and while many of them feed only on reptiles, some are also known to feed on humans. For example, *Amblyomma moreliae* feeds on a wide range of reptiles, but has also been reported to bite various mammalian hosts, including humans [65]. Similarly, *Bothriocroton hydrosauri*, the southern reptile tick, can feed on livestock and humans, even though it is usually associated with the stump-tailed lizard *Tiliqua rugosa* and other reptiles [65]. More recently, the reptile tick *Amblyomma albolimbatum* has also been recorded biting a human [114]. Some of those ticks can also harbour various tick-borne infections. For example, the aforementioned *B. hydrosauri* has been found to harbour bacteria from the genus *Rickettsia*, in particular, *R. bonei*, which causes Flinders Island spotted fever [115].

Mites

There are over 20 species of reptile mites known in Australia [116–119], composing of both native and introduced species. However, the mite fauna of Australian reptiles is not as well documented as those of Australian birds and mammals [116, 117], so there may be many more undescribed reptile mite species. Of the mites reported from Australian reptiles, the species that are known to be zoonotic are actually the introduced species such as *Ophionyssus natricis* and mites in the genus *Hirstiella* [119, 120], both of which, as previous discussed, can infect and cause dermatitis in humans [74–76]. Worryingly, some introduced mite species have taken readily to infecting Australian native reptiles, which have facilitated their propagation and spread in the wild [119–121]. There may be native reptile mites which are potentially zoonotic, but as Spratt and Beveridge [93] noted, there is currently limited taxonomic capacity in Australia for identifying and describing new species of mites due to the lack of sustained research interest. Thus, there may be other species of potentially zoonotic mites on reptiles and other Australian wildlife which are currently undocumented.

Protozoans

There is evidence to indicate that *Sarcocystis nesbitti* is present in Australian scrub pythons, *Simalia amethistina* [122]. This parasite was responsible for an outbreak of muscular sarcocystosis in Malaysia in 2012 [82, 83]. The main concern relating to this parasite is for potential contamination of the water supplies with faeces from infected snakes, as the sporocysts are somewhat resistant to chlorination, and infection may occur from drinking contaminated water or eating uncooked food which have been washed with contaminated water [83].

Captive Reptiles as a Potential Pathway for Zoonoses

Due to local dietary habits, consumption of reptiles is much less common in Australia in comparison with other parts of the world, which means many foodborne parasites from reptiles which are common in other regions are far less prevalent in Australia. Nevertheless, there are some sections of the population which could be at risk of such zoonoses. Reptiles such as snakes, goannas, crocodiles, and turtles are regularly consumed by some Australian Indigenous communities [123], which may put them at risk of those reptile-borne parasites. Additionally, the rise in consumption of crocodile meat may also be a concern. While commercially sold crocodile meat usually comes from farmed or ranched crocodiles which are regularly monitored and inspected for parasites, wild-harvested crocodiles are often included in meat made available for human consumption [124]. Thus, there are some reptile parasites that are potential foodborne zoonoses in Australia. However, a more common source of zoonotic infections from reptiles in Australia may actually come from inadvertent contact with the infective stages of their parasites, through shared environment and cohabitation. This includes reptiles that are kept as pets.

According to a report by Animal Medicines Australia, as of 2022, there are an estimated 538,000 reptiles kept as pets across Australia, with 41% of the reptile-owning household having two or more reptiles, and snakes appear to be the most popular pet reptile [125]. Ethical and animal welfare concerns have been raised regarding the trade and private keeping of reptiles as "pets" [126], as well its impact on wild populations, especially of threatened or range-restricted species [127]. While Australian reptiles are protected in their range and export is technically prohibited, due to the lack of international protection for those species, Australian reptiles are common on the global exotic pet market, bred in captivity from parental stocks that were initially smuggled out of the country [11]. Additionally, there are persistent efforts at smuggling highly invasive exotic reptiles into Australia for the pet trade [128, 129]. Illegal wildlife trade is recognised as a pathway for the spread of various parasites and pathogens across the world [130••], and even among legal trade, parasites are common, showing that quarantine procedures are lacking [65, 131]. Considering the very low to negligible host specificity of helminths from Australian lizards [132], this can lead to parasite exchange between Australian lizards and introduced reptiles.

Private keeping of captive reptiles provides opportunities for direct contact between humans and reptile parasites. Unfortunately, a significant number of owners lack basic understanding of the requirements for keeping their reptiles in captive conditions [133], let alone awareness of any zoonotic parasites that their pets may potentially harbour. Thus, captive reptiles may become a key source of emerging zoonoses as they can harbour a wide range of parasites with varying degrees of zoonotic potential [134, 135].

Captive conditions which place many different species of animals in shared enclosures can also provide opportunities for parasite transmission and exchange. For example, a group of crested geckoes, *Correlophus ciliatus*, at a theme park in Hong Kong developed heavy infections of *Hexametra angusticaecoides* after they were kept in an enclosure which had previously housed wild-caught Madagascan mossy geckoes, *Uroplatus sikorae* [136•]. Additionally, exposure to and transmission of reptile parasites can also occur during various stages of the trade chain. For example, the case of a captive-bred sugar glider, *Petaurus breviceps*, which was infected with the nematode *Ophidascaris robertsi*, may have resulted from being exposed to the parasite while being held in a store that also housed pythons [104]. Considering the increasing interest in reptile pets, there is a need to monitor the parasite communities of captive reptiles, especially for potentially zoonotic species.

Conclusion

Much like reptiles elsewhere in the world, Australian reptiles are host to a wide range of taxonomically diverse parasites, some of which have varying degrees of zoonotic potential. These consist of both well-known zoonoses which were introduced and have become established in various Australian ecosystems, as well as native species for which very little is known about their ecologies or zoonotic potential. There is generally paucity in knowledge about the parasites (zoonotic or otherwise) of Australian reptiles. To fill in this gap, there needs to be more studies on the ecologies and life cycles of parasites in both native and invasive reptiles of Australia.

The increasing popularity of reptiles as exotic pets will bring more people into contact with reptile parasites. Furthermore, the international trade in reptiles is enabling the spread and exchange of various reptile-borne infections across the globe. Compared with other classes of vertebrate animals, reptiles are generally overlooked as potential sources of zoonoses. But as more people interact with reptiles as pets, subjects for tourism, or food, it is necessary for us to recognise that reptiles can also be host to parasites which have significant public health ramifications.

Author Contributions The manuscript concept and design was by Tommy L. F. Leung. Tommy L. F. Leung conducted the literature search and review, and wrote the main manuscript text. Tommy L. F. Leung has read and approved the final manuscript.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions

Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

Human and Animal Rights and Informed Consent No animal or human subjects by the authors were used in this study.

References

Papers of particular interest, published recently, have been highlighted as:

- • Of importance
- •• Of major importance

1. Bernstein AS, Ando AW, Loch-Temzelides T, Vale MM, Li BV, Li H, Busch J, Chapman CA, Kinnaird M, Nowak K, Castro MC. The costs and benefits of primary prevention of zoonotic pandemics. Sci Adv. 2022;8:eabl4183. https://doi.org/10.1126/sciadv.abl4183.
2. Thompson RC. Zoonotic helminths–why the challenge remains. J Helminthol. 2023;97: e21. https://doi.org/10.1017/S0022149X23000020.
3. Taylor LH, Latham SM, Woolhouse ME. Risk factors for human disease emergence. Philosophical Transactions of the Royal Society of London. Ser B: Biol Sci. 2001;356:983–9. https://doi.org/10.1098/rstb.2001.0888.
4. Gordon CA, McManus DP, Jones MK, Gray DJ, Gobert GN. The increase of exotic zoonotic helminth infections: the impact of urbanization, climate change and globalization. Adv Parasitol. 2016;91:311–97. https://doi.org/10.1016/bs.apar.2015.12.002.
5. Allen T, Murray KA, Zambrana-Torrelio C, Morse SS, Rondinini C, Di Marco M, Breit N, Olival KJ, Daszak P. Global hotspots and correlates of emerging zoonotic diseases. Nat Commun. 2017;8(1):1124. https://doi.org/10.1038/s41467-017-00923-8.
6. Wells K, Gibson DI, Clark NJ, Ribas A, Morand S, McCallum HI. Global spread of helminth parasites at the human–domestic animal–wildlife interface. Glob Change Biol. 2018;24:3254–65. https://doi.org/10.1111/gcb.14064.
7. Majewska AA, Huang T, Han B, Drake JM. Predictors of zoonotic potential in helminths. Philos Trans R Soc B. 2021;376:20200356. https://doi.org/10.1098/rstb.2020.0356.
8. Olival KJ, Hosseini PR, Zambrana-Torrelio C, Ross N, Bogich TL, Daszak P. Host and viral traits predict zoonotic spillover from mammals. Nature. 2017;546:646–50. https://doi.org/10.1038/nature22975.
9. Han BA, Kramer AM, Drake JM. Global patterns of zoonotic disease in mammals. Trends Parasitol. 2016;32:565–77. https://doi.org/10.1016/j.pt.2016.04.007.
10. Bush ER, Baker SE, Macdonald DW. Global trade in exotic pets 2006–2012. Conserv Biol. 2014;28:663–76. https://doi.org/10.1111/cobi.12240.
11. Janssen J: A primer to the global trade of reptiles: magnitude, key challenges, and implications for conservation. In: Underkoffler SC, Adams HR. editors. Wildlife Biodiversity Conservation: Multidisciplinary and Forensic Approaches. Cham: Springer International Publishing; 2021. https://doi.org/10.1007/978-3-030-64682-0_17
12. Uetz P, Freed P, Aguilar R, Reyes F, Kudera J. Hošek J. editors. The Reptile Database, http://www.reptile-database.org, accessed 16 Oct 2023
13. de Miranda EB. The plight of reptiles as ecological actors in the tropics. Front Ecol Evol. 2017;5:309533. https://doi.org/10.3389/fevo.2017.00159.
14. Lovich JE, Ennen JR, Agha M, Gibbons JW. Where have all the turtles gone, and why does it matter? Bioscience. 2018;68:771–81. https://doi.org/10.1093/biosci/biy095.
15. Somaweera R, Nifong J, Rosenblatt A, Brien ML, Combrink X, Elsey RM, Grigg G, Magnusson WE, Mazzotti FJ, Pearcy A, Platt SG. The ecological importance of crocodylians: towards evidence-based justification for their conservation. Biol Rev. 2020;95:936–59. https://doi.org/10.1111/brv.12594.
16. Aho JM. Helminth communities of amphibians and reptiles: comparative approaches to understanding patterns and processes. In: Esch GW, Bush AO, Aho JM editors. Parasite communities: patterns and processes. Dordrecht: Springer Netherlands; 1990 https://doi.org/10.1007/978-94-009-0837-6_7
17. •• Mendoza-Roldan JA, Modry D, Otranto D. Zoonotic parasites of reptiles: a crawling threat. Trends Parasitol. 2020;36:677–87. https://doi.org/10.1016/j.pt.2020.04.014. **Recent review covering major issues relating to zoonotic infections from reptiles**
18. Marin C, Lorenzo-Rebenaque L, Laso O, Villora-Gonzalez J, Vega S. Pet reptiles: a potential source of transmission of multidrug-resistant *Salmonella*. Front Vet Sci. 2021;7:613718. https://doi.org/10.3389/fvets.2020.613718.
19. Pees M, Brockmann M, Steiner N, Marschang RE. *Salmonella* in reptiles: a review of occurrence, interactions, shedding and risk factors for human infections. Front Cell Dev Biol. 2023;11:1251036. https://doi.org/10.3389/fcell.2023.1251036.
20. Ebani VV. Domestic reptiles as source of zoonotic bacteria: a mini review. Asian Pac J Trop Med. 2017;10:723–8. https://doi.org/10.1016/j.apjtm.2017.07.020.
21. Steinman A, Banet-Noach C, Tal S, Levi O, Simanov L, Perk S, Malkinson M, Shpigel N. West Nile virus infection in crocodiles. Emerg Infect Dis. 2003;9:887. https://doi.org/10.3201/eid0907.020816.
22. Graham SP, Hassan HK, Chapman T, White G, Guyer C, Unnasch TR. Serosurveillance of eastern equine encephalitis virus in amphibians and reptiles from Alabama, USA. Am J Trop Med Hyg. 2012;86:540. https://doi.org/10.4269/ajtmh.2012.11-0283.
23. Mendoza-Roldan JA, Mendoza-Roldan MA, Otranto D. Reptile vector-borne diseases of zoonotic concern. Int J Parasitol: Parasites Wildl. 2021;15:132–42. https://doi.org/10.1016/j.ijppaw.2021.04.007.

24. Uhrig EJ, Spagnoli ST, Tkach VV, Kent ML, Mason RT. *Alaria* mesocercariae in the tails of red-sided garter snakes: evidence for parasite-mediated caudectomy. Parasitol Res. 2015;114:4451–61. https://doi.org/10.1007/s00436-015-4686-6.
25. Möhl K, Große K, Hamedy A, Wüste T, Kabelitz P, Lücker E. Biology of *Alaria* spp. and human exposition risk to *Alaria* mesocercariae—a review. Parasitol Res. 2009;105:1–15. https://doi.org/10.1007/s00436-009-1444-7.
26. Kuchta R, Kołodziej-Sobocińska M, Brabec J, Młocicki D, Sałamatin R, Scholz T. Sparganosis (*Spirometra*) in Europe in the molecular era. Clin Infect Dis. 2021;72:882–90. https://doi.org/10.1093/cid/ciaa1036.
27. Scholz T, Kuchta R, Brabec J. Broad tapeworms (Diphyllobothriidae), parasites of wildlife and humans: recent progress and future challenges. Int J Parasitol: Parasites Wildl. 2019;9:359–69. https://doi.org/10.1016/j.ijppaw.2019.02.001.
28. Liu Q, Li MW, Wang ZD, Zhao GH, Zhu XQ. Human sparganosis, a neglected food borne zoonosis. Lancet Infect Dis. 2015;15:1226–35. https://doi.org/10.1016/S1473-3099(15)00133-4.
29. Li MW, Song HQ, Li C, Lin HY, Xie WT, Lin RQ, Zhu XQ. Sparganosis in mainland China. Int J Infect Dis. 2011;15:e154–6. https://doi.org/10.1016/j.ijid.2010.10.001.
30. Lu G, Shi DZ, Lu YJ, Wu LX, Li LH, Rao LY, Yin FF. Retrospective epidemiological analysis of sparganosis in mainland China from 1959 to 2012. Epidemiol Infect. 2014;142:2654–61. https://doi.org/10.1017/S0950268814000144.
31. Zhang X, Hong X, Liu SN, Jiang P, Zhao SC, Sun CX, Wang ZQ, Cui J. Large-scale survey of a neglected agent of sparganosis *Spirometra erinaceieuropaei* (Cestoda: Diphyllobothriidae) in wild frogs in China. PLoS Negl Trop Dis. 2020;14:e0008019. https://doi.org/10.1371/journal.pntd.0008019.
32. Liu W, Tan L, Huang Y, Li WC, Liu YS, Yang LC. Prevalence and molecular characterization of *Spirometra erinaceieuropaei* spargana in snakes in Hunan Province. China J Helminthol. 2020;94:e131. https://doi.org/10.1017/S0022149X20000139.
33. Badri M, Olfatifar M, KarimiPourSaryazdi A, Zaki L, Madeira de Carvalho LM, FasihiHarandi M, Barikbin F, Madani P, VafaeEslahi A. The global prevalence of *Spirometra* parasites in snakes, frogs, dogs, and cats: a systematic review and meta-analysis. Vet Med Sci. 2022;8:2785–805.
34. Yudhana A, Praja RN, Supriyanto A. The medical relevance of *Spirometra* tapeworm infection in Indonesian Bronzeback snakes (*Dendrelaphis pictus*): a neglected zoonotic disease. Vet World. 2019;12:844. https://doi.org/10.14202/vetworld.2019.844-848.
35. Spratt DM. Species of *Angiostrongylus* (Nematoda: Metastrongyloidea) in wildlife: a review. Int J Parasitol: Parasites Wildl. 2015;4:178–89. https://doi.org/10.1016/j.ijppaw.2015.02.006.
36. Cowie RH, Ansdell V, Dunavan CP, Rollins RL. Neuroangiostrongyliasis: global spread of an emerging tropical disease. Am J Trop Med Hyg. 2022;107:1166–72. https://doi.org/10.4269/ajtmh.22-0360.
37. Anettová L, Izquierdo-Rodriguez E, Foronda P, Baláž V, Novotný L, Modrý D. Endemic lizard Gallotia galloti is a paratenic host of invasive *Angiostrongylus cantonensis* in Tenerife. Spain Parasitol. 2022;149:934–9. https://doi.org/10.1017/S0031182022000336.
38.• Turck HC, Fox MT, Cowie RH. Paratenic hosts of *Angiostrongylus cantonensis* and their relation to human neuroangiostrongyliasis globally. One Health. 2022;15:100426. https://doi.org/10.1016/j.onehlt.2022.100426. **Recent comprehensive review on the paratenic hosts of *Angiostrongylus cantonensis***, *including lizards*
39. Yang L, Darasavath C, Chang K, Vilay V, Sengduangphachanh A, Adsamouth A, Vongsouvath M, Keolouangkhot V, Robinson MT. Cluster of angiostrongyliasis cases following consumption of raw monitor lizard in the Lao People's Democratic Republic and review of the literature. Trop Med Infect Dis. 2021;6:107. https://doi.org/10.3390/tropicalmed6030107.
40. Liu GH, Sun MM, Elsheikha HM, Fu YT, Sugiyama H, Ando K, Sohn WM, Zhu XQ, Yao C. Human gnathostomiasis: a neglected food-borne zoonosis. Parasit Vectors. 2020;13:616. https://doi.org/10.1186/s13071-020-04494-4.
41. Nogrado K, Adisakwattana P, Reamtong O. Human gnathostomiasis: a review on the biology of the parasite with special reference on the current therapeutic management. Food Waterborne Parasitol. 2023;33:e00207. https://doi.org/10.1016/j.fawpar.2023.e00207.
42. Ishiwata K, Nakao H, Nose R, Komiya M, Hanada S, Enomoto Y, Nawa Y. Gnathostomiasis in frog-eating snakes from Japan. J Wildl Dis. 1997;33:877–9. https://doi.org/10.7589/0090-3558-33.4.877.
43. Sohn WM, Lee SH. The first discovery of larval *Gnathostoma hispidum* (Nematoda: Gnathostomidae) from a snake host, *Agkistrodon brevicaudus*. Korean J Parasitol. 1998;36:81–9. https://doi.org/10.3347/kjp.1998.36.2.81.
44. Woo HC, Oh HS, Cho SH, Na BK, Sohn WM. Discovery of larval *Gnathostoma nipponicum* in frogs and snakes from Jeju-do (Province), Republic of Korea. Korean J Parasitol. 2011;49:445. https://doi.org/10.3347/kjp.2011.49.4.445.
45. Kurokawa M, Ogata K, Sagawa S, Miyaoka Y, Noda S, Nawa Y. Cutaneous and visceral larva migrans due to *Gnathostoma doloresi* infection via an unusual route. Arch Dermatol. 1998;134:638–9. https://doi.org/10.1001/archderm.134.5.638.
46. Pozio E Taxonomy, biology and epidemiology of *Trichinella* parasites. In: Dupouy-Camet J, Murrell KD editors: FAO/WHO/OIE guidelines for the surveillance, management, prevention and control of trichinellosis. World Organisation for Animal Health Press, 2007
47. Pozio E, Foggin CM, Marucci G, La Rosa G, Sacchi L, Corona S, Rossi P, Mukaratirwa S. *Trichinella zimbabwensis* n. sp. (Nematoda), a new non-encapsulated species from crocodiles (Crocodylus niloticus) in Zimbabwe also infecting mammals. Int J Parasitol. 2002;32:1787–99. https://doi.org/10.1016/S0020-7519(02)00139-X.
48. Pozio E, Owen IL, Marucci G, La Rosa G. *Trichinella papuae* in saltwater crocodiles (*Crocodylus porosus*) of Papua New Guinea. Emerg Infect Dis. 2004;10:1507–9.
49. Pozio E, Foggin CM, Gelanew T, Marucci G, Hailu A, Rossi P, Morales MA. *Trichinella zimbabwensis* in wild reptiles of Zimbabwe and Mozambique and farmed reptiles of Ethiopia. Vet Parasitol. 2007;143:305–10. https://doi.org/10.1016/j.vetpar.2006.08.029.
50. Pozio E, Marucci G, Casulli A, Sacchi L, Mukaratirwa S, Foggin CM, La Rosa G. *Trichinella papuae* and *Trichinella zimbabwensis* induce infection in experimentally infected varans, caimans, pythons and turtles. Parasitology. 2004;128:333–42. https://doi.org/10.1017/S0031182003004542.
51. Lo YC, Hung CC, Lai CS, Wu Z, Nagano I, Maeda T, Takahashi Y, Chiu CH, Jiang DD. Human trichinosis after consumption of soft-shelled turtles. Taiwan Emerg Infect Dis. 2009;15:2056–8. https://doi.org/10.3201/eid1512.090619.
52. Anderson RC. Nematode parasites of vertebrates: their development and transmission. 2nd ed. New York: CABI Publishing; 2000.
53. Peichoto ME, Sánchez MN, López A, Salas M, Rivero MR, Teibler P, de Melo TG, Tavares FL. First report of parasitism by *Hexametra boddaertii* (Nematoda: Ascaridae) in *Oxyrhopus guibei* (Serpentes: Colubridae). Vet Parasitol. 2016;224:60–4. https://doi.org/10.1016/j.vetpar.2016.05.017.
54.• Hossain ME, Kennedy KJ, Wilson HL, Spratt D, Koehler A, Gasser RB, Šlapeta J, Hawkins CA, Bandi HP, Senanayake SN. Human neural larva migrans caused by *Ophidascaris robertsi* ascarid.

Emerg Infect Dis. 2023;29:1900–3. https://doi.org/10.3201/eid2909.230351. **First recorded case of human infection with *Ophidascaris robertsi* causing visceral and neural larva migrans**

55. Lavrov DV, Brown WM, Boore JL. Phylogenetic position of the Pentastomida and (pan) crustacean relationships. Proceedings of the Royal Society of London. Series B Biol Sci. 2004;271:537–44. https://doi.org/10.1098/rspb.2003.2631.
56. Riley J. The biology of pentastomids. Adv Parasitol. 1986;25:45–128. https://doi.org/10.1016/S0065-308X(08)60342-5.
57. Tappe D, Büttner DW. Diagnosis of human visceral pentastomiasis. PLoS Negl Trop Dis. 2009;3:e320. https://doi.org/10.1371/journal.pntd.0000320.
58. Sulyok M, Rózsa L, Bodó I, Tappe D, Hardi R. Ocular pentastomiasis in the Democratic Republic of the Congo. PLoS Negl Trop Dis. 2014;8:e3041. https://doi.org/10.1371/journal.pntd.0003041.
59. Lavarde V, Fornes P. Lethal infection due to *Armillifer armillatus* (Porocephalida): a snake-related parasitic disease. Clin Infect Dis. 1999;5:1346–7. https://doi.org/10.1086/313460.
60. Tappe D, Sulyok M, Riu T, Rózsa L, Bodó I, Schoen C, Muntau B, Babocsay G, Hardi R. Co-infections in visceral pentastomiasis, Democratic Republic of the Congo. Emerg Infect Dis. 2016;22:1333. https://doi.org/10.3201/eid2208.151895.
61. Hardi R, Babocsay G, Tappe D, Sulyok M, Bodó I, Rózsa L. *Armillifer*-infected snakes sold at congolese bushmeat markets represent an emerging zoonotic threat. EcoHealth. 2017;14:743–9. https://doi.org/10.1007/s10393-017-1274-5.
62. Takaki Y, Irie T, Takami Y, Asakawa M, Yoshida A. Tongue worm (subclass: Pentastomida) infection and treatment in two domesticated reptiles–a case report. Parasitol Int. 2022;91:102617. https://doi.org/10.1016/j.parint.2022.102617.
63. Mendoza-Roldan JA, Lia RP, Tarallo VD, Annoscia G, Bezerra-Santos MA, Otranto D. *Raillietiella hemidactyli* (Pentastomida: Raillietiellidae) in *Tarentola mauritanica* geckoes: a new zoonotic parasite for Europe. Acta Trop. 2022;228:106316. https://doi.org/10.1016/j.actatropica.2022.106316.
64. Apanaskevich DA. Host-parasite relationships of the genus *Hyalomma* Koch, 1844 (Acari, Ixodidae) and their connection with microevolutionary process. Parazitologiia. 2004;38:515–23.
65. Burridge MJ, Simmons LA. Exotic ticks introduced into the United States on imported reptiles from 1962 to 2001 and their potential roles in international dissemination of diseases. Vet Parasitol. 2003;113:289–320. https://doi.org/10.1016/S0304-4017(03)00060-8.
66. Norval G, Sharrad RD, Gardner MG. Three instances of reptile ticks parasitising humans. Acarologia. 2020;60:607–11. https://doi.org/10.24349/acarologia/20204389.
67. Kwak ML, Jones MD, Harman ME, Smith SN, D'souza A, Knierim T, Barnes CH, Waengsothorn S, Amarga AK, Kuo CC, Nakao R. The East Indies reptile tick *Amblyomma helvolum* Koch, 1844 (Acari: Ixodidae), taxonomy, biology and new host records, including the first record of human infestation. Ticks Tick-borne Dis. 2023;14:102224. https://doi.org/10.1016/j.ttbdis.2023.102224
68. Santodomingo A, Cotes-Perdomo A, Foley J, Castro LR. Rickettsial infection in ticks (Acari: Ixodidae) from reptiles in the Colombian Caribbean. Ticks and Tick-borne Diseases. 2018;9:623–8. https://doi.org/10.1016/j.ttbdis.2018.02.003.
69. Paștiu AI, Matei IA, Mihalca AD, D'Amico G, Dumitrache MO, Kalmár Z, Sándor AD, Lefkaditis M, Gherman CM, Cozma V. Zoonotic pathogens associated with *Hyalomma* aegyptium in endangered tortoises: evidence for host-switching behaviour in ticks? Parasites & Vectors. 2012;5:301. https://doi.org/10.1186/1756-3305-5-301.
70.• Kar S, Rodriguez SE, Akyildiz G, Cajimat MN, Bircan R, Mears MC, Bente DA, Keles AG. Crimean-Congo hemorrhagic fever virus in tortoises and *Hyalomma aegyptium* ticks in East Thrace, Turkey: potential of a cryptic transmission cycle. Parasit Vectors. 2020;13:201. https://doi.org/10.1186/s13071-020-04074-6. **Report of Crimean-Congo haemorrhagic fever virus detected in a species of tick which primarily feeds on tortoises, but is also known to bite mammals, including humans**
71. Nowak M. The international trade in reptiles (Reptilia)—the cause of the transfer of exotic ticks (Acari: Ixodida) to Poland. Veterinary Parasitology. 2010;169:373–81. https://doi.org/10.1016/j.vetpar.2010.01.006.
72. Fajfer M. Acari (Chelicerata)-parasites of reptiles. Acarina. 2012;20(2):108–29.
73. White SD, Bourdeau P, Bruet V, Kass PH, Tell L, Hawkins MG. Reptiles with dermatological lesions: a retrospective study of 301 cases at two university veterinary teaching hospitals (1992–2008). Vet Dermatol. 2011;22:150–61. https://doi.org/10.1111/j.1365-3164.2010.00926.x.
74. Wozniak EJ, DeNardo DF. The biology, clinical significance and control of the common snake mite, *Ophionyssus natricis*, in captive reptiles. J Herpetol Med Surg. 2000;10:4–10. https://doi.org/10.5818/1529-9651-10.3.4.
75. Amanatfard E, Youssefi MR, Barimani A. Human dermatitis caused by *Ophionyssus natricis*, a snake mite. Iran J Parasitol. 2014;9:594–6.
76. d'Ovidio D, Pantchev N, Santoro D. Hirstiella spp. infestation in a client-owned iguana (Iguana Iguana) associated with skin lesions on its owner. Top Companion Animal Med. 2023;55:100802. https://doi.org/10.1016/j.tcam.2023.100802.
77. Mendoza-Roldan JA, Ribeiro SR, Castilho-Onofrio V, Marcili A, Simonato BB, Latrofa MS, Benelli G, Otranto D, Barros-Battesti DM. Molecular detection of vector-borne agents in ectoparasites and reptiles from Brazil. Ticks Tick-borne Dis. 2021;12:101585. https://doi.org/10.1016/j.ttbdis.2020.101585.
78. Jordaan BJ, van As J, Netherlands EC. Morphological and molecular diagnosis of two new species of *Trypanosoma* Gruby, 1843 infecting South African cordylid lizards (Squamata: Cordylidae: Cordylinae), *Trypanosoma* (Squamatrypanum) ndumoensis n. sp. and *Trypanosoma* (*Trypanosoma*) *tokoloshi* n. sp. J Eukaryotic Microbiol. 2023;70:12970. https://doi.org/10.1111/jeu.12970.
79. Njagu Z, Mihok S, Kokwaro E, Verloo D. Isolation of *Trypanosoma brucei* from the monitor lizard (*Varanus niloticus*) in an endemic focus of Rhodesian sleeping sickness in Kenya. Acta Trop. 1999;72(2):137–48. https://doi.org/10.1016/S0001-706X(98)00092-8.
80. Botto-Mahan C, Correa JP, Araya-Donoso R, Farías F, San Juan E, Quiroga N, Campos-Soto R, Reyes-Olivares C, González-Acuña D. Lizards as silent hosts of *Trypanosoma cruzi*. Emerg Infect Dis. 2022;28:1250. https://doi.org/10.3201/eid2806.220079.
81. Fayer R. *Sarcocystis* spp. in human infections. Clin Microbiol Rev. 2004;17:894–902. https://doi.org/10.1128/cmr.17.4.894-902.2004.
82. Lau YL, Chang PY, Tan CT, Fong MY, Mahmud R, Wong KT. *Sarcocystis nesbitti* infection in human skeletal muscle: possible transmission from snakes. Am J Trop Med Hyg. 2014;90:361. https://doi.org/10.4269/ajtmh.12-0678.
83. Italiano CM, Wong KT, AbuBakar S, Lau YL, Ramli N, Syed Omar SF, Kahar Bador M, Tan CT. *Sarcocystis nesbitti* causes acute, relapsing febrile myositis with a high attack rate: description of a large outbreak of muscular sarcocystosis in Pangkor Island, Malaysia, 2012. PLoS Negl Trop Dis. 2014;8:e2876. https://doi.org/10.1371/journal.pntd.0002876.
84. Papini R, Manetti C, Mancianti F. Coprological survey in pet reptiles in Italy. Vet Record. 2011;169:207. https://doi.org/10.1136/vr.d4398.

85. Upton SJ, Zien CA. Description of a *Giardia varani*-like flagellate from a water monitor, *Varanus salvator*, from Malaysia. J Parasitol. 1997;83:970–1. https://doi.org/10.2307/3284303.
86. Reboredo-Fernández A, Ares-Mazás E, Galán P, Cacciò SM, Gómez-Couso H. Detection of zoonotic and livestock-specific assemblages of *Giardia duodenalis* in free-living wild lizards. Rev Bras Parasitol Vet. 2017;26:395–9. https://doi.org/10.1590/s1984-29612017034.
87. Rinaldi L, Capasso M, Mihalca AD, Cirillo R, Cringoli G, Cacciò S. Prevalence and molecular identification of *Cryptosporidium* isolates from pet lizards and snakes in Italy. Parasite. 2012;19:437. https://doi.org/10.1051/2Fparasite.2F2012194437.
88. Traversa D, Iorio R, Otranto D, Modrý D, Šlapeta J. *Cryptosporidium* from tortoises: genetic characterisation, phylogeny and zoonotic implications. Mol Cell Probes. 2008;22:122–8. https://doi.org/10.1016/j.mcp.2007.11.001.
89. Pedraza-Díaz S, Ortega-Mora LM, Carrión BA, Navarro V, Gómez-Bautista M. Molecular characterisation of *Cryptosporidium* isolates from pet reptiles. Vet Parasitol. 2009;160:204–10. https://doi.org/10.1016/j.vetpar.2008.11.003.
90. Garcia-R JC, Pita AB, Velathanthiri N, Pas A, Hayman DT. Mammal-related *Cryptosporidium* infections in endemic reptiles of New Zealand. Parasitol Res. 2023;122:1239–44. https://doi.org/10.1007/s00436-023-07824-4.
91. Wilson SK, Swan G. A complete guide to reptiles of Australia. 6th ed. Chatswood: Reed New Holland; 2020.
92. Pichelin S, Thomas PM, Hutchinson MN. A checklist of helminth parasites of Australian reptiles. Records of the South Australian Museum. Monograph Ser. 1999;5:1–61.
93. Spratt DM, Beveridge I. Wildlife parasitology in Australia: past, present and future. Aust J Zool. 2019;66:286–305. https://doi.org/10.1071/ZO19017.
94. Zhu XQ, Beveridge I, Berger L, Barton D, Gasser RB. Single-strand conformation polymorphism-based analysis reveals genetic variation within *Spirometra erinacei* (Cestoda: Pseudophyllidea) from Australia. Mol Cell Probes. 2002;16:159–65. https://doi.org/10.1006/mcpr.2001.0406.
95. Dickman CR. Overview of the impacts of feral cats on Australian native fauna. Canberra: Australian Nature Conservation Agency; 1996.
96. Stephanson JM. Biology and immunobiology of *Spirometra* in Western Australia. Doctoral dissertation. Perth: Murdoch University; 1985
97. Tran QR, Tran MC, Mehanna D. Sparganosis: an under-recognised zoonosis in Australia? BMJ Case Reports CP. 2019;12:e228396. https://doi.org/10.1136/bcr-2018-228396.
98. Prociv P, Spratt DM, Carlisle MS. Neuro-angiostrongyliasis: unresolved issues. Int J Parasitol. 2000;30:1295–303. https://doi.org/10.1016/S0020-7519(00)00133-8.
99. Jeremiah CJ, Harangozo CS, Fuller AJ. Gnathostomiasis in remote northern Western Australia: the first confirmed cases acquired in Australia. Med J Aust. 2011;195:42–4. https://doi.org/10.5694/j.1326-5377.2011.tb03188.x.
100. Shamsi S, Steller E, Zhu X. The occurrence and clinical importance of infectious stage of *Echinocephalus* (Nematoda: Gnathostomidae) larvae in selected Australian edible fish. Parasitol Int. 2021;83:102333. https://doi.org/10.1016/j.parint.2021.102333.
101. Sprent JF. The life history and development of *Amplicaecum robertsi*, an ascaridoid nematode of the carpet python (*Morelia spilotes variegatus*). I. Morphology and functional significance of larval stages. Parasitology. 1963;53:7–38. https://doi.org/10.1017/S0031182000072498.
102. Sprent JF. The components of host specificity in infections with ascaridoid nematodes. Proc First Int Congress Parasitol. 1966;1:15–8. https://doi.org/10.1016/B978-1-4832-2913-3.50020-4.
103. Gonzalez-Astudillo V, Knott L, Valenza L, Henning J, Allavena R. Parasitism by *Ophidascaris robertsi* with associated pathology findings in a wild koala (*Phascolarctos cinereus*). Vet Record Case Rep. 2019;7:e000821. https://doi.org/10.1136/vetreccr-2019-000821.
104. Agúndez MG, Rodríguez JE, Juan-Sallés C, Spratt DM. First report of parasitism by *Ophidascaris robertsi* (Nematoda) in a sugar glider (*Petaurus breviceps*, Marsupialia). J Zoo Wildl Med. 2014;45:984–6. https://doi.org/10.1638/2014-0107.1.
105. Bimi L, Kailyn Odamtten F, Anto F, Kwamena TA. *Ophidascaris* sp in an African rock python (*Python sebae*) in Ghana: a case report. J Med Microbiol Infect Dis. 2021;9:103–7. https://doi.org/10.52547/JoMMID.9.2.103.
106. Jones HI. Physalopterine nematodes in Australian reptiles: interactions and patterns of infection. Aust J Zool. 2014;62:180–94. https://doi.org/10.1071/ZO13033.
107. King C, Jones HI. The life cycle of the reptile-inhabiting nematode *Abbreviata hastaspicula* (Spirurida: Physalopteridae: Physalopterinae) in Australia. Int J Parasitol: Parasites Wildl. 2016;5:258–62. https://doi.org/10.1016/j.ijppaw.2016.08.002.
108. Makki M, Dupouy-Camet J, Sajjadi SM, Moravec F, Naddaf SR, Mobedi I, Malekafzali H, Rezaeian M, Mohebali M, Kargar F, Mowlavi G. Human spiruridiasis due to *Physaloptera* spp. (Nematoda: Physalopteridae) in a grave of the Shahr-e Sukhteh archeological site of the Bronze Age (2800–2500 BC) in Iran. Parasite. 2017;24:18. https://doi.org/10.1051/parasite/2017019.
109. Nicolaides NJ, Musgrave J, McGuckin D, Moorhouse DE. Nematode larvae (Spirurida: Physalopteridae) causing infarction of the bowel in an infant. Pathology. 1977;9:129–35. https://doi.org/10.3109/00313027709085251.
110. Kelehear C, Spratt DM, O'Meally D, Shine R. Pentastomids of wild snakes in the Australian tropics. Int J Parasitol: Parasites Wildl. 2014;3(1):20–31. https://doi.org/10.1016/j.ijppaw.2013.12.003.
111. Barton DP, Morgan JA. A morphological and genetic description of pentastomid infective nymphs belonging to the family Sebekidae Sambon, 1922 in fish in Australian waters. Folia Parasitologica. 2016;63:026. https://doi.org/10.14411/fp.2016.026.
112. Riley J, Self JT. Some observations on the taxonomy and systematics of the pentastomid genus *Armillifer* (Sambon, 1922) in South East Asian and Australian snakes. Syst Parasitol. 1981;2:171–9. https://doi.org/10.1007/BF00009530.
113. Barker SC, Walker AR, Campelo D. A list of the 70 species of Australian ticks; diagnostic guides to and species accounts of *Ixodes holocyclus* (paralysis tick), *Ixodes cornuatus* (southern paralysis tick) and *Rhipicephalus australis* (Australian cattle tick); and consideration of the place of Australia in the evolution of ticks with comments on four controversial ideas. Int J Parasitol. 2014;44:941–53. https://doi.org/10.1016/j.ijpara.2014.08.008.
114. Egan SL, Lettoof DC, Oskam CL. First record of the stump-tailed lizard tick, *Amblyomma albolimbatum* (Ixodida, Ixodidae) parasitising a human. Ticks Tick-borne Dis. 2022;13:101873. https://doi.org/10.1016/j.ttbdis.2021.101873.
115. Stenos J, Graves S, Popov VL, Walker DH. *Aponomma hydrosauri*, the reptile-associated tick reservoir of *Rickettsia honei* on Flinders Island, Australia. Am J Trop Med Hyg. 2003;69:314–7. https://doi.org/10.4269/ajtmh.2003.69.314.
116. Domrow R, Lester LN. Chiggers of Australia (Acari: Trombiculidae): and annotated checklist, keys and bibliograpy. Aust J Zool Suppl Ser. 1985;33:1–11. https://doi.org/10.1071/AJZS114.
117. Domrow R. Acari Mesostigmata parasitic on Australian vertebrates: an annotated checklist, keys and bibliography. Invertebr Syst. 1987;1:817–948. https://doi.org/10.1071/IT9870817.

118. Derne BT, Hutchinson MN, Weinstein P, Gardner MG, Halliday B. Parasite in peril? A new species of mite in the genus *Ophiomegistus* Banks (Parasitiformes: Paramegistidae) on an endangered host, the pygmy bluetongue lizard *Tiliqua adelaidensis* (Peters)(Squamata: Scincidae). Austral Ecol. 2019;44:420–32. https://doi.org/10.1111/aec.12692.
119. Walter DE, Shaw M. First record of the mite *Hirstiella diolii* Baker (Prostigmata: Pterygosomatidae) from Australia, with a review of mites found on Australian lizards. Aust J Entomol. 2002;41:30–4. https://doi.org/10.1046/j.1440-6055.2002.00272.x.
120. Norval G, Halliday B, Sih A, Sharrad RD, Gardner MG. Occurrence of the introduced snake mite, *Ophionyssus natricis* (Gervais, 1844), in the wild in Australia. Acarologia. 2020;60:559–65. https://doi.org/10.24349/acarologia/20204385.
121. Norval G, Halliday B, Sharrad RD, Gardner MG. Additional instances of snake mite (*Ophionyssus natricis*) parasitism on sleepy lizards (*Tiliqua rugosa*) in South Australia. Trans R Soc S Aust. 2021;145:183–93. https://doi.org/10.1080/03721426.2021.1934629.
122. Wassermann M, Raisch L, Lyons JA, Natusch DJ, Richter S, Wirth M, Preeprem P, Khoprasert Y, Ginting S, Mackenstedt U, Jäkel T. Examination of *Sarcocystis* spp. of giant snakes from Australia and Southeast Asia confirms presence of a known pathogen–*Sarcocystis nesbitti*. PLoS One. 2017;12:0187984. https://doi.org/10.1371/journal.pone.0187984.
123. Ferguson M, Brown C, Georga C, Miles E, Wilson A, Brimblecombe J. Traditional food availability and consumption in remote Aboriginal communities in the Northern Territory, Australia. Aust N Z J Public Health. 2017;41:294–8. https://doi.org/10.1111/1753-6405.12664.
124. DEPWS. Wildlife Trade Management Plan for the saltwater crocodile (*Crocodylus porosus*) in the Northern Territory of Australia, 2021–2025. Northern Territory Department of Land Resource Management. Darwin; 2020.
125. Animal Medicines Australia. Pets in Australia: a national survey of pets and people. Animal Medicines Australia: Canberra; 2022.
126. Warwick C. The morality of the reptile" pet" trade. J Animal Ethics. 2014;4:74–94. https://doi.org/10.5406/janimalethics.4.1.0074.
127. Marshall BM, Strine C, Hughes AC. Thousands of reptile species threatened by under-regulated global trade. Nat Commun. 2020;11:4738. https://doi.org/10.1038/s41467-020-18523-4.
128. Toomes A, García-Díaz P, Wittmann TA, Virtue J, Cassey P. New aliens in Australia: 18 years of vertebrate interceptions. Wildl Res. 2019;47(1):55–67. https://doi.org/10.1071/WR18185.
129. Stringham OC, García-Díaz P, Toomes A, Mitchell L, Ross JV, Cassey P. Live reptile smuggling is predicted by trends in the legal exotic pet trade. Conserv Lett. 2021;14:e12833. https://doi.org/10.1111/conl.12833.
130.•• Bezerra-Santos MA, Mendoza-Roldan JA, Thompson RA, Dantas-Torres F, Otranto D. Illegal wildlife trade: a gateway to zoonotic infectious diseases. Trends Parasitol. 2021;37:181–4. https://doi.org/10.1016/j.pt.2020.12.005. **Recent review on how the illegal wildlife trade can spread various zoonotic infections**
131. Halán M, Kottferová L. Parasitic helminths in snakes from the global legal trade. Helminthologia. 2021;58:415–9. https://doi.org/10.2478/helm-2021-0041.
132. Goldberg SR, Bursey CR. Intestinal helminths in nine species of endemic Australian lizards, *Lophognathus longirostris* (Agamidae), *Heteronotia binoei* and *Lucasium stenodactylum* (Gekkonidae), *Ctenotus grandis*, *Ctenotus helenae, Cyclodomorphus branchialis*, *Egernia depressa*, *Eremiascincus richardsonii*, *Morethia butler*i, and Mo. Comp Parasitol. 2012;79:247–68. https://doi.org/10.1654/4570.1.
133. Howell TJ, Warwick C, Bennett PC. Self-reported snake management practices among owners in Victoria. Aust Vet Record. 2020;187:114. https://doi.org/10.1136/vr.105409.
134. Hallinger MJ, Taubert A, Hermosilla C, Mutschmann F. Captive agamid lizards in Germany: prevalence, pathogenicity and therapy of gastrointestinal protozoan and helminth infections. Comp Immunol Microbiol Infect Dis. 2019;63:74–80. https://doi.org/10.1016/j.cimid.2019.01.005.
135. Bustos ML, Sánchez MN, Teibler GP, Peichoto ME. Parasitic fauna of captive snakes (Serpentes, Colubridae) from northeastern Argentina. South Am J Herpetol. 2023;26:44–55. https://doi.org/10.2994/SAJH-D-21-00002.1.
136.• Barton DP, Martelli P, Luk W, Zhu X, Shamsi S. Infection of *Hexametra angusticaecoides* Chabaud & Brygoo, 1960 (Nematoda: Ascarididae) in a population of captive crested geckoes, *Correlophus ciliatus* Guichenot (Reptilia: Diplodactylidae). Parasitology. 2020;147:673–80. https://doi.org/10.1017/S0031182020000219. **Study which shows an example of how captive reptiles can transmit and acquire parasites from each other while in captivity**