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There's something strange about the way that environmental reporting is almost unrelenting downbeat. Take the case of amphibians - a group beset by habitat loss, chytrid fungus and global warming, and now considered to be facing extinction on an unparalleled scale, according to media coverage.

Yet if you go behind these headlines, things don't appear quite as depressing. In fact, as we highlight in our news pages here, the number of amphibian species known to science has actually risen, not just by one or two, by a whopping 60% (yes, sixty percent!) in total over the past 35 years, to a figure of 8,118 living species on the earth at the start of this year.

So the question is how can these statements be reconciled? Well, the fact of course is that although scientists are discovering more species, so there are every increasing risks to the survival of amphibians, which are linked in most cases with human actions on the environment, whether it be from pollution to the clearance of vast tracts of rainforest. Those that have limited distributions are likely to be most imperilled. In fact, there will almost certainly have been some amphibian species that have gone extinct over recent decades before they even became known to science. We simply don't know the numbers involved.

Up until the turn of the century, the conservation debate focussed very much on individual species. Alongside a more general desire to promote the well-being of the planet as a whole, however, so this focus has been lost. When it comes to environmental coverage today, the arguments are concentrated on climate change, which I think in many way is unfortunate, as it depersonalises the issues and impacts.

For cold-blooded species such as amphibians and reptiles, a significant temperature shift can be particularly devastating - whichever way it goes - especially within a very short period of time, in terms of a geological timeframe. Once a number of species in an area are lost, with currently no realistic likelihood of resurrecting them, even if there are areas of habitat that would be suitable, the effects will soon ripple up the food chain as well.

This has emerged recently in the Central American country of Panama. Studies there have now revealed that more than half of the specialised snakes found in the Parque Nacional G. D. Omar Torrijos Herrera that prey on amphibians have declined in numbers too, since chytrid fungus swept through the region, decimating the snakes' food source. The researchers believe that the impact will in turn work further up the food chain, to apex predators such as birds of prey.

Even apex predators clearly suffer from human actions though, and because of the direct conflicts that can arise with people, so their numbers can plummet faster than ever, if they are directly persecuted by us. In this issue, crocodilian expert Colin Stevenson explains what has happened with this group of reptiles over recent years and considers their future.

He points out that any successful conservation programme is likely to result in increased conflict between crocodilians and ourselves, unless we are willing to invest in taking steps to mitigate the threat, as part of an overall conservation strategy. Here again though, the truth is not entirely acknowledged, not least by natural history film-makers, who love to dramatise croc encounters. The truth of the matter is actually that the vast majority of crocodilians alive today pose no threat to people. Above all else therefore, perhaps we need more balance in the conservation debate today!!

David Alderton

Email: practicalreptilekeeping@gmail.com

David has extensive practical experience with this group of creatures, going back over 40 years. He has written and broadcast widely about their care and biology.

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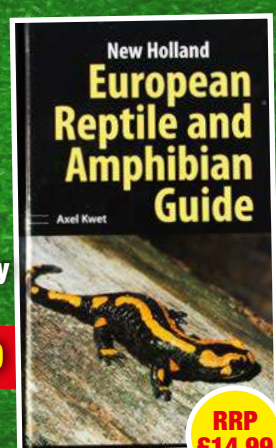
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▶ Most people would be very surprised to learn that more new species of reptile and amphibian have been discovered in the first two decades of the 21st century than during any other previous period in zoological history. In fact, there are currently 8,118 living species of amphibian on the planet, reflecting an increase of more than 60% in their numbers since 1985. G. Valentine highlights some more of the most significant recent finds, which have tended to be concentrated in Madagascar and north-eastern parts of South America.

Twenty-five new frogs found on Cameroon's Mount Oku

While amphibians all over the world are undergoing a continuous decline, their status in certain regions, such as Central Africa, remains unknown due to incomplete information. A new paper, published by two scientists addresses the knowledge gap by providing an updated list of already 50 amphibian species living on Mount Oku, Cameroon, but makes for worrying reading. A staggering 44% of the amphibians in this montane region are threatened with extinction.

Scientists Dr Thomas M. Doherty-Bone from the Royal Zoological Society of Scotland, and Dr Václav Gvoždík, affiliated with both the Czech Academy of Sciences and the National Museum in Prague, have spent more than 10 years studying the Cameroonian mountain. As a result of their thorough surveys, literature review, and re-examination of museum specimens, there are now 50 species known from the locality, which doubles previous numbers. In their newly published checklist the researchers have listed 49 species of frogs and toads, as well as one caecilian species – a limbless, snake-like amphibian.



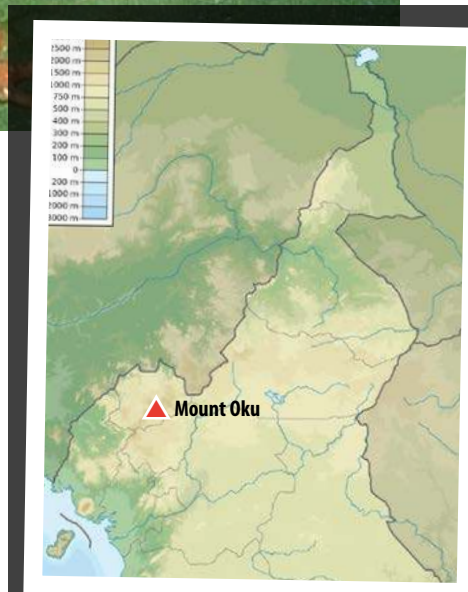
Under threat

However, the number of threatened species seems to increase proportionally. Many of the newly recorded frogs, for instance, appear to be extremely endangered yet they have not been assessed by the International Union for Conservation of Nature (IUCN). Therefore, the authors have used the IUCN criteria to propose conservation assessments for them. If

▲ Originally described from Nigeria in 2011, the Schiotz's Puddle Frog has now been recorded from this area of Cameroon too. Although it has been regularly observed, it might be threatened with extinction due to habitat degradation and climate change.

Photo courtesy Thomas M. Doherty-Bone / CC-BY 4.0.

► The location of Mount Oku. Map courtesy Urutseg/Wikipedia.



the suggested statuses are approved, together with the updated declines of previously abundant in the area species, the proportion of the threatened species would rise to nearly half (48%) of the Mount Oku's entire amphibian fauna.

In their study, the scientists also review the research and conservation work undertaken at the mountain so far, including the work they have initiated themselves. Although Mount Oku's forest turned out to be the best managed among the rest in the region, threats such as forest loss, encroachment and degradation are still largely present and increasing.

Additional threats, including use of agrochemicals, climate change and diseases, have also been identified. However, conservation actions for the amphibians of Mount Oku are on the rise, considering both the population and the ecosystem-level perspectives.



▲ Endemic amphibians of Mt Oku. Clockwise from top-left: Lake Oku clawed frog, *Xenopus longipes*; Mount Oku subalpine toad, *Wolterstorffina chirioi*; Mount Oku caecilian *Crotaphatrema lamottei*; Lake Oku puddle frog, *Phrynobatrachus njiomock* found almost exclusively in forest around Lake Oku; puddle frog *Phrynobatrachus* sp. aff. *wernerii*; spiny puddle frog, *Phrynobatrachus chukuchuku*. Photo courtesy Thomas M. Doherty-Bone / CC-BY 4.0.

Further information

Thomas M. Doherty-Bone, Václav Gvoždík. **The Amphibians of Mount Oku, Cameroon: an updated species inventory and conservation review.** *ZooKeys*, 2017; 643: 109 DOI: 10.3897/zookeys.643.9422

New treefrogs found in South America



Sarayacu treefrog. Photo courtesy Daniel Rivadeneira, Pablo Venegas, Santiago Ron/Pensoft Publishers.

➤ Small horns are present above the upper eyelids of the devil frog, with this individual being found in Bolivia.

Two new species of treefrog have been discovered in the Amazon Basin of Bolivia, Peru, and Brazil, after both had been previously misidentified as another superficially identical species.

One of them has received a name translating to 'demon' or 'devil', while the second one was named in honour of famous American filmmaker Stanley Kubrick, because of his masterpiece *A Clockwork Orange*, released in 1971.

Having conducted analyses of their genetics, appearance and calls, scientists C. Daniel Rivadeneira, Dr. Pablo J. Venegas, and Dr. Santiago R. Ron concluded that the amphibians represented two previously unknown species that were formerly grouped under the name of the Sarayacu treefrog (*Dendropsophus parviceps*). As a result of this research collaboration between Ecuador's Catholic University (PUCE) and Peru's Centro de Ornitología y Biodiversidad (CORBIDI), the treefrogs were recently described as being new to science.

Naming the new species

But why the Stanley Kubrick reference? The scientists point out that back in 1972,

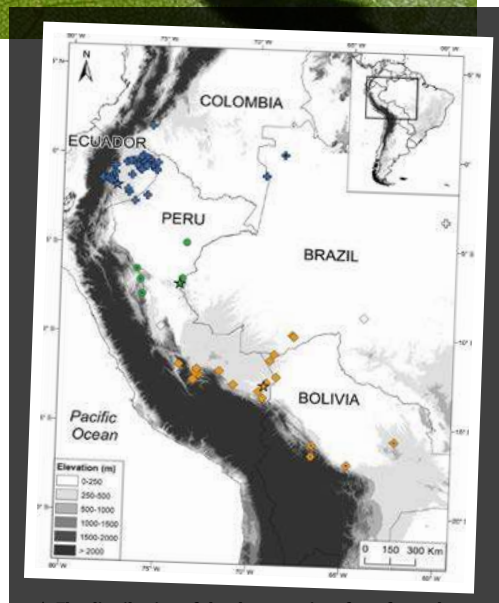


▲ The newly-discovered Kubrick's treefrog (*Dendropsophus kubricki*) showing the bright-orange markings on its underparts. Photo courtesy Pablo Venegas CC-BY 4.0

when Anthony Burgess explained the title of his famous novel *A Clockwork Orange*, he said: "I've implied the junction of the organic, the lively, the sweet – in other words, life, the orange – and the mechanical, the cold, the disciplined..."

"Without being aware of it in that context, Burgess was using a good metaphor that was equally applicable to describe ecosystems," explain the researchers. "Nature works as the interplay between life and its cold, mechanical, and disciplined physical matrix."

In addition, both of these frogs, now known to science as *Dendropsophus kubricki* and *D. kamagarini*, are characterised by having a bright orange blotch on the shanks and in the axillary region, reminiscent of the 'orange pieces of nature'. In addition, the species name 'kamagarini' translates as 'demon' or 'devil', originating from the Matsigenka language which is spoken in southeastern Peru. This is because one of the characteristic features of *D. kamagarini* is the horn-like protuberances on its upper eyelids.



▲ The distribution of the three species of treefrog - the newly-identified Kubrick's tree frog is shown in green, with orange markings indicating known localities of the devil frog, while localities where the Sarayacu treefrog has been reported are in green. Map courtesy Daniel Rivadeneira, Pablo Venegas, Santiago Ron/Pensoft Publishers.

Further information

Daniel Rivadeneira, Pablo Venegas, Santiago Ron. **Species limits within the widespread Amazonian treefrog *Dendropsophus parviceps* with descriptions of two new species (Anura, Hylidae).** *ZooKeys*, 2018; 726: 25 DOI: 10.3897/zookeys.726.13864

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NEW ANT FOUND IN THE MOST UNLIKELY SURROUNDINGS

While new ant species are usually discovered in surveys involving researchers searching through leaf litter, it turns out that sifting through the stomach contents of insect-eating frogs might prove a no less effective method of finding them, especially when it comes to rare species. Such is the case underpinning the discovery of a new species of rarely collected long-toothed ant, which was first found in the stomach of a so-called little devil poison dart frog (*Oophaga sylvatica*) in Ecuador.

The new ant species, named *Lenomyrmex hoelldobleri* after renowned myrmecologist (ant scientist) Bert Hölldobler on the occasion of his 80th birthday, was described based on a single individual, which was a female worker. It is the seventh known species in this rarely collected neotropical genus.

A diverse ecosystem

Like its relatives within the group, this ant amazes with its slender and elongate mouthparts, and yet it is larger than all of them. The remarkable jaws would indicate specialised predatory habits, but so far, however, nothing is known about the feeding behaviour of this new species.

The amphibian, whose diet largely consists of ants, was collected from the Ecuadorian region called the Chocó. Unfortunately, despite being one of the



The new species of ant, seen in profile.
Photo courtesy Dr Christian Rabeling, CC-BY 4.0.



▲ The peculiar mouthparts of the new species. Photo courtesy Dr Christian Rabeling, CC-BY 4.0.

▼ A little devil or harlequin poison dart frog from the Ecuadorian Chocó enabled the new species of ant to be discovered.

Photo Dr Morley Read/www.shutterstock.com



▲ The overall range of the *Lenomyrmex* genus of ants, including this new species.

Map courtesy Dr Christian Rabeling, CC-BY 4.0.



most biologically diverse areas in the world with exceptionally high levels of endemism (meaning that a high number of the species found here occur nowhere else on earth), this part of the country is also one of world's most threatened areas.

A safe method of study

In conclusion, the scientists point out that studying vertebrate stomach contents is not only a way of studying the trophic ecology, meaning the feeding relationships between organisms, but also can represent an interesting source of both little-known and new arthropod species, including ants.

Furthermore, the scientists are keen to emphasise that nowadays, there is no need to kill a frog in order to study its stomach contents. Stomach flushing methods have been developed and successfully applied in numerous studies, which avoids killing individuals to obtain invaluable insights of this type.

Further information

Rabeling C, Sosa-Calvo J, O'Connell LA, Coloma LA, Fernández F (2016)

***Lenomyrmex hoelldobleri*: a new ant species discovered in the stomach of the dendrobatid poison frog, *Oophaga sylvatica* (Funkhouser).** *ZooKeys* 618: 79-95. doi: 10.3897/zookeys.618.9692

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Three new chameleon species discovered

Daniel Hughes liked to catch lizards when he was a child, but never imagined that he would be catching and discovering new species of chameleons when he grew up! Working for his doctorate within the University of Texas at El Paso's (UTEP's) Ecology and Evolutionary Biology programme, he has now discovered three new species of chameleons.

This reptilian trio, previously believed to be a single species, were found in different parts of the Albertine Rift area of Central Africa. "We are hopeful that the formal descriptions of these three endemic chameleon species will be used to increase conservation awareness and encourage protection efforts across these irreplaceable regions," says Hughes.

The specimens were collected in the Democratic Republic of the Congo mainly by Hughes' mentor Dr Eli Greenbaum, associate professor of biological sciences. The location is rich with biodiversity, but because of political unrest, researchers have been reluctant to go there. However, Greenbaum has been travelling and conducting research in the area for about 10 years.

Naming of the species

Hughes joined Greenbaum three years ago in the field, and specifically came to UTEP to study under him in 2013. The new scientist was able to describe the three new chameleon species after carefully analysing geographical, morphological (appearance) and DNA data; a process that was followed by nearly two years of external confirmation.

The Itombwe forest chameleon
(*Kinyongia itombwensis*).
Photo courtesy Eli Greenbaum, Ph.D.



Tolley's forest chameleon
(*Kinyongia tolleyae*).
Photo courtesy Eli Greenbaum, Ph.D.

Two of the new chameleons - the Rugege highlands forest chameleon (*Kinyongia rugegensis*), and the Itombwe forest chameleon (*Kinyongia itombwensis*), are so-called after the mountain ranges in which they were found. The third chameleon, Tolley's forest chameleon (*Kinyongia tolleyae*), is named after herpetologist Krystal Tolley. As principal scientist at the South African National Biodiversity Institute in Cape Town, South Africa, she has contributed significantly to chameleon research and also first taught Hughes how to catch chameleons in Uganda!

"I think I went into shock when I found out, but I was also really happy," admits Tolley. "I have been working on chameleons for many years, and they really are my main topic of research. So to have a species named after me, within a group of animals where I've invested most of my research career, is such a privilege. I've also been lucky enough actually to see this species in Uganda, together with both Danny and Eli. It's a sassy little thing, which really makes it a good fit!"

A unique yet vanishing environment

Hughes explains the Albertine Rift (AR) is not only geologically unique, but it also harbours more endemic vertebrate species than any other area of similar size on continental Africa. "In these remote regions that are sometimes thousands of miles away from many people, it can be hard to relate," he says.

"So, hopefully with our work, we can start to bridge that gap to broaden a general awareness that everyone's actions have implications for these species from threatened regions that they may never see. If conservation efforts in the various countries of the Albertine Rift do not rapidly improve, many rare and potentially other new species will be lost."

There are now 206 described species of chameleons on the planet and Hughes hopes to continue finding many more. "A recent modelling study demonstrated that many habitats in the Albertine Rift, including those where the new species of chameleons are endemic, will likely be destroyed in the coming decades," explains Greenbaum. "As chronicled in my book entitled *Emerald Labyrinth: A Scientist's Adventures in the Jungles of the Congo*, the coming years will almost certainly be the last opportunity to discover surviving new species in the rapidly declining forests of Central Africa."

The Rugege highlands forest chameleon (*Kinyongia rugegensis*). Photo courtesy Eli Greenbaum, Ph.D.



Further information

Daniel F. Hughes, Chifundera Kusamba, Mathias Behangana, Eli Greenbaum.
Integrative taxonomy of the Central African forest chameleon, *Kinyongia adolfiiriderici* (Sauria: Chamaeleonidae), reveals underestimated species diversity in the Albertine Rift. *Zoological Journal of the Linnean Society*, 2017; DOI: 10.1093/zoolinnean/zlx005

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Three new species of tiny frog found in the Andes

An international team of scientists, led by a University of Michigan ecologist have discovered three additional, previously unknown frog species in the Peruvian Andes. These amphibians were spotted in the mountain forests and Andean grasslands of the Pui Pui Protected Forest in central Peru.

All three species measure 2.5in (1in) or less in length, from snout to vent. "We have now described five new species of frogs from this region since 2012, with several more to come in the near future," says Rudolf von May, a postdoctoral researcher in the Rabosky Lab at the U-M Museum of Zoology and the Department of Ecology and Evolutionary Biology.

A fertile ground for new finds

"Our discoveries demonstrate the need for further scientific exploration of Andean habitats of this type," he says. "While the Pui Pui Protected Forest was established in 1985, virtually no biological surveys were conducted in the park for nearly three decades, and the potential for additional discoveries is enormous."

The three new frog species all belong to the genus *Pristimantis*, which represents the most diverse genus of frogs in the tropical Andes. With nearly 500 species, they are part of the family Craugastoridae,

► The hill dweller rubber frog (*Pristimantis bounides*) is known from two sites at elevations of 3350m (10,991ft) and 3463m (11,362ft). Its designated species name 'bounides' is derived from the Greek noun 'bounos', which means "dweller of the hills" and refers to the mountain forests where this frog was found. It occurs in a region of mixed vegetation including large areas of mosses, small bushes, trees, and Peruvian feather grass.

Photo courtesy Rudolf von May.



commonly known as land-breeding or terrestrial-breeding frogs.

While most frogs lay eggs in water, terrestrial-breeding frogs use a specialised reproductive mode called direct development. A clutch of embryos hatches directly into froglets; there are no free-living tadpoles in the case of these species. This allows the group to exploit a wide variety of habitats, away from areas of standing water, as long as those locations contain sufficient atmospheric moisture.

Terrestrial-breeding frogs appear to have undergone an evolutionary radiation at high elevations in Peru, as many species resemble one another and have similar life histories. In contrast, a so-called 'adaptive radiation' occurs when a single ancestral group produces many descendant species adapted to different habitats and ways of life.

The region itself

The Pui Pui Protected Forest covers 61,000 hectares (150,000 acres) and includes dozens of lakes and streams that feed several rivers in the upper

Amazon River watershed. About 70 percent of the protected forest is covered by Andean grasslands, and about 30 percent is cloud forest.

"Our findings suggest that the Pui Pui Protected Forest houses unique biological communities containing species found nowhere else," says von May's colleague Edgar Lehr. "One reason for this is that the area has a steep topographic gradient including a broad array of habitats and local microclimates that contribute to the high species diversity that exists amongst amphibians there."

It was back in 2003 that von May and Lehr first discussed the possibility of exploring the Pui Pui region. Finally, during early 2012, Lehr received funding from the National Geographic Society to survey the area, and they carried out the first expeditions that year. Two other herpetologists joined subsequent trips: Jiri Moravec of the National History Museum in Prague, Czech Republic and Juan Carlos Cusi from the Museum of Natural History of Universidad Nacional Mayor de San Marcos, based in Lima, Peru.



◀ Humboldt's rubber frog (*Pristimantis humboldti*) has been documented from a single site at 3318m (10,886ft). The species' name commemorates the German naturalist and explorer Alexander von Humboldt (1769-1859), who travelled widely in the New World between 1799 and 1804.

Photo courtesy Rudolf von May.

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Altogether, the team spent nearly three months in the field between 2012 and 2014, in a region where mountains taller than 3960m (13,000ft) are common. "Our team worked with local guides and park rangers," von May explains. "The equipment, food and camping supplies used in the expeditions had to be carried by horses and mules."

Further discoveries in the area

Earlier this year, the researchers described two other new species of Peruvian frogs from this area - *Pristimantis ashaninka* and *Pristimantis attenboroughi*. The first

▲ The Pui Pui rubber frog (*Pristimantis puipui*) was recorded from a single site near Laguna Sinchón, which marks the approximate centre of the Pui Pui Protected Forest, at an elevation of 3890m (12,762ft) above sea level. The species name is derived from the native Quechua words "pui pui" meaning "eyes of water," which is a reference to the many lakes of the Pui Pui Protected Forest.

Photo courtesy Jiri Moravec.

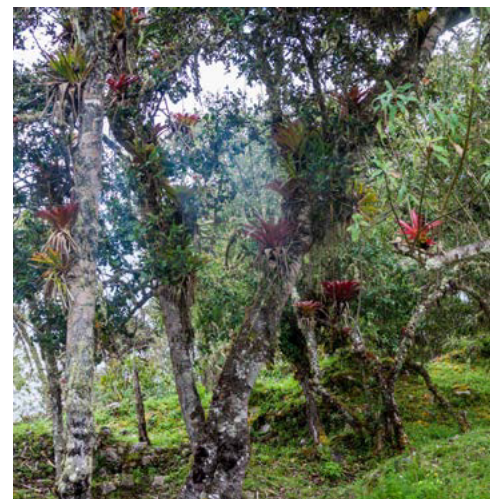
was named after the Ashaninka, a group of indigenous people from the Peruvian and Brazilian Amazon, some of whom live near Pui Pui. The second species was named after the naturalist and broadcaster Sir David Attenborough. There are also another five previously unknown species that they have found here, which will be revealed in due course. These consist of two new lizards and a further three unrecognised species of frog.

Most of the frogs were discovered by searching through moss and grass, as well as under rocks, small bushes and other vegetation. In some cases, the researchers found the frogs after hearing the males calling during light afternoon or evening rains.

Given that the newly discovered frog species live in the Pui Pui Protected Forest, much of their habitat is formally protected. However, amphibians worldwide face multiple threats—including habitat loss, the deadly chytrid skin fungus and climate change—and Andean amphibians are no exception. In the Peruvian Andes specifically, habitat loss is currently the main threat. Of special concern are localised forest felling and manmade fires which are being used to expand the area of land currently available for agricultural crops and livestock grazing.

◀ Juan Carlos Cusi collecting skin swab samples of amphibians in the Pui Pui Protected Forest.

Photo courtesy Jordan Milla of Universidad Nacional Mayor de San Marcos, Lima, Peru



▲ Peruvian cloud forest is a precious and unique habitat for many species. Amphibians here have developed a breeding cycle that is quite different from that of many others of their own kind elsewhere in the world.

Photo courtesy Matyas Rehak/www.shutterstock.com

Further information

Edgar Lehr, Rudolf Von May, Jiří Moravec, Juan Carlos Cusi. **Three new species of *Pristimantis* (Amphibia, Anura, Craugastoridae) from upper montane forests and high Andean grasslands of the Pui Pui Protected Forest in central Peru.** *Zootaxa*, 2017; 4299 (3): 301 DOI: 10.11646/zootaxa.4299.3.1



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New toads found in Nevada

Photo courtesy Malgorzata Litkowska/www.shutterstock.com



Three new species of toads have been discovered living in Nevada's Great Basin in an expansive survey of the 500,000sq km (190,000sq ml) ancient lake bottom in the USA.

"We've found the new toads in small, wet habitats surrounded by high desert, and completely cut off from other populations," Dick Tracy, a renowned biology professor at the University of Nevada, Reno, and lead scientist on the project, explains. "These are absolutely new, true species that have been separated from other populations for 650,000 years."

➤ A large expanse of the state of Nevada is occupied by the Great Basin, which lies south of the Humboldt River.

Map courtesy Peter Hermes Furian/www.shutterstock.com

▼ Areas of water in Nevada's Great Basin today are significantly reduced in expanse, causing the ancestors of today's toads to have become isolated, resulting in the creation of new species.

Photo courtesy Ariene Treiber Waller/www.shutterstock.com



The new discoveries

The three amphibians that Tracy has found have been christened the Dixie Valley toad, the Railroad Valley toad and Hot Creek toad. None of them are connected geographically. They were found during Tracy's 10 year survey of the desert-dominated Great Basin. His team used 30 "shape" metrics and DNA studies to analyse these toads' characteristics to determine if each was distinguishable from the closely related western toad, which is found throughout the western United States.

The evidence supports the recognition of three distinct new species. The toads are small in size, yet each have a range of unique physical features that differ from each

Did you know?

Discoveries of new amphibians are extremely rare in the United States with only three new frog species having been recorded since 1985 - and finding a new toad is an even rarer event. The last species of toad discovered north of Mexico was the Wyoming toad (*Anaxyrus baxteri*), back in 1968. It was feared extinct in the wild for a time, although it survives thanks to captive-breeding.



A Wyoming toad. Photo courtesy USFWS Mountain-Prairie. Photo: Sara Armstrong.

other, as well as other toads in the region. Each of the species display slightly different colours, and they are about 5cm (2in) long when full grown.

Found just in time?

"The Dixie Valley toad is a pretty toad, with flecks of gold on an olive background," Prof Tracy explains. "It's not like the big, common green toads you might find in other marshes around the west or even in Rancho San Rafael Park in Reno."





◀ Prof Tracy studying the Dixie Valley toad in his laboratory in Reno.

Photo courtesy Mike Wolterbeek, University of Nevada, Reno

The Dixie Valley toad is in Churchill County about 160km (100ml) east of Reno. The toad is only found in this isolated spring-fed marsh which makes up less than 10sq km (4sq ml), surrounded by an arid region where aquatic resources are both rare and widely scattered.

Dixie Valley is the hottest and most geothermally active region in the Basin and Range Province. Unfortunately, the habitat occupied by this newly described species is also adjacent to a proposed site for a geothermal power plant that could dry up the marsh and threaten the toad's survival.

Thankfully, the power plant development is on hold while the Bureau of Land Management (BLM) reviews the geothermal project and the possible impacts on the new toad species. A campaign by the Center for Biological Diversity, a national environmental group based in Tucson, Arizona, led to more than 1000 letters being received by the BLM asking them to reconsider permitting the power plant being built at the site of the newly

discovered species.

Protection for this species?

"If this power plant goes ahead and the habitat dries up, this recently discovered species could go extinct," Tracy says. "It's a good candidate for an Endangered Species Act listing. This is a tough conflict between commerce and biological resources, and we need to seek compromises so if the project proceeds, it won't hurt these toads."

The tiny isolated toad populations consist of much smaller individuals compared with other western toad species. In fact, the Dixie Valley toad has the smallest body size among the region's complex of related species in the western United States, and can be further recognised from other toads in the complex by the large glands present on its hind legs, leaving aside its distinctive colouration.

The overall population of the Dixie Valley toad is unknown, but with its range apparently being severely

restricted, this suggests that the population of this species is probably very small and especially vulnerable to environmental changes.

"The toads are perfectly concealed in the dense vegetation of their habitat," Prof Tracy says. "You could easily miss seeing them during the day, making accurate counts difficult. But, during one trip at dusk, these toads were everywhere, giving the impression that they were locally abundant. And, without the water in this habitat, this toad species would completely disappear."

The other species

The Railroad Valley toad is in the Tonopah Basin in the central Nevada desert, and the Hot Creek toad is about 56km (35ml) away located in the Hot Creek Mountain Range, in a drainage area isolated from the Railroad Valley toad. All three new species are natives of the Great Basin in Nevada, which was once covered by large marshes and giant inland lakes during the Pleistocene epoch and yet is now amongst the most arid regions in the United States with only one percent of the landscape containing water.

"Our goal has been to understand the relationships among toad populations in the Great Basin," Prof Tracy explains. "We've found that our knowledge of amphibian diversity in the western United States remains incomplete and that novel discoveries continue to occur, even in unlikely settings. This is really, really neat; it's an exciting thing, to find something not known to exist before!"

▼ The newly-discovered Dixie Valley toad faces an immediate challenge to its survival.

Photo courtesy Mike Wolterbeek, University of Nevada, Reno.



◀ The new toads are all smaller than the western green toad (*Anaxyrus debilis*) seen here, to which they are closely related.

Photo courtesy Matt Jepsen/
www.shutterstock.com

Further information

C. Richard Tracy *et al.* **A diamond in the rough desert shrublands of the Great Basin in the Western United States: A new cryptic toad species (Amphibia: Bufonidae: *Bufo* (*Anaxyrus*)) discovered in Northern Nevada.** *Zootaxa*, July 2017



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Spiders resembling miniature birds

It is not just the number of cold-blooded vertebrate species that has increased dramatically over recent years. Even more discoveries have been made in the field of invertebrates, with potentially millions of additional new species belonging to this group still awaiting discovery, according to some scientists.

In 1854, a curious-looking spider was found preserved in amber that was 50 million years old. With an elongated neck-like structure and long mouthparts that protruded from the “head” like an angled beak, the arachnid bore a striking resemblance to a tiny pelican.

A few decades later when living pelican spiders were discovered in Madagascar, scientists found that their behaviour is just as unusual as their appearance. Yet because these spiders live in remote parts of the world they have remained largely unstudied—until recently.

At the Smithsonian’s National Museum of Natural History, curator of arachnids and myriapods Hannah Wood has examined and analysed hundreds of pelican spiders both in the field in Madagascar and through study of pelican spiders preserved in museum collections. Her analysis, focused on spiders of the *Eriauchenius* and *Madagascarchaea* genera, sorted the spiders she studied into 26 different species—18 of which have never before been described.

Wood says pelican spiders are well known among arachnologists not only for their unusual appearance, but also for the way they use their long “necks” and jaw-like mouthparts to prey on other spiders. “These spiders attest to the unique biology that diversified in Madagascar,” she says.

Pelican spiders are active hunters, prowling the forest at night and following long silk draglines that lead them to their spider prey. When a pelican spider finds a victim, it swiftly reaches out and impales it on its long, fang-tipped “jaws,” or chelicerae. Then it holds

Eriauchenius milajaneae is one of the 18 new species of pelican spiders from Madagascar described by the scientists. This species was named after Wood’s daughter, and is known only from one remote mountain in the southeast of Madagascar. Wood made a field expedition to this mountain to find this spider in 2008 but was unsuccessful. So far, this species is only known from two females and one juvenile held in museum collections. Photo courtesy Hannah Wood, Smithsonian.



the spider away from its body, keeping itself safe from potential counterattacks, until the victim dies.

Back from the dead

Today’s pelican spiders are genuine living fossils, according to Wood—remarkably similar to species found preserved in the fossil record from as long as 165 million years ago. Since the living spiders were found after their ancestors had been uncovered in the fossil record and their lineage was presumed extinct, they can be considered a “Lazarus” taxon - meaning ‘back from the dead’.

In addition to Madagascar, modern-day pelican spiders have been found in South Africa and Australia—a distribution pattern that suggests their ancestors were dispersed to these landmasses when the Earth’s supercontinent Pangaea began to break up around 175 million years ago.

Madagascar is home to vast numbers of plant and animal species that exist only on the island, but until recently, just a few species of pelican spiders had been documented there.

In 2000, however, the California Academy of Sciences launched a massive arthropod inventory in Madagascar, collecting spiders, insects and other invertebrates from all over the island.

Better insights

Wood used those collections, along with specimens from other museums and spiders that she collected during her own field work in Madagascar, to conduct her study. Her detailed observations and measurements of hundreds of specimens led to the identification of 18 new species—but Wood says there are almost certainly more to be discovered, especially as field workers continue to collect specimens across Madagascar.

The spiders that Wood personally collected, including several of the new species, will join the U.S. National Entomological Collection at the Smithsonian, the second-largest insect collection in the world, where they will be preserved and will be accessible for further research by scientists around the globe.

All of the pelican spiders that Wood described live only in Madagascar, an island whose tremendous biodiversity is currently threatened by widespread deforestation. The new species add to scientists’ understanding of that biodiversity, and will help Wood investigate how pelican spiders’ unusual traits have evolved and diversified over time. They also highlight the case yet again for conserving what remains of Madagascar’s forests and the amazing biodiversity that exists there.

Further information

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▲ *Eriauchenius bourginis* is a pelican spider from Madagascar recently redescribed by the scientists. This species occurs in the central eastern part of Madagascar, but its closest relative, *E. zirafy*, a new species of pelican spider described by the scientists, only occurs far away in the northeastern rainforests. The distributions of these two sister species suggests that a long time ago their ancestor was widespread, then a climatic or geologic change resulted in populations becoming isolated. As time passed, these isolated populations, subject to different environments and evolutionary pressures, eventually became two separate species. Photo courtesy Hannah Wood, Smithsonian.

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Photo courtesy Dirk Ercken/www.shutterstock.com

New research into the behaviour of blue poison dart frogs

Chloe Heslington BSc (Hons) and James Brereton MSc report on their studies investigating the way in which these dart frogs use their enclosure, and the significance of providing ultra violet (UV) light for them.

Dendrobatid frogs represent some of the most popular species represented in herpetological collections today. With their visually attractive bright colouration and attractive patterning (which actually serves as a warning of their toxicity to would-be predators), dart frogs make striking exhibits, particularly when housed in a naturalistic enclosure. Their small size means that they do not require a great deal of space, their breeding habits are fascinating to observe, and some species are now being spawned very frequently.

Blue is the colour!

One particular species, the blue poison dart frog (*Dendrobates azureus*/*Dendrobates tinctorius azureus*), is particularly well-

represented in both private and public collections today. According to a search of the Zoological Information Management System (ZIMS), there are at least 2,700 examples represented in the world's zoos and aquaria, and almost certainly, many thousands more are being kept by hobbyists in their collections.

A number of reasons underlie the popularity of this particular species, not least the fact that it is relatively large, at least in dart frog terms! It typically grows to between 3-4.5cm (1.2-1.75in) overall, making it relatively conspicuous. Its deep azure blue colouration, as reflected by its scientific name, is highly distinctive, with even blue markings being relatively usual in amphibians (or indeed reptiles), let alone cases



▲ One of the frogs that formed part of this study.
Photo courtesy the authors.

Did you know?

Although called poison dart frogs, examples of these frogs bred in vivarium surroundings lack the deadly skin secretions of their wild relatives, which are effectively distilled from toxins present in their invertebrate prey. This, however, does not occur with those reared in collections, although they should not be handled in any case, because of the risk of causing injury to their sensitive skins.

where blue is by far the dominant colour.

This blue characteristic is also one of the reasons why it is sometimes considered to be a form of the dyeing poison dart frog (*D. tinctorius*), whose members have variable blue markings, along with other colours on their bodies. The inter-relationships between different dart frogs are still not clearly understood or universally agreed.

The blue poison dart frog nevertheless makes a good introduction to the hobby, as it can be cared for quite easily and also its breeding requirements are more

▲ The dyeing poison dart frog is a close relative of the blue poison dart frog, with blue colouration tending to be confined to the legs and undersides of the body, as shown here in the "Bakhuish" morph.

straightforward than in the case of many species.

Suitable set-ups

There has been a great rise in the popularity of naturalistic exhibits over recent years, thanks to advances in technology, and both dart frogs and mantellas are often housed in such exhibits today. Naturalistic set-ups do pose a challenge, however, in terms of long term maintenance, as keepers must also develop

horticultural skills, so as to maintain the plants growing in the vivarium.

This is in addition to meeting the husbandry needs of the vertebrate occupants and the invertebrate 'custodians' that recycle the waste matter, some of whom in turn will then be eaten by the other occupants. However, a well-designed, planted enclosure can have great value for its inhabitants. Bromeliads, for example, can provide a more naturalistic setting for some



▲ A blue dart frog resting on the leaf of a bromeliad. Photo courtesy Dirk Ercken/www.shutterstock.com



dart frogs to rear their young, with a number of these plants having a cup full of water at their centre, created by a rosette of their leaves that traps rainwater here.

The importance of lighting

Alongside advances in specific lighting systems for plants that have made this possible, by encouraging healthy plant growth, the value of ultra violet light (UV) for amphibian husbandry is also being more widely appreciated. It is now already well-acknowledged that most diurnal reptile species require a source of UV light for their captive husbandry, although for nocturnal reptiles, as well as amphibians, the situation is not as clear-cut. Whilst some nocturnal reptiles and amphibians can be kept and reared without a source of UV light, it is suggested that UV is important for both normal behaviour, and potentially has health benefits as well.

Clearly, however, there is ‘no one-size-fits-all’ rule for UV light, as the UV output required for a bearded dragon (*Pogona vitticeps*) will far exceed the requirements for a nocturnal royal python (*Python regius*). One of the best estimates of suitable UV provision for herptiles in collections was created by Ferguson and his colleagues in 2009 (as listed under Further Reading at the end of this article).

The team collected UV readings in a range of herptile microhabitats and were able to categorise species into one of four Ferguson zones, based on their natural UV exposure. As a result, many forest-dwelling species fall under zone 1, the zone

Table 1. Ethogram for the poison dart frog.	
Behaviour	Description
Feeding	The frog gets close to the food item, the forequarters are lowered, and it moves its head towards the prey, with the tongue extended slightly, and then the food item is put into the mouth. This is followed by the ingestion of food by swallowing.
Jumping	A method of locomotion, with the frogs moving by lifting all four legs off of the floor and moving forward.
Climbing	The frog moves all four legs individually and placing one in front of the other each time, is observed to do so moving in an upwards direction.
Creeping	Another form of locomotion; the frog walks around, moving limbs one in front of the other in a forward motion.
Vocalising	The vocal sac located in the frog’s throat will inflate to amplify the sound and a noise will be released from the mouth.
Hunting	The frog is searching for food, a prey species is present, and the amphibian is watching it whilst alert. The frog remains still, however, and does not move.
Wrestling	Two individuals come into physical contact, one will grasp the other behind the forelimbs and the submissive will attempt to escape. The frogs will continuously be moving around.
Chasing	One or more individuals repeatedly follow another individual as it moves across the enclosure.
Foraging	The frog searches for food, the head is lowered, and movement may happen at the same time. The animal is watching closely for food sources present.
Resting	There is a lack of movement, the frog remains still and in the same place.
Amplexus	Mating behaviour where the male anuran grasps the female with his forelimbs just behind those of the female. Usually seen when the female is releasing eggs as this is a form of fertilisation; however it can be seen prior to this, when she is due to release eggs. The frogs remain still whilst this is occurring.
Not Visible	The frog cannot be seen by the observer.

▼ The markings of these frogs are quite distinctive, which can make it easier to distinguish between them.
Photo courtesy Wildfeuer/ CC-BY-SA 3.0

with lowest UV requirements. However, as UV is a natural component of the dart frog’s wild habitat, the suggestion is that a low exposure to UV should be provided. This therefore served as the starting point for our investigation.

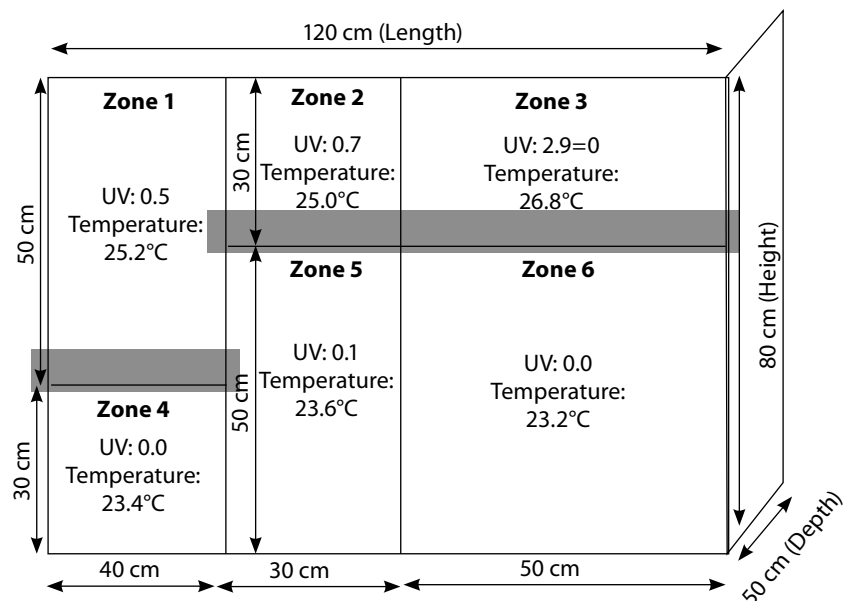


Planning our research

The study was planned to investigate both the enclosure use and behavioural diversity of five blue poison dart frogs, with a specific focus on UV radiation. We wanted to observe the range of the behaviour that they displayed, and to understand whether UV was a influencing variable on the way they used the enclosure, by calculating a modified Spread of Participation Index and Simpson’s Index.

Factors that we looked at included the time of day, by comparing morning observations with those made during the afternoon. The study also investigated whether there was a correlation between the extent that the subjects utilised their enclosure and the diversity in the different behaviours which they exhibited. Data sets were analysed to show whether there was an apparent relationship between them both.

To record behaviour, an ethogram (a list of behaviours with definitions) was developed which included all



▲ The frequency with which these frogs climbed up in their enclosure was one of the behaviours that was measured.

Photo courtesy Natalia Kuzmina/www.shutterstock.com

▲ Diagram of exhibit zones and their average UV output. Illustration courtesy of the authors.

the major behaviours that the frogs engaged in, in order to be able to categorise them for the purpose of this study (see Table 1). At the end of every minute, both the location and the behaviour of each frog was noted. As there were difficulties in individually identifying every frog in the study however, a scan sampling method was applied.

Design of the enclosure

The dart frog exhibit is a large,

vertical naturalistic exhibit containing a range of bromeliads and mosses. The frogs are able to access all levels of the enclosure by making use of artificial rockwork, branches and live plants. The exhibit was broken into six different zones, based on their location in the exhibit, and their average UV exposure. To assess their use of the exhibit, the location of each frog was recorded every minute.

Observations were carried out



▲ Image of part of the dart frog exhibit.

Photo courtesy Grace Jackson.

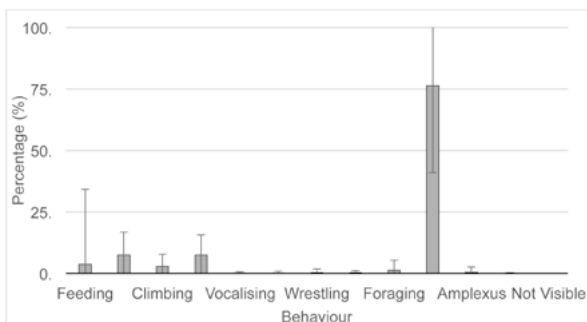
over a period of two months, from November through until January, and were undertaken between 09:00 and 17:00 each day. The UV output that the frogs would experience in each zone was measured using a Solarmeter, from both the point furthest away from, and closest to the UV light that was accessible to the frogs. An average of these values was used to calculate the UV exposure for each zone.

▼ Average activity per frog for the observation period.

Chart courtesy of the authors.

The findings

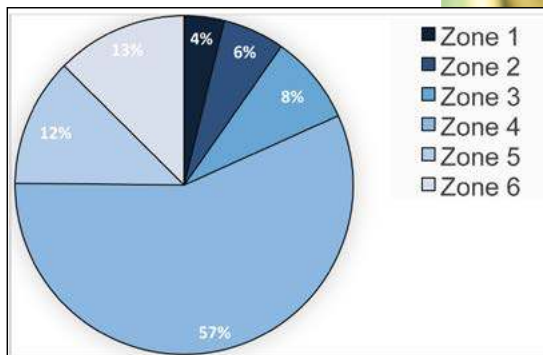
Overall, dart frogs showed considerable variation in terms of



A pair of these frogs about to enter amplexus, when the male holds on to the female's body, prior to spawning taking place.

Photo Vaclav Sebek/www.shutterstock.com





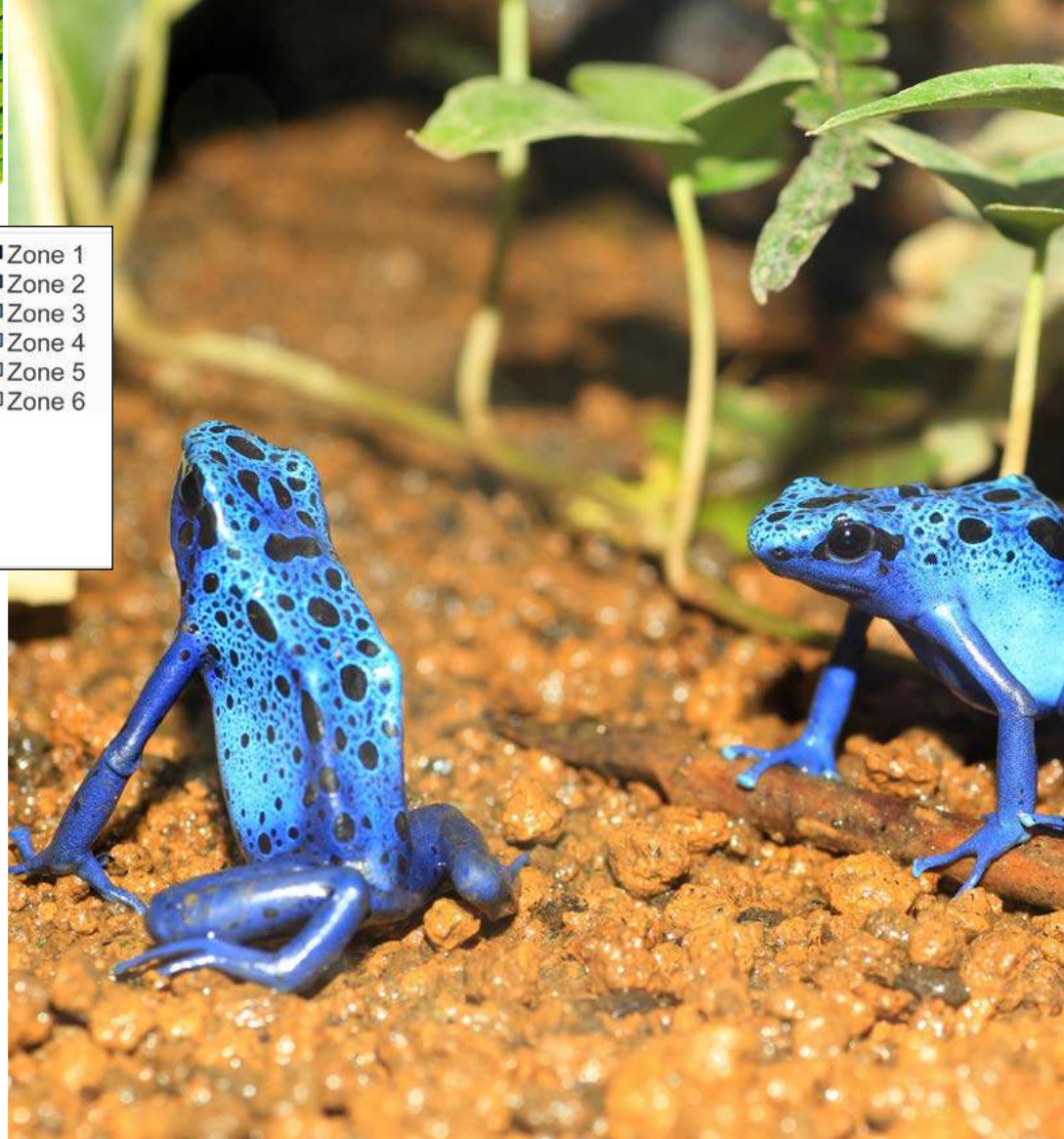
▲ Proportional zone use of all exhibit areas by dart frogs during the study. They showed a preference for zone 4.

Chart courtesy of the authors.

their behaviour. Inactive resting behaviour took up the majority of their time, but the amount of time spent resting was highly variable. Locomotory behaviours such as jumping and creeping featured frequently in the activities of these frogs too.

In terms of enclosure use, the dart frogs used their exhibit relatively evenly, making use of all exhibit zones. It should be noted that zones 1, 2, and 3 - the highest ones - were all least used, with the dart frogs showed a preference for particular zones, especially zone 4. This zone is neither one of the largest zones, nor is it the highest.

The dart frogs also showed a diurnal rhythm to their activity. During early morning observations, the frogs were found in the highest areas of the exhibit. In the afternoon, by contrast, the frogs made greater use of regions located lower down in their accommodation. When



▼ A blue dart frog exhibiting creeping behaviour, as defined in this study.

Photo courtesy Brandon Alms/www.shutterstock.com

food was provided in the exhibit, the amphibians then used a much greater proportion of zones in the exhibit as they chased down their prey.

Discussion

Several studies have already covered the suitability and relevance of

naturalistic exhibits for animal behaviour (see Rose *et al.* 2014). However, there is still relatively little research that has been carried out on enclosure design for many reptiles and amphibians. The amphibians in this study were able to make use of their entire enclosure, and also used specific zones during specific times of day.

It is possible that this activity may in part reflect wild behaviour; using higher canopy regions during the morning may have value for amphibians in allowing them to heat up more quickly or to catch prey there. However, given the dearth of wild behavioural studies on these frogs, it is very difficult to say with any certainty. This work has shown however, that amphibians in vivarium surroundings can and will use a range of different microhabitats throughout the day if they are given the choice and ability to do so.

One particularly interesting facet of this study is the application of UV light. While amphibians have been maintained in collections without access to UV, there is evidence to suggest that even forest-dwelling amphibians would be exposed to





▲ The blue poison dart frog originates from the forests of southern Suriname and the adjoining area of northern Brazil, in northern South America. Photo courtesy Ian Redding/www.shutterstock.com

University Centre Sparsholt, located in Hampshire, in southern England, specialises in providing a range of animal and plant-related degree courses. Some of the courses currently offered include a FdSc in Applied Zoo Science, a BSc (Hons) in Wildlife Ecology and Conservation, a FdSc in Animal Management and an MSc in Applied Zoo Biology. In addition to teaching resources, the Centre also has a Animal Health and Welfare Centre, which is home to domestic and exotic species such as red pandas (*Ailurus fulgens*) and red crowned cranes (*Grus japonensis*). The reptile collection includes radiated tortoises (*Astrochelys radiata*), sail-finned lizards (*Hydrosaurus spp.*) and red-eyed tree frogs (*Agalychnis callidryas*), as well as a dedicated crocodile room for a West African dwarf crocodile (*Osteoleamus tetralaspis*)! For further information, see <https://www.sparsholt.ac.uk/university-centre/>

small amounts of UV in their natural habitat every day, and that UV has much greater value to animals than just protection against metabolic bone disease.

Significantly, it has been shown in a range of different groups that UV exposure in suitable amounts brings benefits from immunological, health, and behavioural perspectives. Most of these benefits, however, such as improved immune function, are impossible for the average keeper to measure without specialist equipment and an approved research licence.

Based on our observations, dart frogs were given the choice to access zones containing UV light that were within the suitable range for a Ferguson zone 1 species. While the

frogs did not spend the majority of their time in these higher UV zones, they did make use of them on a daily basis.

Significance for their care

In terms of management, our study suggests that dart frogs can make good use of a complex, naturalistic exhibit, and that UV exposure in line with the Ferguson zone 1 recommendations may potentially have value for them. On the other hand, dart frogs must also have somewhere to escape entirely from UV; some zones should contain no UV. Environmental complexity is also key; this may encourage hunting behaviours, plus a range of different locomotory behaviours.

What about for other amphibian species? UV light potentially may have benefits for a range of species – but the quantity of UV light should be biologically relevant, and amphibians should be given a choice as to whether they expose themselves or not. Other factors can be significant too, with an albino ornate horned frog (*Ceratophrys cornuta*) likely to have far lower UV requirements than other morphs. If you are in search of guiding principles in this regard, then refer to the paper by Ferguson *et al.*

Conclusion

Overall, dart frogs appear to show strikingly different behaviours, based on the time of day. They display climbing behaviour and seek greater exposure to UV light during the

morning, and use the lower regions of their exhibit later. Generally, the frogs used Ferguson zone 1 areas of their exhibit far more than zones 2 or 3, which may suggest the frogs can detect and avoid either brightly lit, or high-UV environments.

While we cannot say for sure that the frogs are indeed choosing to use the UV zones, we have shown that dart frogs will voluntarily expose themselves to some UV when it is provided. The study has also shown that despite their small size, dendrobatid frogs will make use of large exhibit sizes when these are accessible to them. ♦

** If you would like any more information on the project, the authors can be contacted via James. Brereton@sparsholt.ac.uk*

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Awaking from the deep sleep



Whether it has been a cold winter, or a relatively mild one, as has been the case this year, it is vital to get your tortoise eating again at a relatively early stage after it emerges from hibernation. Here are some advice and tips to help you, from Don Harper.

Rekindling your tortoise's appetite after hibernation is vital to its health, both in the short and long term. Otherwise, this may mark the start of a downward spiral that can ultimately lead to its demise within a year or so. Weight gain in tortoises to make up for that lost over the winter period takes place during the early months after emerging from hibernation. This therefore makes it critical to persuade your pet to start eating again without delay. Otherwise, you will find that having failed to put on sufficient

weight this year, so your tortoise will be in worse condition when it comes to hibernating again in the autumn. The only safe thing to do then may be to keep it awake over the winter.

It is well-worth investing in a tortoise table, even if you intend for your tortoise to spend much of its time out in your garden over the warmer months ahead. Using a tortoise table now means that you will be able to keep your pet at its optimum temperature, around 24°C (75°F), warming it up over the

course of several days. This will then encourage the tortoise to eat, and will allow you to continue feeding it indoors until the weather is warm enough to put it outside in the garden again. It provides a means of ensuring your tortoise can continue feeding normally even if the spring proves to be as bad as the winter. A UV (ultra violet light) source over the tortoise table is important too, as this will act as a further appetite stimulus, thanks to the UVA component of this type of light.

What to do

The first thing that most tortoises require on emerging from hibernation will be a drink of water. Over the period of their dormancy, they are likely to have become dehydrated to a degree, and this will suppress their appetite. Tortoises which are in this state spend longer with their eyes closed, and are less inclined to wander around their quarters.

You can often overcome this quite easily simply by means of a warm bath. Depending on the size of your tortoise, you may need to buy a cheap washing-up bowl which will serve for this purpose. This also has the advantage of being relatively stable, and won't be tipped over easily. Even so, as a precaution, place it in an area where if water is spilt, it can be mopped up and the floor disinfected afterwards.

Avoid positioning the bath in a





▲ Suspect mouth rot in a tortoise which tries to eat, but persistently fails to do so properly.

Fresh food

In spite of the colder winter weather, it should be possible to see signs of plant growth outdoors, and to track down dandelions for your pet now as well. If you dig up some of these roots, and bury them vertically in plant pots filled with soil, keeping them moist, you should soon find that they start sprouting, growing quicker inside in a relatively warm and well-lit surroundings than outdoors. Rich in calcium, these will also help to lower your feeding costs at this stage.



draught though, or leave your tortoise exposed to being harmed by dogs or cats. Fill it partially up to the level of the reptile's lower jaw, with water about 21°C (70°F), but do not make it any deeper at this stage, while the tortoise is still drowsy. Gently place your tortoise in the water and watch its reaction. When it has just woken up, it is likely to dip its head down into the water, and will start to drink freely. This is a good sign.

Leave your tortoise here for perhaps five minutes at a time. You will soon

notice when your pet loses interest in drinking, as it will then start to try to get out of its bath. It is a good idea to keep up with daily baths for perhaps a week or so, and certainly until the tortoise is eating readily again, to ensure that it is adequately rehydrated. After this, it will drink occasionally from a water container as usual.

Offering food

Following its period of slumber, your tortoise is likely not to be especially focussed on food at first - literally! When providing food, place this a short distance in front of the tortoise, rather than immediately in front of its face. It is then more likely to move forward slightly and extend its neck to start eating. Do not be surprised if the reptile appears to be slightly uncoordinated at this stage, and may miss with its initial attempts to bite at its food. This is quite normal.

One of the best foods to offer at this stage is fresh tomato, sliced into quarters. Lace the fruit with a powdered supplement such as Vetark's Nutrobal, to boost the tortoise's vitamin and mineral levels. Tortoises seem to relate readily to the red colour of tomatoes, and also appreciate their juicy nature, which helps them to rehydrate.

Weighing up

One of the best guides to checking on your tortoise's state of health, and not just following hibernation, will be to weigh your pet regularly, keeping a note of the findings. You can then see how its condition is progressing. Buy some scales specifically for this purpose, and a small pocket diary where you can record the results. This will also ultimately help you to determine whether your tortoise will be fit to hibernate again in the autumn this year.

In most cases, with regular, daily

▲ Especially soon after coming out of hibernation, tortoises will usually eat tomatoes readily.

baths and being kept in a warm, well-lit environment, a healthy tortoise should be eating again within a week to 10 days of emerging from hibernation. If you do not see any improvement over this period however, with the reptile appearing dull and inactive, then seek veterinary advice.

It is not uncommon for tortoises emerging from hibernation to be afflicted by so-called 'mouth rot' and this will deter your pet from eating. This is basically a bacterial infection, which gives rise to a cheesy, yellowish deposits building up within the mouth. Even if it is difficult to look into your tortoise's mouth, you are likely to notice a bad odour here.

Rapid treatment can soon lead to a full recovery, with your vet usually having to removing the accumulated material from the mouth, and treat the infection. This frequently requires the tortoise to be sedated, as these reptiles are usually very reluctant to co-operate by opening their mouths. There may be other causes of its dullness and inappetence however, and blood tests can now be carried out to help to isolate the source of a problem of this type.❖

Seeking advice

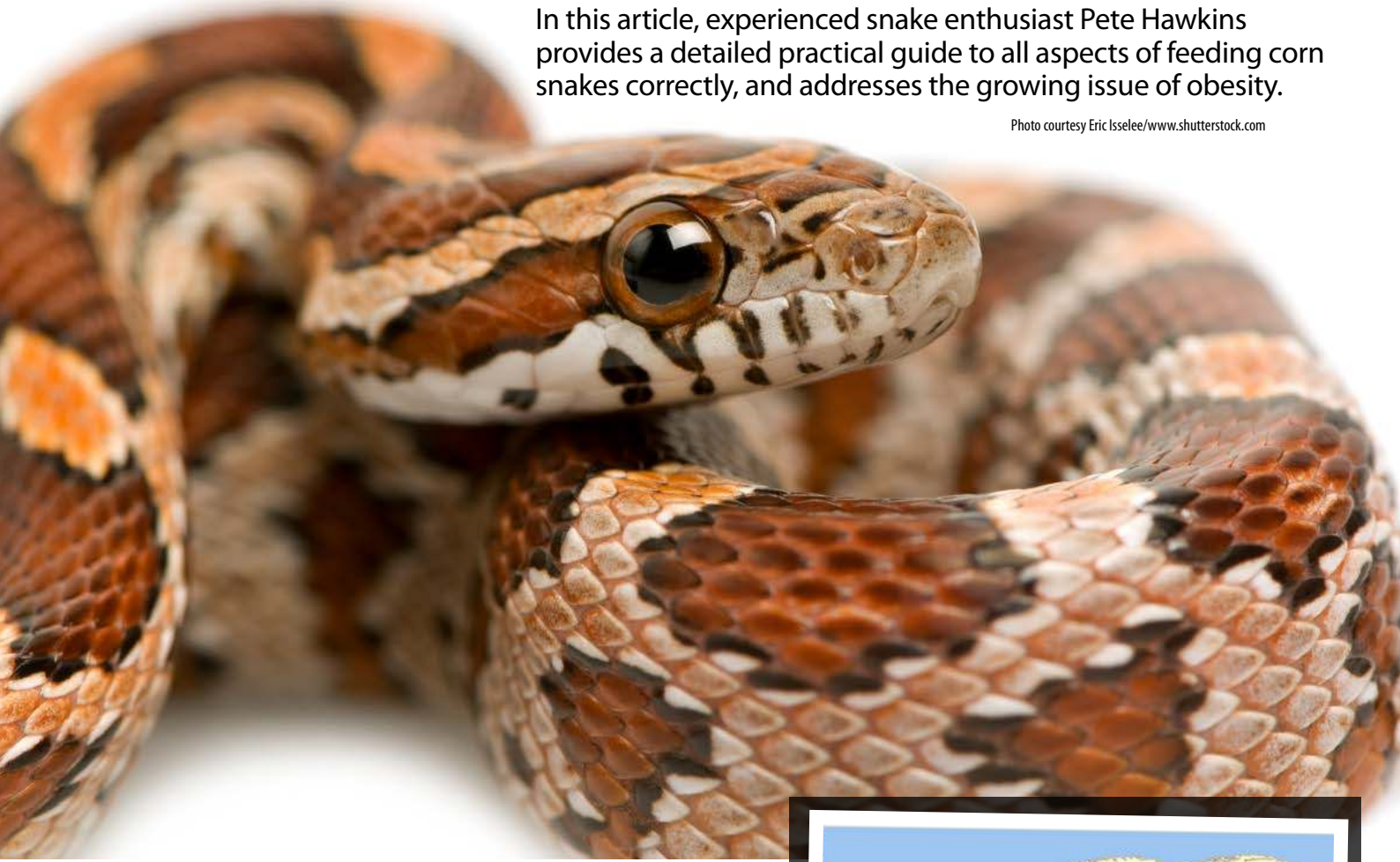
Specialist vet Mark Rowland, BVSc, CertZooMed, MRCVS of the Trinity Veterinary Centre in Maidstone, Kent, has come up with a checklist of signs which require immediate veterinary attention, in tortoises that have just woken up from hibernation. They are:-

- Any eye problems - such as cloudiness or signs of possible blindness.
- Any signs of frostbite and gangrene affecting the legs.
- Swellings on the head and body.
- General signs of inactivity, plus failure to eat or thrive in warm surroundings.
- Green-coloured urine.

Feeding corns correctly

In this article, experienced snake enthusiast Pete Hawkins provides a detailed practical guide to all aspects of feeding corn snakes correctly, and addresses the growing issue of obesity.

Photo courtesy Eric Isselee/www.shutterstock.com



In common with other snakes, the popular corn snake (*Pantherophis guttatus*) is carnivorous. In their natural habitat, which is southern and central parts of the USA, these snakes readily hunt a wide variety of prey. They are opportunistic predators, frequently taking mice and other rodents, but are also known to feed on amphibians, birds and sometimes even birds' eggs as well.

Adaptable - up to a point!

This suggests that corn snakes are very adaptable in their feeding habits, and that is certainly true - but only up to a point! People often have strange ideas about what type of food to offer them. Over the years, I've been asked as to whether they can eat roaches or fish? What about meat such as beef or pork, and how about eggs or fish - or even



▲ The natural distribution of the corn snake.

Artwork courtesy Nk/
Wikipedia/ CC BY-SA 3.0

vegetables? And the answers vary from no, definitely not, in the case of vegetables through to possibly so in terms of eggs.

In many cases, food of this type is nutritionally poor - particularly in terms of its calcium: phosphorus ratio. Snakes consume whole animals and benefit from the calcium locked up in their bones, in which beef on its own, for example, is significantly deficient.

The other thing is that if you offer an unsuitable food such as vegetables to a corn snake, then this will not elicit a feeding response in any case. Even offering insects



◀ Quail eggs can be offered to provide variety in a corn snake's diet. Photo courtesy Nattika/www.shutterstock.com

such as roaches will be unlikely to attract your snake's attention and encourage it to strike.

I have to admit that I do know keepers who have fed fish to their corn snakes, and they have taken it, but for me, this is not part of their natural diet and so I won't use it. I have occasionally provided quail eggs to members of the rat snake group in the past, including corns, but haven't done so recently, as this is not a staple food for them.

Suitable foods

As interest in keeping snakes has continued to grow throughout this century, so has the range of food that is commercially available for them. It has now reached the stage where there is really little point feeding the above foods that they will eat, even for the sake of variety. It is quite possible to achieve this aim now simply by using a number of the different items that are now available from many reptile stores, as well as specialist mail-order suppliers.

Items that I can now buy and offer to my corns (as well as my other snakes) are:

- Rats
- Mice
- Chicks
- Hamsters
- Gerbils
- Quails
- Multimammate mice
- Guinea pigs

▲ The multimammate mouse (*Mastomys natalensis*) is a relatively new addition to the list of commercially available foods for snakes, although it has been bred for laboratory research for nearly 80 years. It is a rodent that is naturally found widely across Africa and is slightly larger in size than a house mouse.

Photo courtesy Rosa Jay/
www.shutterstock.com



I purchase all of the above in a frozen form, and have them delivered direct to me. This then ensures that I have a variety of options available at all times, to suit my snakes. As you can see, there is really therefore no excuse for not being able to offer a range of different foods to your snake. This approach also allows you to cater easily for new arrivals, and get them eating well, although you do need a small freezer for this purpose, in order to store their food.

How often should I feed my corn snake?

The answer to this question depends very much on the age and size of

your snake, as well as the size of the feeder animals that you have available, to a lesser extent. Some breeders recommend feeding hatchling corns two or three times a week, with a pinky mouse. I feel this is excessive, and can store up problems in the future. My advice would be to offer food every five days at that stage, through until the snake is 6-7 months of age.

After this stage, I would then recommend feeding every 7-10 days for corn snakes, up until about two years of age. After this stage, I then increase the feeding interval to 14-21 days, not forgetting that as your snake grows, so it can be offered larger prey. For the first two months, ➤

The feeding frequency - and not just the food offered - depends on the size of your corn snake.

Photo courtesy bluedogstudios/www.shutterstock.com



your corn snake will only be able to eat pinkies, but subsequently, you can start to introduce rat pups to the feeding menu.

It is a good idea to rotate the food that you provide, especially as rats are nutritionally superior to mice. They tend to have more muscle and less fat in their bodies, making them a better food source in the longer term, but dietary variety is valuable too, so do not exclude mice on this basis.

Feeding habits

Snakes in the wild are dependent on catching prey, and hunting opportunities are obviously limited. Even if they have a chance to strike, there is no guarantee that they will be successful in obtaining a meal. Therefore, they are unsurprisingly conditioned to eat when an opportunity presents itself.

In vivarium surroundings therefore, corn snakes would probably eat almost every day if you provided them with food, especially bearing in mind their relatively high metabolism. But in terms of their health, this would inevitably lead to obesity, significant weight-related issues, breeding disappointments and ultimately, a serious likelihood of premature death.

The routine that I have outlined above is one that I have used successfully for well over 30 years with my corns, and passed on to other owners who have used it with great success too. My corns have been healthy, in terms of their diet and weight, on this feeding routine.

You can usually tell when your corn snake is wanting food by its behaviour, as it will show signs of increased activity, hunting around for food. It will appear more lively than usual, effectively pacing around its enclosure at this stage. This does not mean that you need to offer

▼ **Pinkies and fuzzies, showing the different in size. Note also the presence of milk, in the case of the young pinkie lying on its side.**

Photo courtesy Mirek Kijewski/www.shutterstock.com

food instantly though, especially if a feed is not due at that stage. This type of hunting behaviour reflects the snake's natural way of seeking food, and can be considered to be a good form of exercise in vivarium surroundings as well.

Size matters...

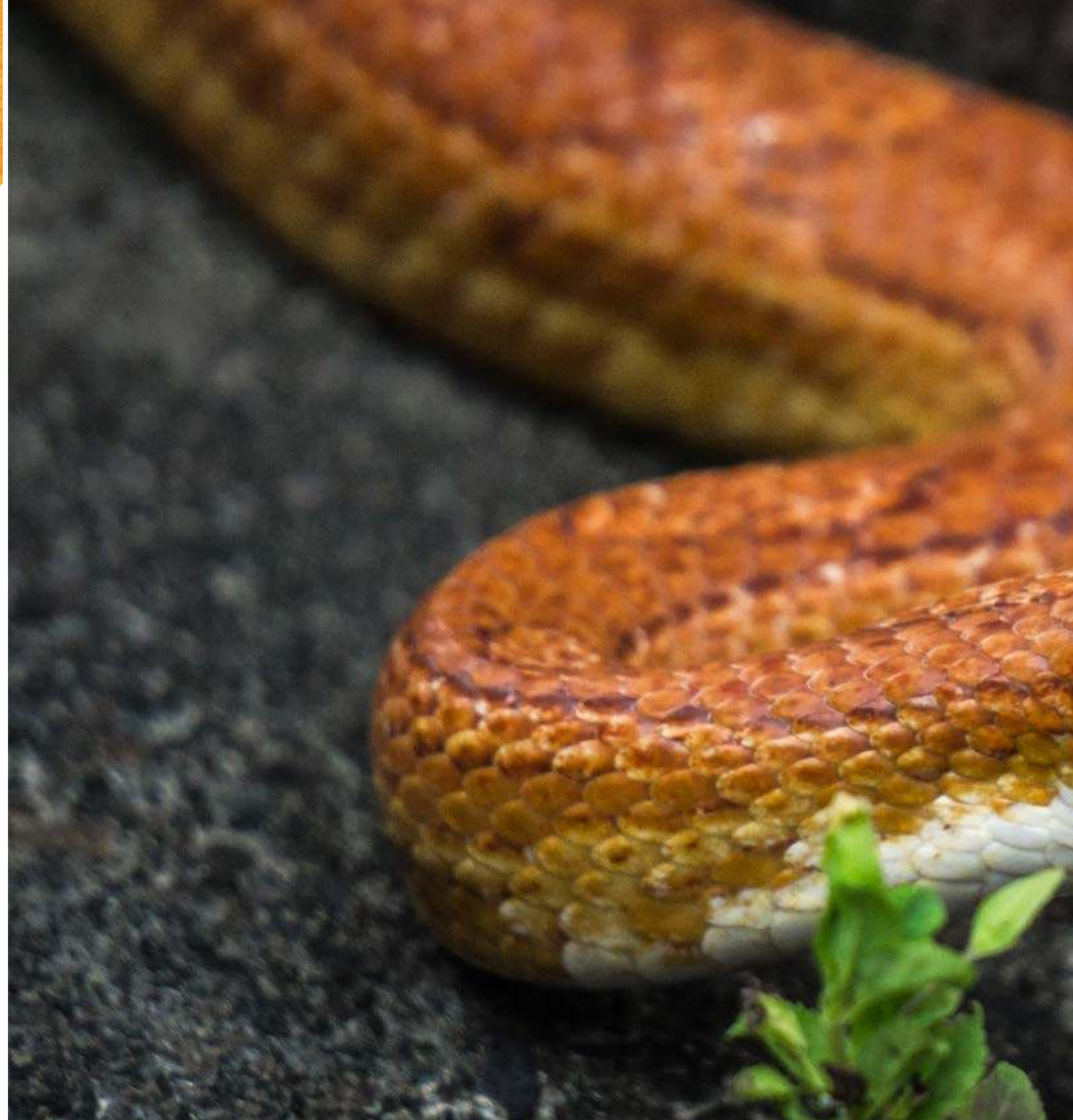
The different descriptions given to rodents used as reptile food can be

rather confusing, especially when you first begin keeping snakes. Starting with the smallest size, a pinkie is the description given to a newborn mouse. It can range from 1-3g (0.04-0.1oz) in weight, depending on the supplier.

Pinkies have no fur and although often considered to be quite fatty, they are in fact high in protein and are actually lower in fat than is popularly believed. Their calcium content will be improved, if they have fed, as may be evident from a white blob seen through the translucent skin in the vicinity of the stomach.

The next stage up is described as a fuzzy. This is a baby mouse which is starting to show signs of developing fur. Obviously bigger in size and weight than a pinkie, fuzzies typically weigh between 3-5g (0.1-0.12oz). Larger still are so-called 'hoppers'. These young mice are around 5-9g (0.12-0.31oz) in weight, and look rather like miniature adults.

Working through equivalent sizes in the case of rats, a new-born individual is known as a pup. These are slightly bigger in size than pinkies, weighing around 5g (0.12oz). The rat equivalent of the fuzzy is called a fluff. By this stage, there is





already a more marked variation in weight, with fluffs typically weighing in between 10-25g (0.35-0.88oz).

Weaners correspond to hoppers, although the different in size is even more pronounced, with these young rats averaging between 25-50g (0.88-1.76oz). You then move on to fully grown rats and

mice, in size terms, usually with a division between smaller and larger individuals, depending on the seller.

When to move up in feeder size?

Snakes will have different weights at the same age, depending on the diet that they have been receiving,

▲ A corn snake on the hunt. Note its alert demeanour.

Photo courtesy Salvira/www.shutterstock.com

as well as their frequency of feeding. Always ask the vendor therefore for an individual's feeding regime, when acquiring a new snake.

With a young corn snake, I feed it on pinkies up until its weight is around 25-30g (0.88-1.05oz). I then move up a feeder size to using fuzzies for it. As a general guide though, when deciding what size of mice or rat to offer to your corn snake, it's a good rule to choose a feeder that is roughly the size - in terms of width - to that of the snake's mid-body section. Slightly bigger shouldn't be a significant issue, but if you choose food that is too large, then it can lead to issues such as regurgitation, which in turn causes stress, and that is definitely not good.

Another point to remember is that if you choose larger prey items, then you will need to increase the time between feeds. It is certainly not uncommon for a corn snake that has been feed a weaner rat not to require feeding again for 10 to 14 days, and sometimes longer, with absolutely no issues arising.

When to feed?

This can be based on your own schedule. In fact, the time of day is almost irrelevant, as long as you have a regular feeding cycle for your snake. Nevertheless, I have known the occasional corn snake that would only feed in darkness, but behaviour of this type is not common.

Offering treats

There is little in the way of treats that are suitable for corn snakes. Some keepers regard chicks as treat items, but nutritionally, apart from having a slightly higher fat content, they are not that dissimilar in nutritional terms from the rodents forming their regular diet. The only common side-effect is the fact that feeding a chick to your snake will often cause it to produce more loose faecal waste than normal, which is why this should be classed as a treat food. Quail eggs too could be offered occasionally, as mentioned earlier.

How long will frozen food keep in the freezer?

Firstly, it is important to use a proper freezer, intended specifically for deep freeze storage, rather than the quick freeze compartment at the top of your fridge. You can purchase quite small deep freeze units which are ideal for storing snake food, keeping it totally separate from



▲ Matching the size of prey to that of your snake is very important, so that it can be swallowed easily and will not be regurgitated. Photo courtesy Marek Velechovsky/www.shutterstock.com

human food.

Bear in mind that the packaging plays an important role as far as storage is concerned. Always choose a good quality, thick freezer bag if the food is not supplied already individually bagged and sealed. In all cases, get it back into a freezer as soon as possible after it is delivered or you collect it, so it cannot start to defrost. Should the items need repackaging, then be sure to exclude as much air as possible, before sealing each bag with a paper and wire tie.

As a guide, you should use hairless/furless animals within six months, or 6-9 months for those with hair, fur or feathers. The storage period may be extended slightly in the case of those where the packaging is unopened, but always use food in rotation.

Bear in mind as well that anything kept in the freezer in a ripped bag or unbagged will rapidly develop freezer burns. Such items tend to look all crystallised and almost grey in colour. Although a corn snake may probably still eat this type of food once it has thawed out and I doubt it would make them ill, it may be far less appetising of course. Think of a freezer-burnt burger or sausage: it just doesn't taste so good, and the texture isn't right either. So avoid offering food in this state to your corn snake if at all possible.

Obesity

This is an increasing problem in reptiles and amphibians generally today, and is something that I and

many others in the hobby have been seeking to raise awareness about now for a number of years. The basic problem is that people frequently don't understand the nutritional needs and feeding habits of reptiles, and so feed them almost like they would a dog or cat. Unfortunately, corn snakes have certainly not escaped unscathed from this lack of knowledge and nutritional understanding. People fail to appreciate that their metabolism is not geared to eating every single day of the week, and that they may be less active in any case in vivarium surroundings, where food is provided for them!

What makes the situation more difficult, however, is that it's actually hard to lay down ideal weights for corn snakes, because of the wide variety of morphs that are now available, which does impact on the weight of the snake, quite apart from the fact that some lineages of corn snakes are naturally bigger in size, reflecting the situation in the wild.

The best thing to do, however, in the case of an individual snake is to weigh it every month, and note this figure in a diary. This will reveal any unexpected changes, and can be very useful information should your snake fall ill, and you need to seek veterinary advice. You can weigh a corn snake either in a bag using a spring balance, or on a suitable pair of scales in a sealed plastic container, always remembering to deduct the weight of the

Corn snake morphs do vary in size, and this will be reflected in their weight. You therefore need to consider the body condition of your snake, to determine whether it could be starting to get overweight. This is an example of the candy cane morph. Photo courtesy Eric Isselee/www.shutterstock.com



enclosure from the overall figure, to obtain the snake's true weight.

Recognising the signs

A snake's body will also provide a clear insight into its condition, and whether it is becoming overweight or even obese. You can obtain the best insight by looking at the shape of the snake via the circumference of its body.

An individual of healthy weight will have a flat underside and an almost semi-circle body. This reflects the fact that the snake utilises as much of the surface area on its stomach as possible for traction, facilitating its movement. An overweight snake will be much more rounded in cross-section. This means that the sides of the belly will not touch the ground as it moves.

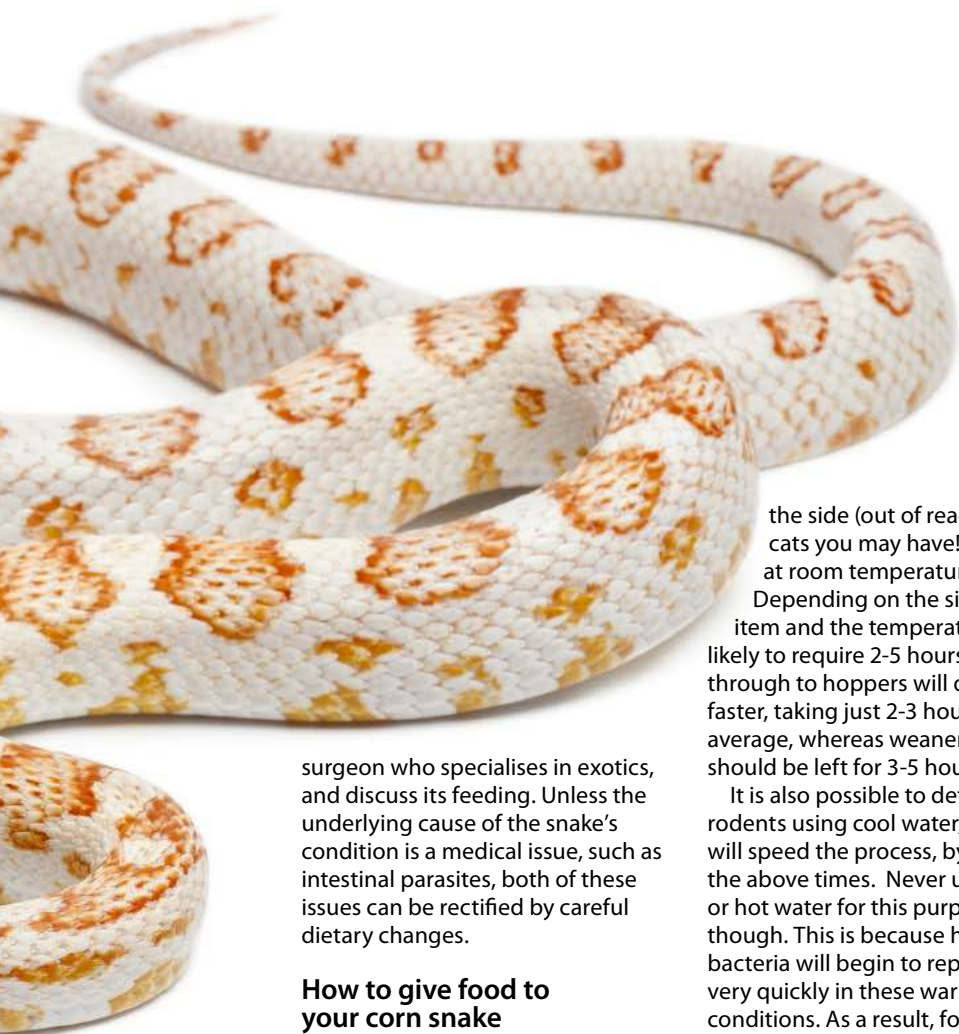
On the other hand, an underweight snake will look almost triangular in shape in cross-section. The sides of the body appear quite vertical, leading straight up to the spine. Should you have a snake that is either underweight or overweight, you should consult a veterinary



▲ Typical signs of freezer burn. The risk is greater if you use thin storage bags. Photo courtesy Tim Belyk/www.shutterstock.com



▲ A small deep freezer unit will be ideal for snake food, but put date labels on the bags so you can use them in rotation, keeping the food fresh and free from freezer burn. Photo courtesy MStock00/www.shutterstock.com



surgeon who specialises in exotics, and discuss its feeding. Unless the underlying cause of the snake's condition is a medical issue, such as intestinal parasites, both of these issues can be rectified by careful dietary changes.

How to give food to your corn snake

Start by taking the frozen food item out of the deep freeze, and if it is packaged individually, which makes the process much easier, leave it in the bag at this stage (although you don't have to do so). Then ideally, defrost it overnight in the fridge, and it will be ready to use the next day, although check it has thawed out thoroughly before offering it to your snake.

You can also place the package on

the side (out of reach of any cats you may have!), leaving it at room temperature in a tub.

Depending on the size of the item and the temperature, this is likely to require 2-5 hours. Pinkies through to hoppers will defrost faster, taking just 2-3 hours on average, whereas weaners upwards should be left for 3-5 hours.

It is also possible to defrost the rodents using cool water, and this will speed the process, by halving the above times. Never use warm or hot water for this purpose though. This is because harmful bacteria will begin to reproduce very quickly in these warm, wet conditions. As a result, following a period of defrosting in this way for a few hours, there will be a lot of dangerous bacteria that you'll be feeding to your corn snake.

Microwaves can be dangerous too, as they can easily leave ice crystals out of sight in the body cavity. There are also disaster stories of rodents exploding within a microwave on occasions, and that is something which I'd definitely not want to be cleaning up! The safest way of defrosting food for your snake is simply to leave it in the fridge, just as it is with our food!

The feeding process

Once you are absolutely certain that the frozen snake food has thawed properly, you then need to warm it up, which will increase its appeal. There are many methods used for this purpose. Some snake keepers will place the food in hot (but not boiling) water and leave it for five minutes, before offering it to their snake.

Personally, I'm a dunker! I'll submerge the top half of the prey in very hot water for about 30 seconds (but again, not boiling water). And then I'll offer it directly to the snake via some large metal tongs. These forceps must have rounded rather than pointed ends for the snake's safety, as it may well lunge at its food.

This method has served me



▲ There are several potential hazards linked with using a microwave to defrost snake food. Photo courtesy Volodymyr_Shtun/www.shutterstock.com

well over the years, although very occasionally, I have had some snakes that refuse to feed on wet prey. I don't know why, but that was definitely the case. So then I'd resort to heating the head end of the prey with a hairdryer for about five minutes. Although a nuisance, this method worked and these individuals would then eat normally.

Feeding in or out of the enclosure?

This is something that I have strong views about! I see it in my Snake Network - my Facebook group - and elsewhere online that people often remove the snake from its vivarium in order to feed it, transferring it to a tub or rub for this purpose, or even a different tank. There seems to be a widespread belief that if you feed the snake in its set-up, it will become aggressive in these surroundings.

This is simply not the case in my experience. The set-up is the snake's territory, so why would you remove it from surroundings where it is established? A place where it feels safe, confident and is stress-free, transferring it instead to a location which offers none of these benefits? Then subsequently, if you adopt this approach, you will need to move



▲ A hairdryer can surprisingly be required on occasions when feeding corn snakes. Photo courtesy WAYHOME studio/www.shutterstock.com

▼ Corn snakes are active by nature, and will climb, as seen here, so that their vivarium needs to be designed accordingly, as this will also help to prevent obesity.

Photo courtesy Jay Ondreicka. www.shutterstock.com



the snake back into its usual set-up, assuming that it has eaten. This in turn causes a significant degree of stress, and risks the possibility of the snake regurgitating its food.

I would always recommend feeding your corn snake in its regular quarters. If it is aggressive here, then it is just being a snake. Feeding outside of its normal environment will not change this situation. If anything, this will just cause stress for the snake, which in turn, can increase the risk of illness.

How long will the food take to digest?

Providing you have the correct temperature gradient established within your setup, then the 48 hour "rule" is very useful. Throughout this period after a feed, do not handle your corn snake (or indeed, any snake), so as to allow the reptile to digest its food properly. Otherwise, the snake is likely to become stressed and will regurgitate its meal.

Should you find that your snake has regurgitated even without being handled, the chances are that the food it was offered was too large to digest. The best thing to do under these circumstances is simply to wait a few more days, and then try feeding the snake again with a smaller prey item.

Why is my corn snake not eating?

A large number of possible causes may explain why your snake has lost its appetite. The main reasons are likely to be that:

- shedding is imminent.



▲ Corn snakes need to feel secure in their quarters if they are to feed properly.

Photo courtesy BB1987/www.shutterstock.com

- it is winter.
- the temperature is incorrect.
- the snake is not hungry.
- the food is not warm.
- the snake is a fussy feeder.
- it is suffering from dehydration.
- it could be suffering from health issues such as mites and/or mouth rot.

▲ Shedding may affect the appetite of some but not all corn snakes

Photo courtesy Murilo Mazzo/
www.shutterstock.com

▼ Coming from a relatively temperate region, corn snakes may naturally suffer a loss of appetite over the winter months, but there can often be other more worrying causes responsible for a loss of interest in food.

Photo courtesy Nashopard/
www.shutterstock.com

Assuming an underlying medical reason can be ruled out, however, then changing the type of food offered can rekindle the snake's appetite. A switch from rats to mice or vice-versa often does the trick. This is actually another benefit of providing a varied diet, within reason, from an early stage, as you are then less likely to end up with a fussy feeder.

Snakes regularly lose their appetites during the shedding period, which can last for a couple of weeks. That said, many corn snakes will still eat regardless when they are about to shed, although if they are due to shed, I withheld food anyway.

This is because if they shed while digesting a meal, it can often lead to areas of the shedded skin becoming stuck on the new, because the skin is stretched as a result of the bulge on the body surface, created by the food in the digestive system. I would much rather not take this risk, preferring a hassle-free shed if at all possible.

What to do

If your corn does not take its food almost straightaway, you can leave this in the setup for another 2-3 hours. If it is not taken after this time, then you must discard it. The

feeding habits of snakes differ and it's also not uncommon for a corn snake to miss a scheduled feed or two while it is growing. If this is the case, just offer more food again in 5-7 days, and monitor the snake's weight closely, weighing it more frequently and making sure that it is adequately hydrated.

If you detect any significant weight loss or your snake continues to refuse to feed, you must consult a veterinary surgeon experienced with exotics, as there could well be some underlying issues present.

One of the most common mistakes is keeping a corn snake at an incorrect temperature. This will definitely stop a snake from feeding, regardless of species. With a digestion time of 24 to 48 hours under the correct conditions, if the temperature is sub-optimal, this will delay the process, which in turn can cause digestive issues.

Furthermore, being less active than normal, so the snake is unlikely to be seeking prey as would normally be the case. It is vital that you have a good heat gradient within the setup. Aim for a basking zone of around 30°C (86°F). A figure that is either a little higher or lower will not create much of an issue, providing there is ample coverage, and a variety of options for your snake to self-regulate its body temperature.

Always remember though, that provided everything is set up satisfactorily for your snake in the first instance, then you should not encounter any serious problems with regard to feeding behaviour going forwards, as long as you always use suitable food, and prepare it properly. ❖





Puzzle Corner

Find the solutions to these puzzles by following the clues, to discover which reptiles, amphibians or invertebrates are hidden within them. The answers can be found on p66.

CREATURE CONVERSION

Can you identify these reptiles and amphibians and, by rearranging the first letter of their common names, come up with the name of a different type of creature?



PHOTO COURTESY JUAN AUNION/WWW.SHUTTERSTOCK.COM



PHOTO COURTESY MATT JEPSON/WWW.SHUTTERSTOCK.COM



PHOTO COURTESY MATT JEPSON/WWW.SHUTTERSTOCK.COM



PHOTO COURTESY MARTIN HEJZLAR/WWW.SHUTTERSTOCK.COM

NEW I.D. NEEDED!

Can you identify these species, and then, using the first letter of the common name of each one, come up with the name of a totally different animal?



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Mutations

Albino alligator.

Good or bad? asks David Alderton

While there's no doubt that mutant reptile in various guises are popular for creating excitement in books and films, the reality is that such creatures are scarce in the wild and no more dangerous than their regularly-coloured cousins. Although Nature keeps experimenting, throwing up individuals which differ in appearance from the usual form on occasions, these are far less likely to survive than others with normal colouration, especially without human intervention.

This has happened in the case of the albino alligator (*Alligator mississippiensis*), the current population of which originated from the wild but is now being bred successfully in captivity. Such animals have attracted a great deal of publicity around the globe, especially in Japan. But in the waterways which alligators normally inhabit, their distinctive colouration would stand out, rather than helping to conceal their presence in their aquatic environment. This would make these particular alligators more vulnerable to predators, especially at an early age.

Big business

Breeding abnormally-coloured reptiles can prove to be very big business, however, especially if the mutation is more colourful than the species itself. Not long ago, it was said that a rare mutant female python caught in the wild was sold for over £40,000. Although colour mutations have been recorded in all the major groups of reptiles and amphibians, it is in the field



A fabled "white" sea turtle.

of snakes that they have attracted most interest, particularly in the case of ball (royal) pythons (*Python regius*).

So-called "albino" Burmese pythons (*Python molurus bivittatus*), where all trace of the dark melanin pigment has been removed from the skin, resulting in bright yellow markings superimposed on a whitish ground colour, are also very popular. As usually happens, their price has fallen significantly as they have become more commonly-bred.

The dark melanin pigment normally has a protective function, in terms of helping to conceal the snake's presence, breaking up its body outline so that it

will be less conspicuous. This is known as disruptive camouflage. It also helps to improve vision, and snakes or indeed other herptiles with red eyes are at a disadvantage in terms of vision, compared with their normally-coloured counterparts, especially in bright surroundings when they are likely to be dazzled.

Within the confines of the vivarium however, these changes are far less significant, because the snakes face no predators. We select them purely on the basis of their visual appeal to us. It is no coincidence that mutations crop up most frequently in the case of those species which are frequently bred. Every

Albino Burmese python.



Genes vs. incubation conditions

It is important to distinguish mutations from the developmental abnormalities which can arise as the result of incubation conditions. It used to be thought that the gross phenomenon of double-headed offspring with a single body, most often recorded in snakes and terrapins, was the result of a mutation but in fact, this is now regarded as being caused by sub-optimal incubation conditions. Even so, mutations of course may not just modify the creature's colouration. They can affect other parts of the body as well.

time that mating takes place, the likelihood of a mutation occurring is present. Statistically therefore, the more breedings that take place, so potentially, the more likely that a mutation will occur.

Combinations

Once two or more separate colour mutations crop up, so it is then often possible to combine them together in a single individual. Such morphs are highly unlikely to evolve in the wild however, simply because the likelihood of two separate mutations surviving and coming together to breed under these conditions is highly remote.

In vivarium surroundings however, they can be carefully propagated, free from outside influence which would threaten or dilute their characteristic genes. Those species which show greatest variation in their patterning or colouration in the natural state may be more likely to produce new colour forms, as shown by the case of the corn snake (*Pantherophis guttatus*).

Over a period of some 45 years since captive-breeding of this species began in earnest, so the number of colour varieties in existence has grown to over 1,000 in total, according to some estimates, effectively confirming the domestication of this particular snake. The bright colouration of some of these mutant forms has undoubtedly encouraged many people to take up snake-keeping as a hobby. Those with particularly vivid colouration, such as the so-called "candy corn snake" rank among the most popular.

In other cases though, the colour of the snake has been darkened, thanks to the presence of additional melanin in its skin. Alternatively, it may have lost all

traces of red and yellow coloration – a condition described as being 'anerythristic'. Mutations of this type generally do not capture public imagination however, often being treated as little more than zoological curiosities when they do crop up – in short, they are not commercial!

As far as lizards are concerned, colour mutations are now common in the case of both the bearded dragon (*Pogona vitticeps*) and the leopard gecko (*Eublepharus macularius*). Although green iguanas (*Iguana iguana*) with a bluish tinge to their appearance are seen occasionally, this colouration is effectively a natural variation in existing populations, rather than a distinctive genetic mutation, compared with the genuine blue form.

Chelonians

Occasional mutations have been recorded in tortoises and terrapins, but few are commercially-available. In the US, there is the yellow form of the red-eared terrapin (*Trachemys scripta elegans*), which has a mustard yellow rather than green shell and retains its distinctive red markings. More striking, however, is the albino variant of the Chinese softshell turtle (*Pelodiscus sinensis*). There are other oddities which have been recorded within the chelonian group too, including a pale version of the African spur-thighed tortoise

(*Geochelone sulcata*). Overall though, the relatively long period of maturity, combined with correspondingly few offspring mitigates against mutations becoming prominent in this reptilian group.

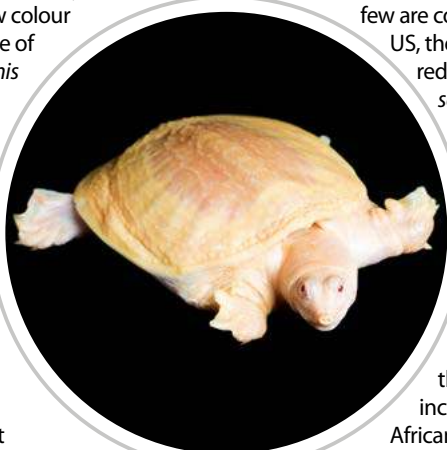
Amphibians

In the case of amphibians, however, females can produce many hundreds of eggs at a single spawning in some cases, and this greatly enhances the likelihood of colour variants emerging. The albino form of the dwarf clawed frog (*Hymenochirus boettgeri*) is now perhaps the most widely-available mutation, although albinos and other varieties are also common in the case of the larger *Xenopus* too.

Colour variants are very well-established in the axolotl (*Ambystoma mexicanum*) as well, with not just the well-known red-eyed albino being commonly kept, but also other forms including black and white (pied) individuals, and even olive and golden variants.

There is a risk, however, that as the popularity of mutations grows, so fewer breeders will be interested in maintaining pure strains of such species. This could have harmful side-effects, should stock be required for conservation projects. The axolotl for example is very rare in the wild, and if there was a move to breed these amphibians for release, it would now be very difficult to guarantee that captive-bred stock was free from the genes for these various colours. ❖

▼ Albino Chinese softshell turtle.



► There can be underlying health issues associated with a few mutations, such as the **enigma form of the leopard gecko**. Individuals in this case are prone to neurological problems.





Grow your own reptile food

Although it is possible to buy salad packs and other vegetables from supermarkets, it is much better to grow your own food for tortoises and other herbivorous reptiles, and you can do this easily, even if you don't have a garden, as David Alderton explains.

The advantages of growing food for tortoises are not just financial, although the savings can be substantial, particularly over the winter period for species such as leopard tortoises, which do not hibernate. A medium-sized leopard can easily munch its way through a bag of salad a day, costing perhaps £8 a week to keep on this basis.

The first thing that has to be said about the 'grow your own' option, however, is that you need to be organised. If you want to rely on this means of providing food, then you must set up a series of containers to guarantee a constant supply. The other thing is that especially in the winter, you need a bright, well-lit window sill where the plants can grow, although if you have a greenhouse, then they will develop well there at this time of year.

But the end result - free of any pesticides - will offer your pet a far more nutritional meal than a bag of salad. Dandelion for example is a very rich source of calcium. On a comparative basis, this plant is richer in this essential mineral than milk!

Tortoise seed kit

ProRep Products market an Edible Weed Kit, which contains everything required to grow your own tortoise food. Their wild plant mixture has been developed from observations of the plants eaten by wild tortoises and contains a mixture of edible annual and perennial plants, without grass. Not all wild plants are suitable as food for tortoises; indeed, some are actually poisonous. ProRep have based their mix on the following, to offer a safe, nutritional and palatable diet for Mediterranean tortoises.



All cultivation photos © ProRep.

Dandelion (<i>Taraxacum officinale</i>)	Shepherd's purse (<i>Capsella bursa-pastoris</i>)
Smooth hawk's beard (<i>Crepis capillaris</i>)	Hairy bittercress (<i>Cardamine hirsuta</i>)
Nipplewort (<i>Lapsana communis</i>)	Wavy bittercress (<i>Cardamine flexuosa</i>)
Chicory (<i>Cichorium intybus</i>)	White/Dutch clover (<i>Trifolium repens</i>)
Smooth sow thistle (<i>Sonchus oleraceus</i>)	Red clover (<i>Trifolium pratense</i>)
Great plantain (<i>Plantago major</i>)	Common vetch (<i>Vicia sativa</i>)
Hoary plantain (<i>Plantago media</i>)	Sainfoin (<i>Onobrychis sativa</i>)
Ribwort plantain (<i>Plantago lanceolata</i>)	Creeping bell-flower (<i>Campanula rapunculoides</i>)
Common mallow (<i>Malva sylvestris</i>)	Field bindweed (<i>Convolvulus arvensis</i>)
Musk mallow (<i>Malva moschata</i>)	Hedge mustard (<i>Sisymbrium officinale</i>)
Dwarf mallow (<i>Malva neglecta</i>)	



1 Open the bag containing the soil and carefully pour a quarter of the bag into one of the small seed trays.



2 Gently firm the soil with the palm of your hand, ensuring the level of soil is even.



3 Open a sachet of seed and distribute the seed evenly over the surface of one small seed tray. Cover the seeds with a very thin layer of soil and firm down gently. Water lightly but do not over water, the soil should not be soggy.



4 Place the small seed tray into the propagator base and cover with the clear lid.



5 Transfer the complete propagator to a warm, well-lit location such as a south-facing window, conservatory or (in warm weather) a bright sheltered position outside. Once the seeds start to grow, turn the tray each day to ensure even growth.



6 Water as needed to keep the soil damp but not wet, as this may cause the seedlings to become mouldy and die off. Once the seedlings fill about three-quarters of the propagator, then remove the lid and continue to water as needed. Allow the seedlings to grow until they are about 15cm (6in) tall, by which stage, they can be used. When the plants are ready to crop, it is often better to cut them with scissors, rather than simply putting the tray in with your tortoises. This is partly because it may be tipped over, creating a mess and putting the food out of reach, but equally, if you then keep the container watered, some of the plants such as dandelions will regrow readily.

Creating a wild seed paddock

You can also sow a paddock where tortoises can graze outdoors. ProRep's 20g seed pack will cover an area of 2sq m (22sq ft) in a run and is best sown in the early spring or early autumn. Start by removing perennial weeds and cultivating the soil to produce a firm, fine seedbed. Leave this for several weeks to allow any unwanted weed seeds to germinate which can then be removed.

Then scatter the contents of the seed packet evenly over the soil surface and rake lightly. For sowings made between March and August, firm the soil lightly around the seeds. Do not firm the soil when sowing at other times. Also, avoid watering prior to germination unless you are able to maintain a moist soil surface for at least two weeks. If this is not possible, it is better to allow the seed to germinate in response to natural rainfall.

You can then let your tortoises start grazing when the weeds have grown to about 8-10cm (3-4in) tall. Ideally, divide the sown area into several sections and allow the tortoises to graze each one in succession while the others are allowed to recover. Do not allow an area to be overgrazed as this will kill the plants. It will also be useful if some of the plants can be allowed to flower so that the annual species in the mix should then set seed for next year.

Dandelion leaves.



INVERTEBRATE FOCUS

Red-nosed planthopper - *Pyrops karenius*

This bizarre creature belongs to a group of insects also sometimes described as lantern flies. It was photographed in Thailand, at the Kaengkracharn national park, and the species has also been found in Burma (Myanmar) as well as in the Karen Hills of India. Its long mottled wings are folded along the side of the body, and it has a distinctive upwardly curved projection on the head which is bright orangish-red in colour.

There are about 60 species of *Pyrops* planthoppers, found essentially in southeast Asia, with this particular species being first recorded back in 1891. The bizarre appearance of these insects helps to conceal their presence on plants, enabling them to remain largely hidden from predators such as birds. If disturbed, they can hop from one stem to another, like a grasshopper, but generally, they move much more slowly.

They feed on sap, and unfortunately, this means that they can be seen as plant pests, partly because of the fact that they can transmit infections in this way. In the case of some planthoppers, ants have been observed collecting the honeydew produced by these insects. It is also not uncommon for various geckos such as the flat-tailed house gecko (*Hemidactylus platyurus*) to trail these insects as well, lapping up the sweet secretions that they release, rather than preying on them.

Photo courtesy kajomyot wildlife photography/www.shutterstock.com



Did you know?

These insects became known as lantern flies thanks to the German-born naturalist and illustrator Maria Sibylla Merian (1647-1717), who claimed that the elongated snout appeared luminous at night in the living insect. This idea was subsequently accepted by the taxonomist Carl Linnaeus, and hence found its way into both the common and scientific names of various members of the group. However, there is no truth in this suggestion!



This is an interesting relationship between planthoppers and various species of gecko, such as the flat-tailed house gecko seen here.

Photo courtesy muhamad mizan bin ngateni/www.shutterstock.com



DO YOU NEED A HELPING HAND OR ADVICE?

Email your queries to practicalreptilekeeping@gmail.com. A selection of submitted questions will appear here every month. Regrettably, replies can only be given through this column, and if you are worried about the health of your animal, seek veterinary advice without delay.

Ball python: a beginner's choice?



I want a ball python, but would this be a good choice for a beginner? Also, what are the main things I will need to know?

Its suitability depends partly on who you ask, and also exactly what you are looking for in a pet snake, *replies Dr Tariq Abou-Zahr MRCVS*. My opinion in short is that ball pythons can make an exceptionally good species for the beginner, as long as you appreciate the well-documented eating habits of this species. Pretty much any ball python will go through periods of fasting during its lifetime, and many will fast before they even reach what can be considered to be an adult weight. Females in particular often decide to fast for a time at some point when they hit the 600-1000g (21-35oz) range.

This fasting should not be a cause for concern, especially if the animal has been eating well, and you have not made any changes to its environment or surroundings. Having said that, the prospect of getting ball pythons to eat again when they do decide to go off food is often one that causes inexperienced snake keepers to lose sleep, especially as the weeks and months

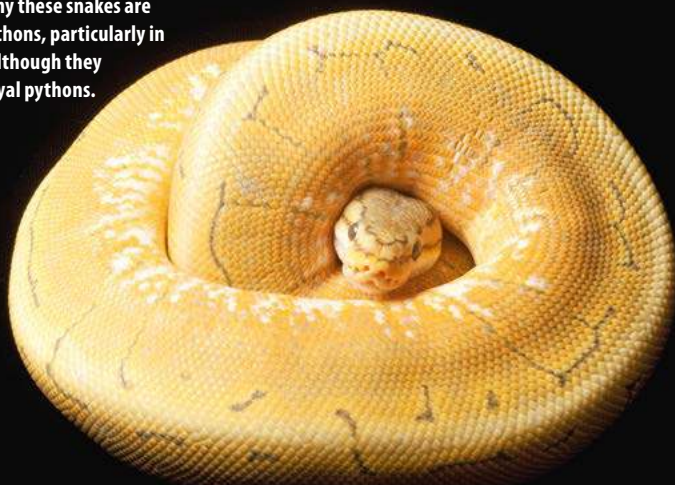


pass by! The best advice I can give is to buy a snake that you are certain is feeding really well. Some ball pythons have an absolutely voracious appetite, and if you ensure you choose one of these, then you will have little to worry about, even if the snake does decide to take a month off here and there.

Ball pythons are very easy to care for as far as day-to-day care is concerned, and they thrive in cosy and secure environments. A plastic tub that slides out of a wooden slot heated by a heat mat is ideal for these snakes. Wooden vivariums work well too, but you must include at least two hides for your ball python, with one located at each end of the enclosure. Providing these snakes with a sense of security is paramount with this species, when designing their accommodation. A ball python is also a good species to get if the prospect of breeding some of the stunning colour and pattern mutations at some point in the future appeals.

I'd advise you to pick up a book such as *The Complete Ball Python* by Kevin McCurley, and join a good online forum to learn more about keeping this species. Alternatively, for a first snake, a colubrid such as a corn snake, king snake, rat snake, house snake or milk snake is also a very good choice, and perhaps slightly more forgiving than some ball pythons might be, and possibly easier to handle. These pythons are my favourite snakes to work with however, and I'd highly recommend them to any prospective owner!

The curled posture of this ghost spinner morph reveals why these snakes are known as ball pythons, particularly in North America, although they are also called royal pythons.



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Tank water needs regular changing?

Turtles can be messy feeders, and maintaining water quality is vital for their well-being, as well as to stop an unpleasant smell developing in the room where they are being housed.



How can I stop the water in my turtle tank smelling and empty it easily? It needs changing every two days.

Buy a special fish-keeping gravel siphon that allows you to drain out the water into a bucket. Those operating off batteries are very easy to use. Just flick a switch to start the water flow. Never ever suck water through a piece of tubing to create a siphon. You may unexpectedly swallow some of the tank water, and this could make you very ill. Tip the soiled water away down an outside drain as well, never down the sink. Don't try to lift the tank with the water in it either. It's surprising just how heavy even a partially-

filled tank can prove to be, with each gallon of water weighing nearly 4kg (9lb).

If you are feeding your turtles on fish or meat, the water will be rapidly polluted by leftover food. You could transfer them instead to a separate lightweight acrylic feeding tank, which will help to prevent unnecessary fouling of the main tank. But it is actually much better to use a balanced pelleted-type food such as Earth Pro Turtle Gold produced by Arcadia. This will contain all the ingredients you need to keep your pets in good health, unlike meat or fish. Feed just enough to meet your turtles' appetites, and fit a power filter in their tank.

The filter will remove much of the resulting dirt from the water, and save you having to strip down the whole tank three or four times a week. You should then only

need to clean the tank and filter about once a week, with the gravel cleaner removing dirt that the power filter missed. It is also possible to obtain a special deodorising product, in the form of a beneficial bacterial cocktail, which prevents any unpleasant odour emanating from the water.

The other alternative would be to remove the gravel altogether, as it is really only decorative. This then makes it much easier for the power filter to operate. In order to choose the right model, you need to have an idea of the volume of water in your tank, or at least the tank's dimensions, so you can choose a correspondingly powerful filter with a high flow rate, usually quoted on the packaging in litres/hour. There is now at least one model available which is specially-designed for turtle tanks.



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Crocodile vs. man

Can there only be one winner?

Colin Stevenson provides an informed insight and perspective on attacks by crocodiles, and what can be done to minimise the risks, while conservationists battle to increase the numbers of these ancient reptiles again, after they have suffered many years of hunting and persecution.

Photo courtesy Jannanong/www.shutterstock.com

Many people around the world today can put their dirty clothes in a washing machine, luxuriate in a warm bath or shower, and then step out and enjoy a cup of tea or coffee, in the safety of their home. Yet for most of human history until very recently, water was gathered from rivers, streams, lakes or from wells.

Indeed, in much of the developing world today, this still remains the case. And of course, if those rivers and lakes are in the tropical or subtropical zones, they may be home to crocodilians. Frequent news stories about crocodile 'attacks', assorted movies featuring over-sized crocodiles eating everyone in sight, and all the crocodile documentaries

you've ever seen showing Nile crocodiles tearing wildebeest or zebras apart serve to feed our paranoia about these remarkable reptiles.

But what is the reality and risk? It's important to recognise that in actual fact, crocodile attacks and crocodile conservation are different sides of the same coin. So let's begin this investigation by winding back the clock to see how things have changed with regard to crocodiles, along with their conservation and our dealings with them, down through the millennia.

Ask not what crocodiles have done to us...but what we have done to them!

People living in areas of the world

➤ A representation of the ancient Egyptian crocodile-god, called Sobek, portrayed on the Temple of Kom Ombo in Egypt.

Photo courtesy Anton Ivanov/www.shutterstock.com





▲ A rare sighting these days - a group of gharials in one of their last remaining strongholds on the Chambai River in India.

Photo courtesy kunaljain7/www.shutterstock.com

▼ This was the view of crocodiles related by early European explorers, who saw them as lethal killers - although we now know only a minority of species represent a danger to people. Once firearms became widely available, so crocodilians were themselves vulnerable to attack, as they could then be killed safely from a distance. This illustration featured originally in a French natural history book by the Comte de Lacépède, published in 1788.

Photo courtesy Morphart Creation/www.shutterstock.com

primal about large predatory species. They all rely on stealth, and those that lurk beneath the water strike a particularly deep fear in people, because we can't see them - until it's too late!

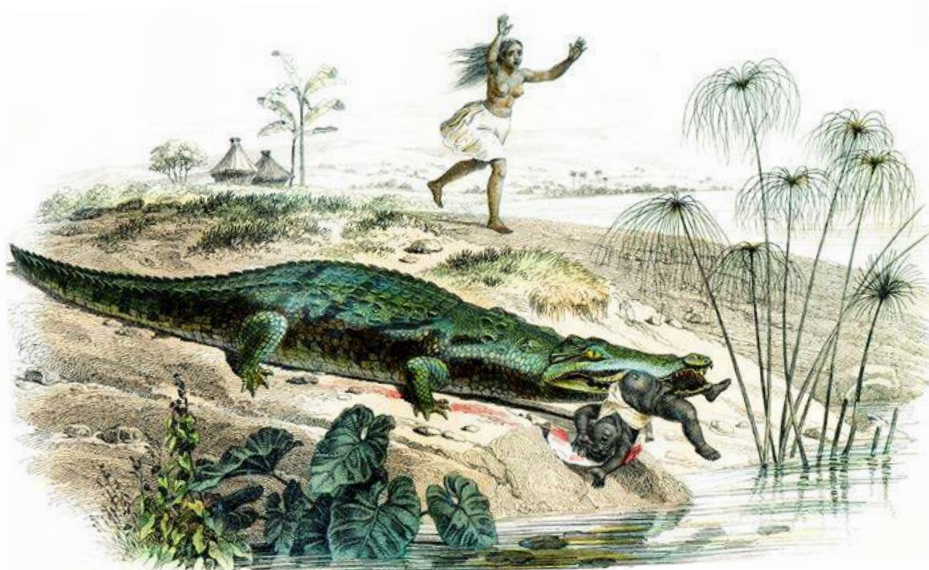
Travellers' accounts

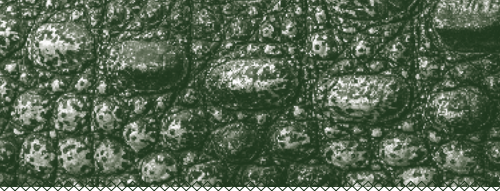
Regardless though, to have travelled within crocodile or alligator habitats during the early 1800s would have been exhilarating. Contemporary reports from explorers or travellers from those times universally describe the local crocodilians as abundant, with the rivers 'teeming' with these saurians. Reliable witness accounts describe hundreds of crocodiles visible just outside the major cities at that time.

Many Europeans travelling downriver in the tropics would amuse themselves by shooting crocodiles from their boats as the animals basked on the shores. Their

where crocodiles abound have developed myths and legends about these predators, creating rituals and beliefs that they hoped would keep them safe from attacks. Ancient writings and paintings depict the power of crocodiles, ranging from Australian Aboriginal people and their Dreamtime stories to the ancient Egyptians (with their crocodile-god, Sobek). Other cultures, including the Greeks, Romans and Mayans also incorporated crocodiles in a similar way into their cultures, particularly as their empires spread.

This isn't surprising: crocodilians have always preyed on people, just as we have always killed and/or eaten crocodiles. But there is something





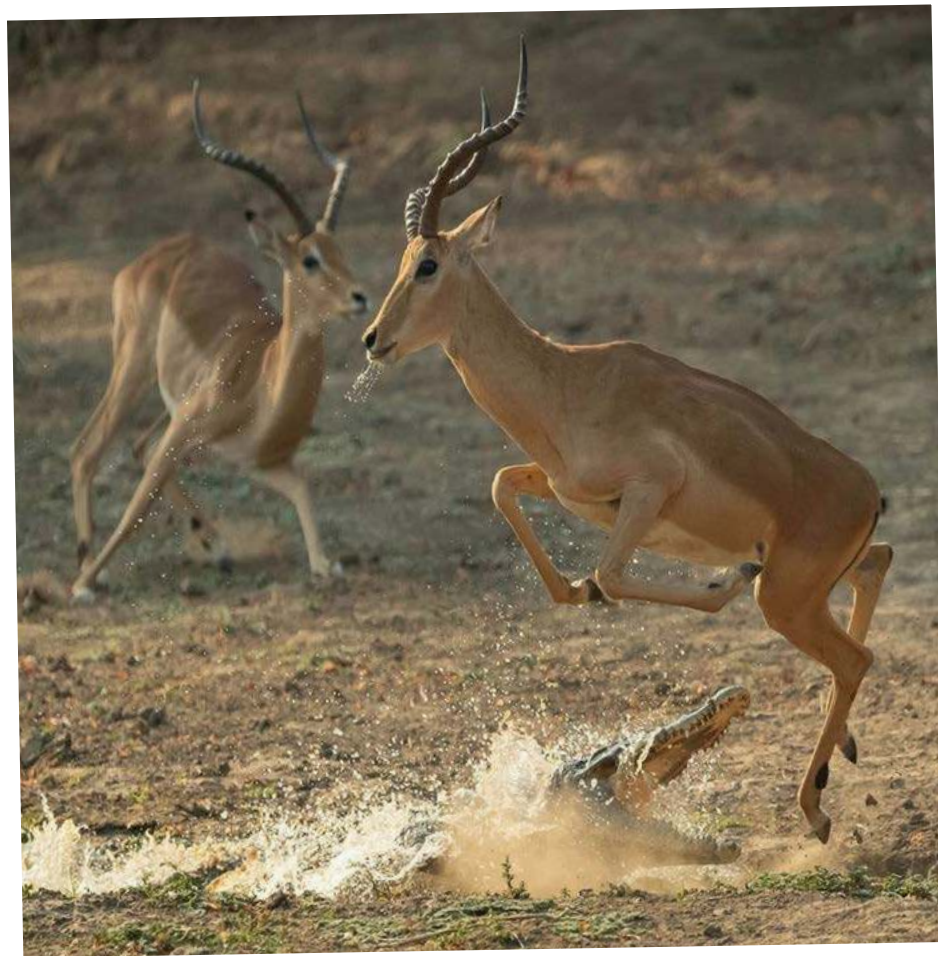
The range of the Cuban crocodile is much reduced today. This individual was photographed swimming in an area of mangrove in the Gardens of The Queen, which is the Cuba's first marine park. Note the protective membrane that covers the eye underwater, enabling the crocodilian to see in these surroundings.

Photo courtesy wildestanimal/www.shutterstock.com

populations until recent times were so dense as to permit easy kills. Back in 922 BC, thousands of alligators were seen in China along the Yangtze River, and they were still extremely numerous as recently as the Ming Dynasty (1368-1644).

Morelet's crocodiles (*Crocodylus moreletii*) near Belize City, gharials (*Gavialis gangeticus*) across the north of India, as well as saltwater crocodiles (*Crocodylus porosus*), Nile crocodiles (*Crocodylus niloticus*) and American alligators (*Alligator mississippiensis*) were all reported to be abundant in the past, and easily sighted.

Many species used to have broader ranges than they have today, including Cuban crocodiles (*Crocodylus rhombifer*) that could be found not only on the island of Cuba but other Caribbean islands during the Pleistocene, as well as the tomistoma or false gharial (*Tomistoma schlegelii*), which probably disappeared from southern China about 1000 years ago.



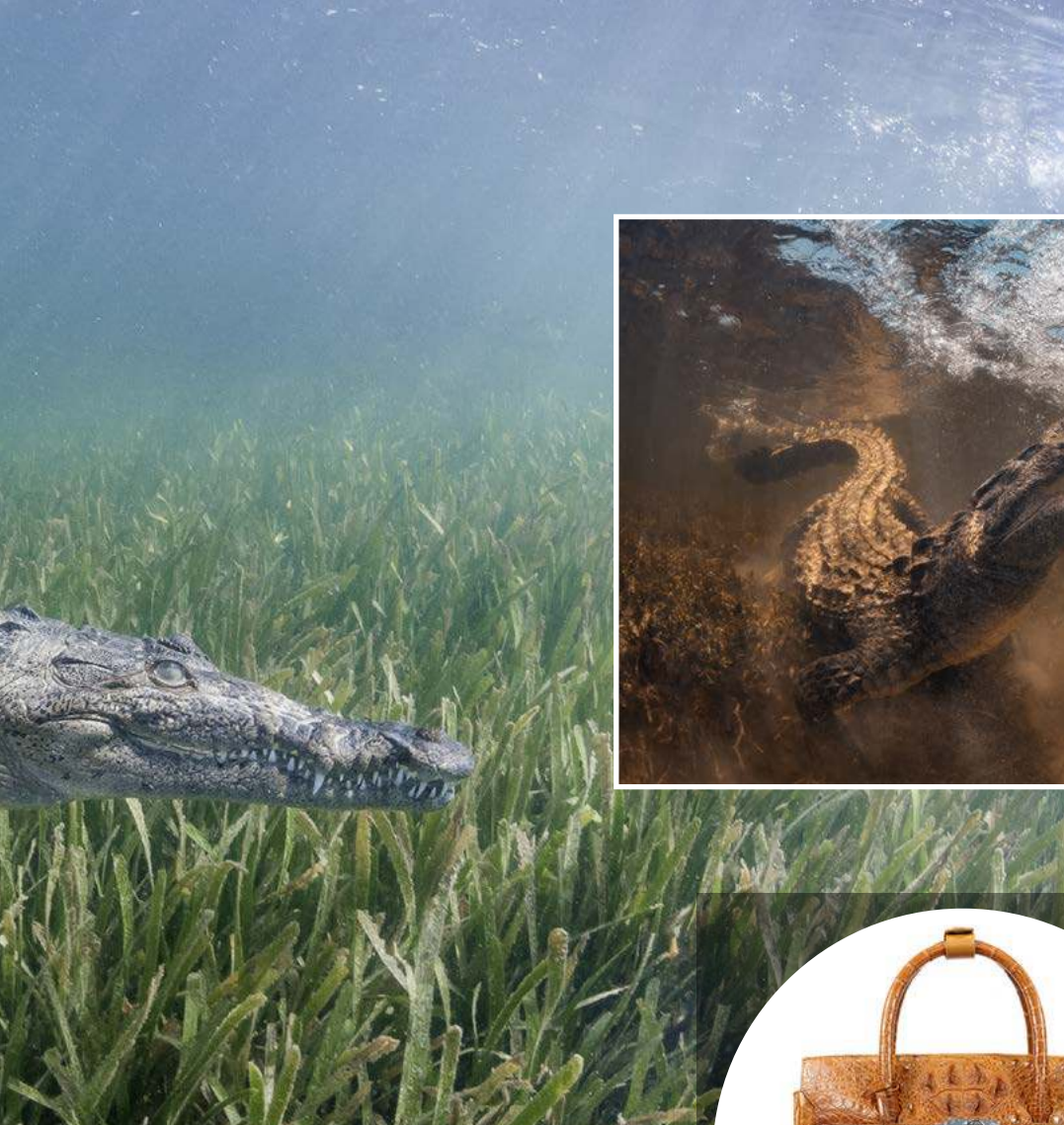
Nile crocodiles had disappeared from the Nile delta by the early 1800s, but remained numerous elsewhere in parts of Africa. Changing temperatures and shifts in sea level resulting from climatic events such as the spread of ice sheets elsewhere on the planet almost certainly contributed to the range contractions of species such as the Cuban crocodile. For others, factors such as the much more recent conversion of wetland habitats for agricultural purposes marked the beginning of serious conservation problems.

Recent impacts on populations

Dam construction – which is often seen as a very recent issue for wildlife conservation – was instrumental in starting the decimation of gharials. In the Indus River within what is now Pakistan, construction of dams effectively cut-off the movement of gharials within the river, restricting them to small pockets of habitat, concentrating the population into smaller groups. This factor, combining with intensive hunting in the late 1800s and early 1900s, led to their decimation.

Although crocodilians have been killed by humans for many thousands

▲ Irregular rainfall patterns and water shortages today are impacting on wildlife. Here two impalas - a type of antelope - are drawn to drink in a very small channel of water where a crocodile is lurking, and they were lucky to escape alive and uninjured from the encounter. Photo courtesy Robert Mwaitekele/www.shutterstock.com



▲ Some crocodiles are to be found in brackish and even saltwater, as shown by this American crocodile swimming in the sea at Banco Chinchorro reef, off the coast of Mexico.

Photo courtesy Alexander Machulskiy/www.shutterstock.com



▲ Massive numbers of crocodilians were being slaughtered for the leather trade, to make items such as bags and shoes. Now this trade is tightly regulated, and crocodile farms have sprung up in countries such as Zimbabwe to meet the demand, without affecting wild populations. The resulting skins also tend to be of better quality than those obtained from wild crocodilians.

Photo courtesy Russamee/www.shutterstock.com

of years, this was very localised – either as a way of feeding or protecting the hunter's immediate family. It was only when the demand for crocodilian skins for the leather trade became widespread during the late 1800s that the situation really began to worsen for this group of reptiles.

By the 1960s, many larger species of crocodilian were becoming difficult to locate, and hunting turned to the smaller, less valuable species. An example of the extent of the pressure on populations at that stage is revealed by trade data from a single state in Brazil between 1950 and 1965. This reveals that 7,517,226 skins were exported from Amazonas, most of which were presumably would have been black caiman, (*Melanosuchus niger*), with the remainder being of the spectacled caiman (*Caiman crocodilus*). As another example, within the US state of Louisiana, some 3-3.5 million American alligators were killed in 50 years from 1880–1933.

What can be done?

Conservation today is much more about management – of the wildlife and environment. It is rightly recognised that protecting the

biodiversity of the planet is crucial, not just for endangered species but for the entire ecosystem and our very own survival. It means that, wherever possible, ecosystem protection must remain the priority. Where development occurs, it should ideally be carried out with a view to maintaining the biodiversity of the area under development. While business will press hard for fewer environmental restrictions, these arguments are getting difficult to justify.

As storms become both less predictable and more severe, with crops failing increasingly because of lack of rain, and as regions became less stable due to unnatural water flow patterns caused by poor development decisions that divert, block or otherwise restrict the flow of river or rain waters along their natural path, the economic cost of overexploitation of the natural world is beginning to hit home.

Wildlife management can work at several levels, considering the situation with crocodilians today, with the following options all being available:

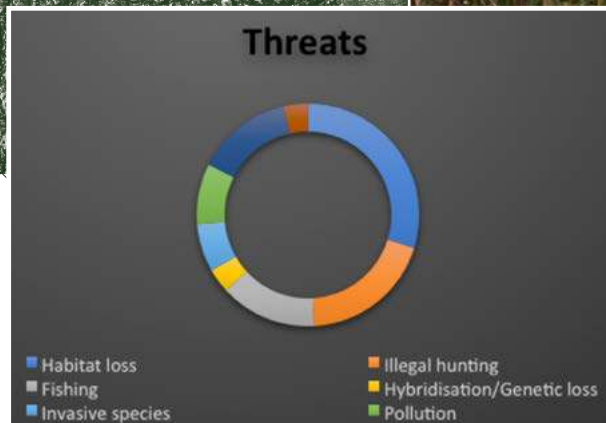
■ **Total protection:** where crocodilians are strictly protected by law. This was the initial method, and in some countries, it remains the only conservation measure for crocodilians, even though enforcement of these laws can often be almost non-existent.

■ **Controlled trade:** restriction of the trade in crocodilians and their parts is an effective tool, especially when supported by national laws and international regulation. It allows wildlife resources to be utilised but in a controlled way, with sustainable use schemes being supported by trade controls, and brings local economic benefits to people in such areas, encouraging them to see a value in protecting wildlife.

■ **Protected areas:** these are localities that incorporate crocodile habitat, where the land itself is protected. In such cases, tourists hopefully are drawn to visit such parks specifically to see wild crocodiles, as well as other wildlife.

■ **Captive-breeding:** crocodilians bred in captivity are kept in zoos, so people can see them, and also can be used for potential reintroduction programmes.

■ **Education:** crocodilians deserve respect not just because they are incredible survivors with a complex biology, but because they are large and potentially dangerous. People who live in areas which are also



▲ The major threats that crocodilians face worldwide today, and their individual significance, is shown in this chart.

Image courtesy of the author

home to large crocodilians need to learn how they can co-exist safely with these animals in the modern world.

By the mid-1970s, international regulations - notably the Convention on International Trade in Endangered Species of Wild Fauna and Flora, better known simply as CITES - were established to stop the illegal trade in wildlife, with the aim of giving populations a chance to recover, when coupled with enforcement of local wildlife legislation.

However, although international trade was largely restricted, illegal trade was almost impossible to regulate in some areas, particularly in parts of South America with its large caiman population. It has been estimated that throughout the 1980s, at least one million caimans were being killed annually, with no more than 20% of the reported trade being legal.

Environmental effects

As in the case of most wildlife on the planet, the depletion of resources and the demand for more by humans is the driver of habitat loss, destruction and degradation that threatens

today's living crocodilians.

The destruction and loss of habitat comes in many forms, including outright loss of habitat due to agriculture, cities and towns, and roads for example. It also is caused by the removal of forest resources

▲ In certain cases, development increases the danger of crocodilian attacks on people. This sign, warning of the presence of crocodiles, is at the edge of an artificial pond created on the Batu Putih Palm Oil Estate in Malaysia's Sandakan District. Crocodiles are now living in this small lake, representing a potential danger for those working on the estate.

Photo courtesy Use Aranas/
www.shutterstock.com

through activities such as logging, gold mining, sand-mining in India, and the conversion of peat swamp forests for palm oil plantations – which is now a serious threat to the tomisoma.

Some of these practices also cause pollution. The mercury used in gold mining enters the water, and works up through the food chain to crocodilians, which are the apex predators. Chemical run-off from agricultural lands can have more direct impacts, both in terms of possible toxicity and adversely affecting the water chemistry.

Clearing forests for logging purposes can in turn result in soil run-off and silt accumulating in and modifying the crocodilians' habitat. This may also reduce the availability of prey for them as well, lessening the number of individuals that the habitat can sustain.

As with many deleterious activities, the impacts tend to be both cumulative and complex. Loss of peat swamp forest may provide a short-term economic windfall, but will result in an immediate degradation of



▲ Fertiliser run-off can affect the vegetation in the waters occupied by crocodilians, impacting both on their habitat and hunting opportunities, particularly as the fish population is likely to be impacted as well. An American alligator is shown here. Photo courtesy SandraG/www.shutterstock.com



caimans and American crocodiles (*Crocodylus acutus*) have become regular victims of collisions with vehicles in Brazil and Florida respectively, as are mugger crocodiles (*Crocodylus palustris*) in India.

Major roads are also notorious factors in dividing and isolating wildlife populations. When highways become impassable barriers, small populations of a species become separated and can no longer move easily between areas. This is what is described as fragmentation of habitat and of wildlife populations.

Dams and barrages stop movements of aquatic species, limiting the range of that population. If the species needs to migrate for breeding, or to reach feeding sites at certain times of the year and can no longer do so, it will rapidly become endangered. These structures also reduce water flows, sometimes down to a trickle.

On the other hand, such obstructions can also increase water levels more rapidly than would normally occur, at times when water is released from the barriers. Gharials are sometimes victims of such events, as nesting and basking beaches are washed away, nests are flooded and young individuals can be washed away further downstream where the habitat may not be suitable for them.

With availability of fresh water set to become a key factor for humans over the coming decades as climate change makes rainfalls more unpredictable, management of river systems will be under much greater pressure to ensure sustainable water flows for farming and for towns and cities. Canals, water extraction facilities, plus plans already under discussion in India to link river systems means that wildlife such as crocodilians will be severely impacted.



▲ Tourists will be drawn to areas where they can see these magnificent reptiles close-up, as has been shown in parts of America, especially with alligators, and in Australia too. Ecotourism therefore helps to preserve the habitat of the crocodilians for other species as well.

Photo courtesy Deborah Ferrin/www.shutterstock.com



▲ Changes in water flow and currents caused by dams have adversely impacted on gharial numbers - and those of other crocodilians too.

Photo courtesy Arsgera/www.shutterstock.com

▲ Increasing numbers of crocodilians are being hit and killed on roads, as urbanisation pushes deeper into their habitat. Photo courtesy MarynaG/www.shutterstock.com

habitat, and a loss of many species.

The impacts are wider still of course, with burning of peat swamps releasing significant greenhouse gases into the atmosphere. This also reduces the planet's ability to lock up some of the carbon, preventing it from getting into the atmosphere and contributing to global warming

(which is a vital benefit of peat swamp forests, as they retain this carbon).

The impact of development

Construction of roads not only opens up forests to further exploitation, but also introduces a new threat to susceptible wildlife: roadkill. Dwarf



Current status of the world's crocodilians

Twelve crocodilian species are now currently considered Lower Risk by the IUCN's Red List of threatened species, as shown below. Seven species, however, are defined as critically endangered and four as vulnerable. There is not enough data on the other two to classify them, but clearly, this absence of knowledge suggests a shortage of numbers making up the population, and is not encouraging.

▲ Illegal widespread killing of caimans in South America for the international leather trade was an issue which has now been tackled, thanks to improved protective measures and international regulations.
 Photo courtesy Vaclav Sebek/
www.shutterstock.com



▲ The West African slender-snouted crocodile (*Mecistops cataphractus*) is a fish-eating species, about which very little is known, and its current population numbers in the wild are unclear. This has meant that it is impossible to assess its status officially, although most experts believe that the species is now seriously endangered.
 Photo courtesy Bappa Pabitra/www.shutterstock.com

Species	Status
Chinese alligator	CR
Philippine crocodile	CR
Orinoco crocodile	CR
Siamese crocodile	CR
Gharial	CR
Cuban crocodile	CR
African slender-snouted crocodile	CR
Tomistoma	VU
American crocodile	VU
Mugger crocodile	VU
Dwarf crocodile*	VU
American alligator	LR/LC
Australian freshwater crocodile	LR/LC
Nile crocodile	LR/LC
New Guinea freshwater crocodile	LR/LC
Saltwater crocodile	LR/LC
Spectacled caiman	LR/LC
Broad-snouted caiman	LR/LC
Yacare caiman	LR/LC
Dwarf caiman	LR/LC
Smooth-fronted caiman	LR/LC
Morelet's crocodile	LR/LC
Black caiman	LR/CD
West African crocodile	Not assessed
Central African slender-snouted crocodile	Not assessed

Chart courtesy of the author



The comeback kings!

In areas which are politically stable and have good law-enforcement, species have generally been able to bounce back from hunting pressures once they are protected, as long as sufficient habitat is still available. Both the saltwater crocodile and its freshwater cousin (*Crocodylus johnstoni*) in northern Australia, as well as American alligators in the south-eastern USA are examples in this group.

'Saltie' numbers had fallen to estimates of around 500 adults by the

1970s, after decades of hunting, but they are now considered to have recovered to their previous level, with the Australian population now probably exceeding 100,000 adults. American alligators are estimated to number between 3-4 million individuals in total across their range.

This comeback has a cost attaching to it, however. As crocodilian populations increase, so do their interactions with people. In the developed world, these usually occur during leisure activities – boating, fishing, swimming – even golf, with

▲ **Moving crocodiles is not really feasible in many parts of their range.** Photo courtesy Volodymyr Burdiak/www.shutterstock.com

alligators being encountered wandering across the links.

In the developing world, however, the activities that bring people into close contact with crocodilians are essential for life. These include collecting water for cooking, cleaning or drinking, washing and bathing, crossing waterways for work, and fishing, both as a livelihood and to obtain food for the family.

Different solutions are therefore required, in order to minimise the risk of conflict. Crocodile management in countries such as Australia focuses on educating people in an area about crocodile behaviour, warning of the danger of venturing too close to the water's edge and swimming. Running alongside the education advice are schemes to manage 'problem' crocodiles.

On-going monitoring

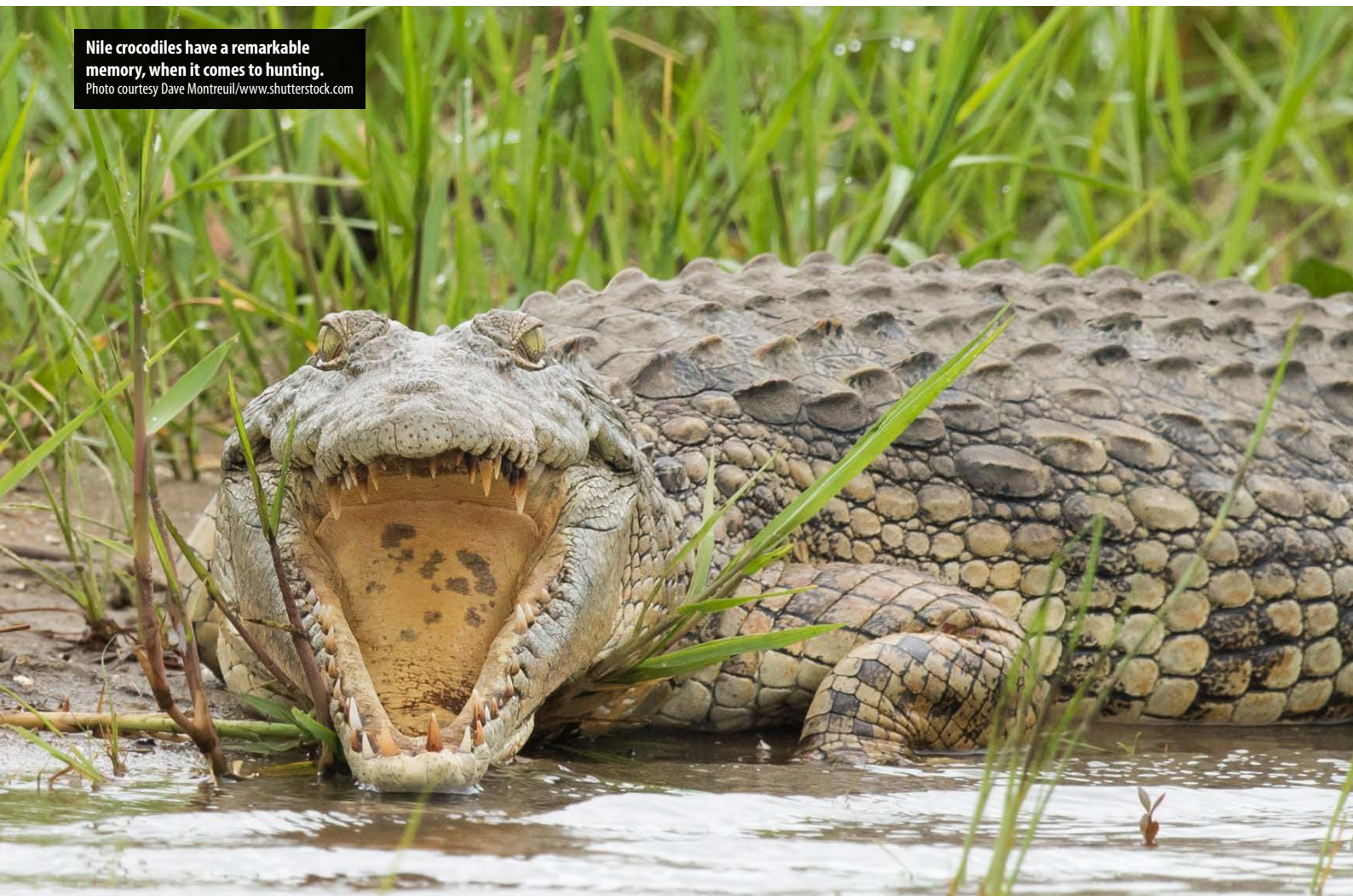
Crocodile attacks are followed up, with the aim being to identify and kill or capture the individuals responsible. This is important, because once crocodilians begin associating humans with food, it has been shown that the likelihood of



▲ Finding alligators on the greens can be an issue when playing golf in parts of Florida today. Photo courtesy pixelworlds/www.shutterstock.com

Nile crocodiles have a remarkable memory, when it comes to hunting.

Photo courtesy Dave Montreuil/www.shutterstock.com



further incidents increases. But the definition of 'problem crocodiles' is more wide-ranging, attempting to minimise the rise of conflicts in the first instance.

Significant numbers of animals are being removed from waterways frequented by people in both the USA and Australia, with around 300 crocodiles being translocated each year from the waters of Darwin Harbour and its surrounds. Education programmes coupled with removal of potentially dangerous crocodiles is generally enough to keep the peace.

Yet this approach is really not adequate in the developing world, where the risk of conflicts are potentially higher, because of people's lifestyles, and resources are scarcer. Increasing crocodilian populations there may be good news for conservation, but not necessarily for local people. They still have to rely on visits to local rivers and lakes for their daily fresh water needs, meaning that they are then more vulnerable to attack by crocodiles, simply because there are more of them there.

Education programmes may help a



little; removal of problem crocodiles occasionally occurs, but it isn't very consistent or effective. In many of these areas, the problem is actually nothing to do with crocodiles: it's purely a socio-economic issue. What that means is the solution is to help the local people with livelihood options and improved infrastructure – even putting in a water pump away from the river can reduce encounters and conflict with crocodiles.

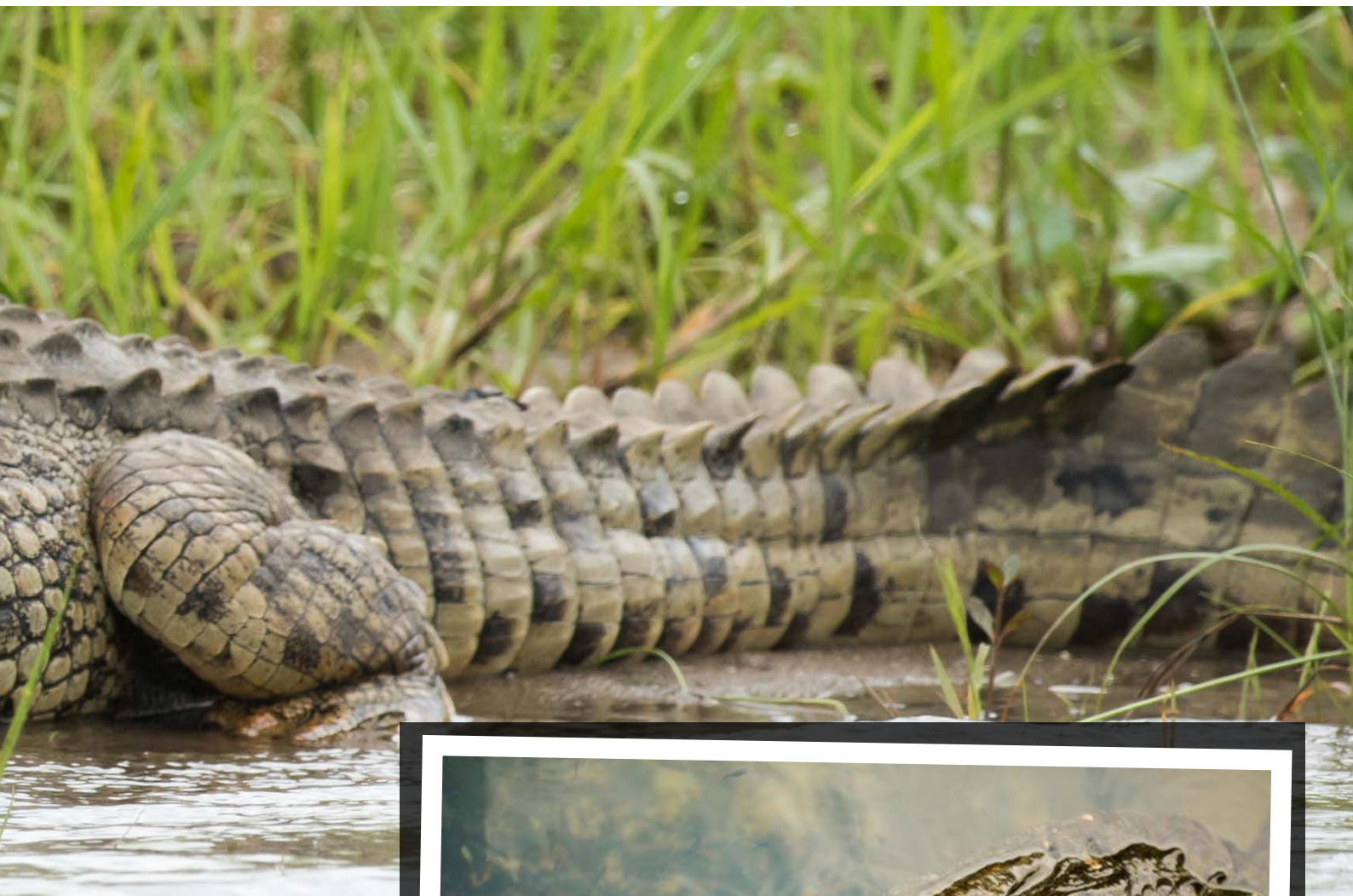
▲ Crocodilians are masters of disguise, as illustrated by this photograph of the remote Daly River, which lies in Australia's Northern Territory. It's always the ones that you need to worry about!

Photo courtesy EA Given/
www.shutterstock.com

A supremely adapted predator

No other animal is better adapted to being an ambush predator in the shallows than a crocodilian. They are ideally suited to this role, thanks to their unique anatomy, and what is interesting is that the typical appearance of a crocodilian has altered remarkably little in general terms, extending right back to the age of the dinosaurs and earlier.

Crocodilians have all their main



senses aligned with the water's surface. The eyes, ears and nose project just above the surface: they can see, hear, smell and breathe from that position. The eyes are able to focus on a horizontal section of the river bank with just tiny adjustments of the eye, rather than requiring elaborate head movements, which would be much more likely to alert prey to the fact that a crocodile was close-by.

Their ears can localise sounds very well, and at the same time, delicate sense organs line the jaws. These are known as integumentary sense organs (ISOs), and will detect any movement or disturbance at the surface of the water near the crocodilian.

Most animals have cryptic patterning or colouration that can serve as camouflage, and crocodiles are no exception, blending in very effectively when submerged. So, in a low position, with almost its entire body hidden beneath the surface (and totally concealed in murky river water), a crocodile is extremely difficult to spot.

It, however, has a very clear picture



▲ **Crocodiles reveal very little of themselves at the water's surface, but will still have a clear view of the world around them, as shown by this American alligator.**

Photo courtesy Katie May Boyle/www.shutterstock.com

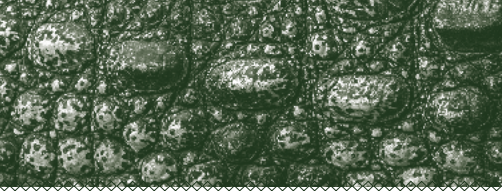
of the area surrounding itself, with all its senses relaying information to its brain. The ability of crocodilians to hunt depends on them being able to remain out of sight, and they are supremely equipped so to do!

If a crocodilian detect a wary prey animal, it can even submerge back just below the surface. Here it will be totally invisible, but will still have ample sensory feedback, enabling it to move closer without alerting its target to the impending danger.

Staying submerged is not a problem. Large crocodiles have been known to remain underwater for over seven hours: the most complex heart and circulation of any vertebrate animal makes this possible.

Misunderstood but still deadly

For many years, it used to be thought that crocodilians, as cold-blooded reptiles, were dim-witted. Now we know this is definitely not the case! They have a remarkable capacity to



learn, observing their environment and noting patterns of behaviour in their prey.

This then allows them to select the ideal location, position and the most favourable time for a successful hunt. Those Nile crocodiles in Africa don't just hang around hoping that a wildebeest will wander past: they know when to expect the migration, as well as where the animals are likely to cross the river, and will be most vulnerable.

So, here is a group of predators that are able to judge where to wait, along with the anatomy and physiology to lurk unseen. They are also deadly when they do strike. It's no wonder that they are such successful predators!

The jaws and teeth of crocodilians are designed for one simple task: gripping on to prey and not letting go. The teeth are conical, pointed (and very sharp in young crocodilians, although less so in older individuals). They are replaced regularly, as they become worn or damaged. The larger teeth are located on top of the gentle undulations of the jawline, providing a better grip.

The power that a crocodilian's jaws can exert is phenomenal: almost 30 newtons per sq millimetre (equivalent to two tons per square inch) of force, and over 1389 newtons (90 tons) of point pressure at the tips of some of those teeth. Whatever they bite, the teeth are going to penetrate and anchor into it without any problem.

Critically, that jaw strength allows these reptiles to grip even quite large prey, and drag it into the water. If a crocodilian feels resistance from its quarry, however, then it simply rolls on its own axis to tilt the unfortunate animal off balance, which then makes it easier to pull down beneath the surface.

When a crocodilian lunges at a target out of the water, the movement is simple: push off from the legs and sweep the tail at the same time. Its momentum will carry it a short distance further too, and smaller individuals can run a few more steps, but crocodilians are essentially water's edge predators.



◀ In Australia, warning signs like this are common in areas which crocodiles are known to frequent.

Photo courtesy Shade design/www.shutterstock.com



▲ A crocodile's formidable teeth exert remarkable pressure. There are also sensors in the jawline, which help them to determine the position of their prey. Photo courtesy Enrique Ramos/www.shutterstock.com

Key safety rules

As this indicates, there is enough information here to keep anyone safe from an attack by any crocodilian. In crocodile country, if you don't need to go near the water, you don't... Don't look for crocodiles, thinking you'll spot them: the dangerous ones are the ones you can't (and won't) see!

On the other hand, don't believe the ridiculous story that crocodilians can run as fast as horses, or indeed, the strange belief they run in a zig-zag fashion. In order to stay safe, all you need to do is simply stay away from the water's edge - and don't forget this advice when pitching a tent as well!

In some developing countries, so as to give local people safe access to the water, there may be crocodile





The formidable saltwater crocodile is the most deadly species as far as people are concerned, based on CrocBITE's figures. Photo courtesy sushi kumudini chikane/www.shutterstock.com



◀ In spite of popular belief, the majority of crocodilian species do not represent any danger to people. This is the smallest species, known as the African dwarf crocodile (*Osteolaemus tetraspis*), which typically grows no bigger than 1.5m (4.9ft) overall. Its diet is based on fish, crabs and other small prey. Photo courtesy Milan Zygmunt/www.shutterstock.com

exclusion enclosures. These are basically cages that the people go into, which crocodilians cannot enter. The cage is positioned at the edge of the water, and aims to allow people to bathe, wash or collect water whilst remaining barricaded away from any crocodilians nearby. As long as the enclosure is adequately maintained, this approach does work very well.

The main culprits

Figures compiled since the year 2000 show that of 3748 incidents recorded in the CrocBITE database (at www.crocodile-attack.info which monitors attacks by crocodilians on people), there were 1538 carried out by saltwater crocodiles, 1061 by Nile crocodiles, 454 by mugger crocodiles, 226 by American crocodiles and 181 by American alligators. A further two species - Morelet's crocodile and tomistoma - together accounted for 80 and 31 incidents respectively.



▲ The tomistoma - also sometimes referred to as the Malayan gharial - grows to a large size, and does attack people, although in the past, it was thought to be a harmless fish-eating species. Photo courtesy BLUR LIFE 1975/www.shutterstock.com

That's just seven species implicated, out of 25 officially-recognised species, being equivalent to less than a third of the total. The others tend to be either too small or possibly too rare to cause any significant problems with people. The facts are very different from the perceived popular image of crocodilians generally being 'man-eaters'.

It may be a surprise to some readers to see tomistoma appear on the above list, given that this species had the reputation of being a fish-eater for decades. The truth is different: in the wild, primates and other mammals are now known to form a significant part of tomistoma's diet.

Tomistoma can attain truly giant sizes, and a 4.5m (14.75ft) male can easily overpower a human. If tomistoma populations continue to recover in their habitats within Malaysia and Indonesia, it is likely that there will be an increasing number of attacks on people by this species in future, so care needs to be taken.

Living in harmony

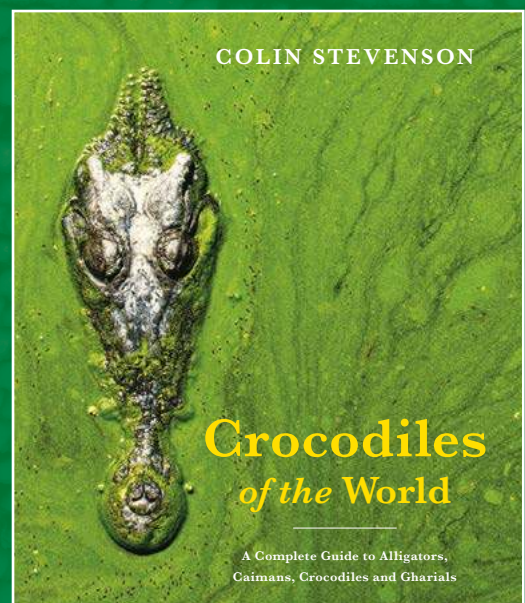
Although incidents with crocodilians appear to be increasing, people living in areas where these reptiles occur have always had to contend with these formidable predators. As

populations increase again in many areas, crocodilians are now reclaiming lost habitat as they expand back into areas from where they were eliminated. This in turn means that several generations of humans who have never had to deal with the risk of crocodilian attacks now suddenly find themselves facing this changed scenario.

Key to this is the fact that all crocodilians today are predators of the water's edge and surface. In the developing nations, political will needs to be brought to bear, in order to ensure that riverside communities have better living conditions that reduce the need to loiter alongside such areas of water. It is especially dangerous to crouch down here, as this presents a smaller and more attractive target for crocodilians in the vicinity.

Crocodiles will continue doing what they have done so successfully for so long: survive. We need to adapt our own lifestyles around a more sustainable model so we too can survive alongside them, in areas where people and crocodiles co-exist. Knowledge, tolerance and basic infrastructure improvements can significantly reduce the danger posed by these magnificent reptiles, thereby allowing us to live together in relative harmony. ❖

Colin's book



* Colin Stevenson has had a lifetime fascination with crocodiles and is a member of the IUCN/SSC Crocodile Specialist Group, as well as the IUCN Commission on Education and Communication. He is heavily involved in dedicated task forces for endangered crocodilian species, has worked with crocs in Australia, India, Brazil and the UK, and has also authored many papers on crocodile conservation and behaviour. His latest book, entitled *Crocodiles of the World*, has recently been published by New Holland at £16.99.

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New colour carpets

Anyone involved with carpet pythons today cannot but be aware of the colour mutations now being developed, as specialist breeder Marc Mense explains.

Even if you want to buy a pure wild type carpet python, you need to be acquainted with the variants, as you could easily end up in this type of conversation:-

Customer: 'I would like to buy a *Morelia spilota mcdowelli*.'

Breeder: 'No problem, I still have a few normal jaguar siblings for sale.'

This can be off-putting, especially because what may be common knowledge among experienced breeders can easily become a source of considerable confusion for beginners. Firstly, there is the rather unclear situation with respect to species and sub-species in the *Morelia spilota*-complex. You then need to take into account regional variants and finally acquaint yourself with the various mutations, hybrids and 'breeders' jargon'.

Jaguars and siblings

Let's start with the jaguars and siblings mentioned in the conversation above. These are probably the best-known and widely-kept mutations of the carpet python. Jaguars have a strongly reduced pattern and a very noticeable yellow base colour.

The first jaguar was hatched in Norway by Jan Eric Engell, from a clutch of eggs laid by a McDowell's carpet python (*Morelia spilota*

A juvenile red hypo-jaguar (*M.s. mcdowelli*).

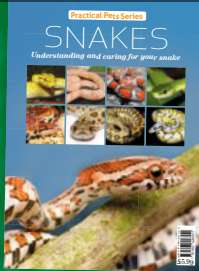


mcdowelli). All the other young in this clutch were normal. This mutation turned out to be co-dominant. As a result, the jaguar characteristic is inherited directly and can be seen in the first generation offspring, when a jaguar is paired with a normal wild type individual. Half of the resulting offspring on average should display this characteristic.

The other 50% of the young carpet pythons which lack the jaguar pattern but come from a clutch with a jaguar parent are called siblings. These siblings do not have the jaguar gene but are valuable for further breeding with a jaguar. This is because breeding results between a jaguar and a sibling result in slightly more jaguar offspring being produced

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Jungle jaguar.



Designer jags

In all designer jaguars, the crossed species/form is mentioned in the name. The more commonly-available examples of this type at present include:-

Jungle jaguar = regular jaguar x *Morelia spilota cheynei* (jungle carpet python)

Papua jaguar = normal jaguar x *Morelia spilota harrisoni* (Papua carpet python)

Bredli jaguar = regular jaguar x *Morelia spilota bredli* (Bredli's python)

Siblings get their name following the same system. This therefore gives rise to the jungle jaguar sibling; Papua jaguar sibling; Bredli jaguar sibling and so on.

than is the case when a jaguar is mated with an ordinary carpet python.

As in nearly all co-dominant mutations, the jaguar also has a 'super form'; in this case, it is always a leucistic animal. Unfortunately up until now, however, not a single super jaguar has proved viable. A super form is the dominant variant of a co-dominant mutation form that results when two co-dominant animals are mated.

This means that that the super form in the first generation passes the mutation to 100% of the young, and should mean that only jaguars and no siblings would result. When breeding a super form with a regular jaguar, the result ought to be 50% jaguars and 50% super form. But neither of these pairings are feasible in the absence of a super jaguar.

I would like to mention here that the usual term 'co-dominant' (which I am using) is not completely accurate but it is so commonly used that it would lead to more confusion if I deviated from it now. All jaguars that are still true-bred, representing pure *Morelia spilota mcdowelli* bloodlines, are called 'regular jaguars'.

The result of back-breeding

One often sees percentages or generations listed next to the jaguar description, such as '75% Papua jaguar' or 'Papua jaguar, 2nd generation'. Both names actually mean the same thing; there has been a further back-cross involving the named species. The hatchlings in this case are the result of a Papua jaguar x *Morelia spilota harrisoni* mating.

A '88% Papua-jaguar' for instance means a cross of a '75% Papua jaguar' with a *Morelia spilota harrisoni*. Such pairings serve only one purpose, being carried out with the aim of improving the colour and patterning of the snakes over subsequent generations. These back-crosses are therefore likely to become

increasingly common in the near future.

Apart from the regular jaguars and the different designer jaguars, high contrast, hypo- and red hypo-jaguars are now recognised. These three variants also first appeared with J.E. Engell in Norway, as a result of his breeding programme with regular jaguars. High contrast jaguars are the least distinctive of these three forms, when compared with regular jaguars. They have a slightly sharper pattern and somewhat brighter colours.

The difference is more marked in hypo-jaguars, with their purer pattern and more powerful colours. Red hypo-jaguars are the most remarkable of the three mutations because they already show reddish pattern upon hatching. As adults, they have an extremely clear pattern and show truly brilliant colours. These three jaguar variants can now be easily bred by crossing a red hypo-jaguar with a red hypo-sibling. On average, the clutch will contain an equal number of all three variants.

This is also a good example of the benefits of using siblings in the breeding of jaguars: crossing a red hypo-jaguar with a normal carpet python will only result in hypo-jaguars and high contrast jaguars but no red hypo-jaguars. Siblings have a distinctive role to play therefore, in the creation of this attractive form.

Granite carpet python

This is another very spectacular and distinctive colour mutation which first appeared years ago in the collection of Dutchman Piet Nuyten. It is descended from Papua carpet python (*M. s. harrisoni*) stock and has become known as the granite carpet python, thanks to its appearance. The body pattern of these animals consists only of fine specks.

The mutation itself is an autosomal recessive. This type of inheritance is probably the most common form seen in snakes. Granite carpet pythons are homozygous, with their appearance corresponding to that of their genetic make-up or genotype. Pairing them together will result in all their offspring also being granite in appearance. There are also heterozygous animals, which resemble the wild type but carry the granite gene and are frequently described as 'hets'.

If you cross a granite carpet python (a homozygous animal) with a wild type *M. s. harrisoni* which is not a het, the result will be 100% heterozygous animals; these snakes will appear visually indistinguishable from wild type pythons but have the granite gene in their genotype (their genetic make-up). If you

A granite Papua carpet python (*M. s. harrisoni*).



Bred & photo by Marc Menze

pair a granite with a an individual that is heterozygous for granite, the offspring will be 50% granite carpet pythons (homozygous) and 50% wild type carrying the granite mutation (heterozygous).

Things get a bit more complicated if you pair two 'hets' (heterozygous animals) together. Statistically, the brood should consist on average of one-third granites (homozygous), one-third wild type but carrying the granite gene (heterozygous), and one-third normal Papua carpet pythons which will not breed further granite carpet pythons.

Unfortunately, the heterozygous animals from such a clutch cannot be distinguished from the true wild type animals that have not inherited the mutation. For this reason, these heterozygous animals are then described as '66% hets', because you have a two-thirds (66%) chance for a heterozygous animal (those animals that are heterozygous are so for the full 100%).

If a 'het' is paired with another that is also heterozygous but not for the granite mutation, you will then get so-called 50% 'hets'. This means that 50% of the young are 'hets' (and there will be no homozygous offspring). At present, there is already a cross of this type with the jaguar mutation, which has resulted in the so-called granite jaguar.

Zebras and caramels

Another co-dominant mutation is the zebra, which cropped up in Germany in a jungle carpet python (*M. s. cheynei*). This mutation gives the animals a finely-striped, zig-zag pattern. The super form is ivory-coloured without a clear pattern. Obviously these specimens have already been crossed with the jaguar mutation which has produced zebra jaguars.

A further co-dominant mutation is the caramel, which arose through breeding of *M. s. mcdowellii*. These carpet pythons have also been crossed with jaguars, producing caramel jaguars. Little is known about the German caramel variant which means that some interesting developments can be expected in this field in the future.

Amelanistic and axantic pythons

There are also a few other really spectacular recessive morphs, such as the amelanistic carpet python. Amelanistic means 'without black' or 'no black'. The first recorded specimens

The super zebra is the dominant result from a zebra x zebra breeding.



Bred & photo by Paul Harris



This zebra morph (*M. s. cheynei*) is a co-dominant mutation.

Photo Marc Menze

Photo Marc Wense



were bred in Australia by Dr. S. Stone (in *M. s. variegata*). In Europe they were bred for the first time by a Swedish python breeder, and are more often described as albinos.

Amelanistic carpet pythons are not only exceptionally beautiful, but they also pose a fascinating challenge for breeders. Aside from normal albinos, there will be albino jaguars, albino granite carpet pythons, albino granite jaguars, albino zebra carpet pythons and so-called snows, which are true albinos. They lack all colour pigments in the skin and in the iris of the eye. A snow is obtained as the result of crossing an amelanistic snake with an axanthic one. The snow mutation is already known in several snake species. These are more or less completely white animals with red eyes, which nevertheless sometimes show tiny traces of pattern.

Axanthic carpet pythons represent another recessive mutation. Axanthic means 'without yellow' or 'no yellow'. The respective results are black-grey or black-white animals, which are not only very attractive but also highly sought-after, as many breeders are keen to produce both black and white jaguars as well as the afore-mentioned snow form. Heterozygous axanthic carpet pythons tend toward a striped pattern, which is very unusual, providing a visual means of distinguishing them from wild type snakes.

In the US, tiger carpet pythons of the sub-species *M. s. mcdowelli* are known. There are, however, different theories about the heredity of this mutation at present. Tiger carpet pythons often show an extreme striped pattern, with high contrast between the pale and dark areas on the body.

Mutations in Bredl's python

Some years ago in the US, the first hypomelanistic Bredl's pythons (*M. bredli*) were bred. Hypomelanistic means 'little black', and in this case, the resulting snakes are a vivid red. Snakes of this type have also been recorded in the wild in Australia, as has a black and white Bredl's form. Breeders there also have other interesting variants including patternless examples of this species.

▲ Axanthic carpet python.

Unexplainable heredity

Most carpet pythons display striped patterning, but this is rarely hereditary, with the exception of het axantics, as mentioned above. Apart from those mutations where the pattern of inheritance is now understood, there are some spectacular specimens which have the potential to breed beautiful new morphs. However the genetic nature of some of the more recent and rarer mutations is currently uncertain. Examples include the labyrinth carpet python (a form of *M. s. mcdowelli*), high-red Bredl's pythons (clutches of these animals often produce hypomelanistic animals in the next generation) and the green Papua carpet pythons (*M. s. harrisoni*).

The breeding of carpet python morphs is growing rapidly in popularity, and not just because there is an increasing demand for such animals, but also because the different combinations open the way to produce even more new variants. If you look at the development of the breeding of corn snake or ball python morphs, it is safe to assume that we are only still at the beginning of breeding carpet pythons mutations. There are undoubtedly very exciting times ahead! ✦



Albino jag female.

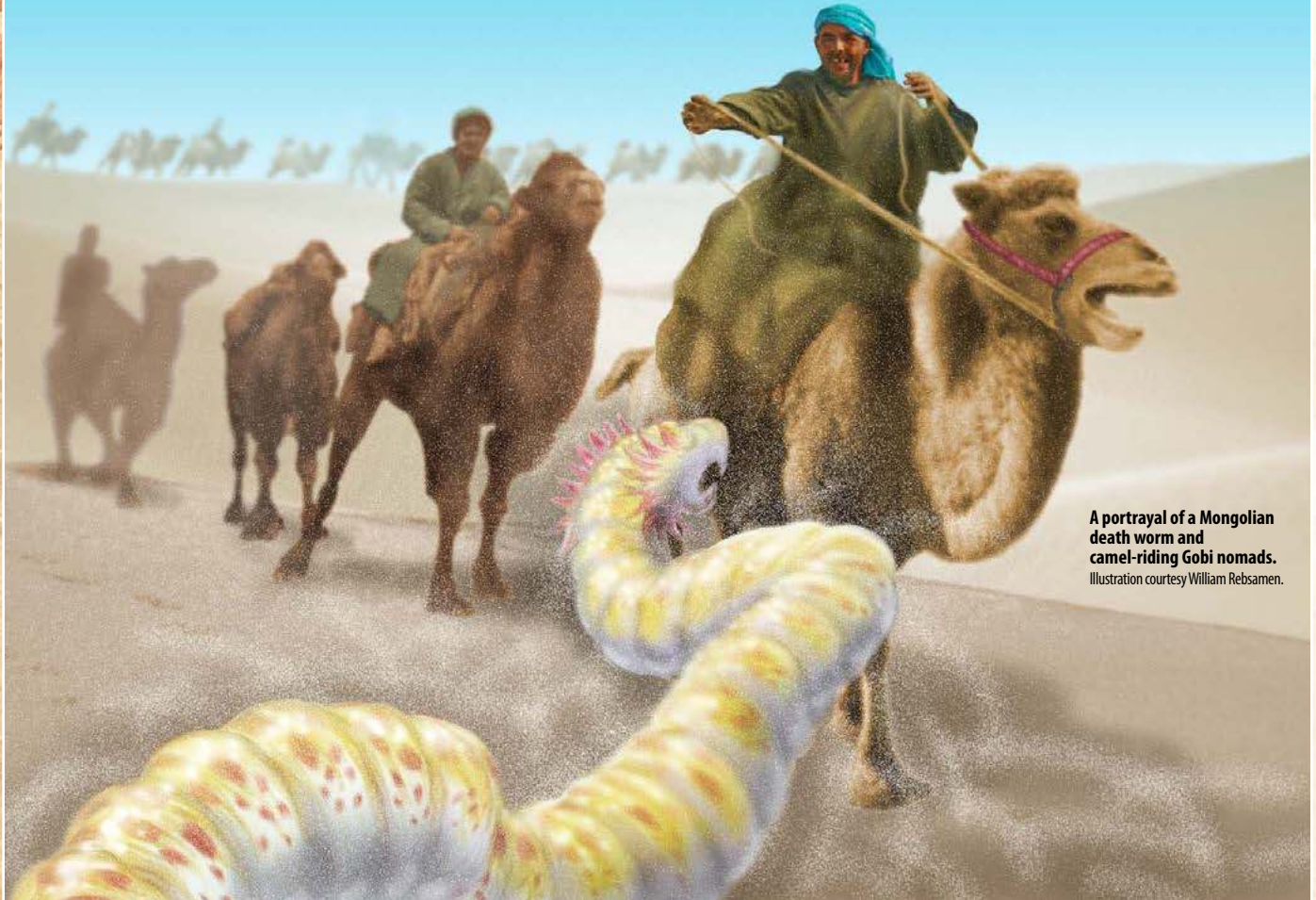
Carpondros

Members of the carpet python group, notably jungles and diamonds, have also been hybridised successfully with the green tree python (*Morelia viridis*). This species is to be found in Australia's Cape York Peninsula, as well as parts of New Guinea and Indonesia, thus overlapping in some areas with carpet pythons. Reports on the behaviour of these artificially-created hybrids, known as carpondros, suggest that they are happy not just to occupy arboreal areas, but are equally at home on the ground.



Herpetological Mysteries

THE MYSTERIOUS CASE OF TOLKEIN, *THE HOBBIT* & THE MONGOLIAN DEATH WORM



A portrayal of a Mongolian death worm and camel-riding Gobi nomads. Illustration courtesy William Rebsamen.

Lord of the Rings author J. R. R. Tolkien was a man with wide interests, aside from being a Professor of Anglo-Saxon, as well as English, at Oxford University. He was well-acquainted with myths and legends - but in *The Hobbit*, which introduced the world to his character of Bilbo Baggins, did he also give a fascinating insight into a creature that remains a source of mystery today? Dr Karl Shuker investigates.

"In the tales of the Hobbit folk there lived in the Last Desert, in the East of Middle-earth, a race that was named the Wereworms. Though no tale of the Third Age of Sun tells of these beings, the Wereworms were likened to dragons and serpents. To Hobbits they were perhaps but memories of those creatures that stalked the Earth during the Wars of Beleriand in the First Age."

David Day – *A Tolkien Bestiary*

Tolkien's works contain a number of creatures unrecognised by science, such as giant spiders, dragons, and

the dreaded watcher in the water (which may have been a monstrous freshwater cephalopod). Yet perhaps the most unexpected – as well as the most fascinating reference – by Tolkien to a cryptid (mystery animal), can be found in *The Hobbit*, which was originally published in 1937. It is so brief and inconspicuous, however, that it could be easily passed over or even entirely overlooked, so its cryptozoological significance will not even have registered with many readers. This is a great pity, because, remarkable as it may seem, the mystery beast in question appears to

➤ J.R.R. Tolkien served as an officer on the Western Front in World War I, after completing his degree, and then helped to compile the widely used *Oxford English Dictionary*. Both *The Hobbit* and *Lord of the Rings* were written after his return to academic life at Oxford.





be none other than the extraordinary Mongolian death worm.

The cause of the mystery

In 'An Unexpected Party', which is the opening chapter of *The Hobbit*, the hobbit in question, called Bilbo Baggins, has received an unheralded visit at his home, Bag End, from the wizard Gandalf and a company of dwarves. Gandalf has informed them that they would do well to include Bilbo, as a burglar, in their planned quest to retrieve their stolen gold from the great dragon Smaug.

The dwarves, however, are far from convinced that Bilbo would be suitable, and they air their doubts very vocally in Bilbo's parlour while he is in the drawing-room (yet, unknown to them, he can still hear what they are saying!). Angered by their dismissive attitude, Bilbo strides back into the parlour, and boldly proclaims that he is more than capable of fulfilling the role that they wish him to undertake, with the telling statement:

"Tell me what you want done, and I will try it, if I have to walk from here to the East of East and fight the wild Were-worms in the Last Desert."

Brave words indeed, but also very puzzling ones, because they are

▲ A representation of Bilbo Baggins, based on Tolkien's original drawings. Illustration courtesy Richard Svensson/ www.shutterstock.com



▲ The description of 'worm' is commonly associated with earthworms and a host of other invertebrates, but is also used to describe some vertebrates, such as the slow worm, seen here.

Photo courtesy Henrik Larsson/www.shutterstock.com.

never explained nor even referred to ever again either in this or in any other Tolkien novel. They are presumably uttered by Bilbo in a figurative sense, to convey that he is willing to tackle anything, however perilous. But even so, what exactly are the wild Were-worms that he refers to, and where is the Last Desert?

Different forms

The term 'worm' has a number of different animal-related meanings. Its most familiar zoological meaning is as a contraction of 'earthworm' – the common name for most terrestrial oligochaetes. However, many other, unrelated zoological invertebrate taxa that include long, elongate species also have 'worm' in their names – tapeworms, peanut worms, acorn worms, beardworms, thorny-headed worms, ragworms, roundworms, flatworms and many others. There are even a few vertebrates known as worms, such as the slow worm (*Anguis fragilis*), which is of course a species of limbless lizard.

In animal mythology, 'worm' is one of several related terms – others include 'orm', 'ormer', and 'wyrm' – given to certain serpent dragons. These are limbless, wingless dragons that basically resemble huge serpents except for their dragon-like head, such as Britain's Lambton worm, Linton worm, and Kellington worm. This category of dragon was also often characterised by having noxious breath (rather than breathing fire), and the ability to rejoin up into a single entity again if an individual of this particular type

was cut up into segments.

Conversely, in Tolkien's works, he applies the term 'worm' to a classical dragon equipped with four legs, a pair of wings, and the ability to breathe fire, which possessed a very elongated body. As an example, Smaug in *The Hobbit* was a prime example of Tolkien's dracontological definition of 'worm'.

Consequently, the were-worm may be a *bona fide* type of invertebrate worm, albeit one of formidable size and/or temperament if it warranted being fought against, as opposed merely to being trodden on! Alternatively, it could be a Smaug-like dragon, but what about the 'Were-' component of its name? What does that mean?

Story-telling myths?

This prefix, from the Old English 'wer', generally denotes 'human' –



► A portrayal of the Lambton Worm, from a book of fairy tales published in 1894. Source PD.

hence a werewolf, for instance, is a human that can transform itself into a wolf; a weretiger is a human that can transform itself into a tiger, and so on. Could it be, therefore, that a were-worm is a human that can transform itself either into a gigantic invertebrate-type worm or, perhaps more plausibly, into a dragon?

Alternatively, is it a true invertebrate-type worm, or indeed a dragon, but one that exhibits highly advanced, human-like intelligence? Or could it even refer to a being that was half-human, half-dragon, akin in form perhaps to the ancient Indian snake deities or nagas, which possessed human heads (and sometimes a thorax and arms too) but had serpent bodies? Any of these solutions, however, would involve an entity of truly monstrous nature.

As for the Last Desert, where these were-worms reputedly dwell: all that appears to be known about this arid realm is that according to hobbit folklore, it is located at the very easternmost end of Middle-earth, and therefore lies far to the east of the Shire where the hobbits live.

A possible explanation

So where does the Mongolian death worm fit into the story? By way of background, this much-dreaded

➤ A view of the Gobi desert in Mongolia - reputedly home to the Mongolian death worm. Little has changed here over the course of centuries, with camels still providing transportation across this inhospitable region.

Photo courtesy MicheleB/www.shutterstock.com



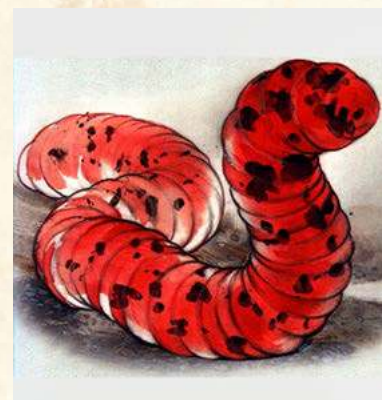
cryptid is red in colour and vermiform (worm-like) in appearance, being said to measure up to 1.5m (5ft) long. It reputedly inhabits the Gobi Desert, which spans parts of southern Mongolia and northern China.

Moreover, according to the nomads living in fear of it there, it is able not only to squirt a lethal acidic venom at anyone confronting it, but can also kill directly via touch (or even indirectly if a person touches it with an implement made of metal) in a mysterious manner that is extraordinarily reminiscent of electrocution.

Yet even the versatile death worm cannot transform into a human or vice-versa. So what connection can there be between this cryptid and Tolkien's were-worm, other than that they both inhabit deserts?

A key change revealed

A comprehensive two-part study of *The Hobbit*, entitled *The History of The Hobbit*, was published in 2007 by HarperCollins in the UK (and by Houghton Mifflin in the USA). This book contained Tolkien's unpublished drafts of *The Hobbit*, together with a commentary written by Tolkien scholar John D. Rateliff.



▲ An artistic portrayal of the Mongolian death worm. Courtesy Ivan Mackerie.

These drafts revealed how this novel underwent many changes – some minor, some major – between the very first version and the final, published edition. One such change is of paramount importance to the subject of this present article of mine, because it concerns Bilbo's statement regarding the were-worms. It turns out that in the very first, original draft of *The Hobbit*, there was no mention at all of were-worms, or of the Last Desert. Instead, what it did state, very thought-provokingly, is as follows: “*[that Bilbo would walk to] the Great Desert of Gobi and fight the Wild Wire worms of the Chinese.*”



➤ The Gobi Desert is located in eastern Asia.

Photo courtesy /www.shutterstock.com

◀ A figurine of a female naga. Photo courtesy the author.



How remarkable that the Last Desert as named in the final, published edition of *The Hobbit* was clearly inspired, therefore, by none other than the real-life Gobi Desert! And no less significant is that the ostensibly shape-shifting were-worm was apparently no such thing in the original draft of *The Hobbit*, being a wire worm instead. But what did this term signify?

In view of the reference to the Chinese, could it have referred to one of those famously serpentine-bodied Oriental dragons? However, they tend to waft languorously through the sky, or rise up from the seas or from deep freshwater pools, rather than reside in deserts, and are often viewed in ancient Eastern traditions as deities. So this identity for Tolkien's wild wire worms seems rather unlikely. And why, in any case, would he have applied the adjective 'wire' to such dragons?

Certainly, the term 'wire worm' is intriguing, given that in zoological parlance, a wire worm is the elongate limbless worm-like larva of a click beetle, belonging to the taxonomic family Elateridae. But I hardly think that Tolkien was referring to some hobbit-inimical, hyper-aggressive click beetle grub when writing of 'Wild Wire worms'!

Early accounts from Mongolia

All of which brings us, therefore, back to the Mongolian death worm. This cryptozoological creature has definitely – indeed, exclusively – been reported from the Gobi Desert, and is, undeniably, zoologically worm-like in its overall appearance.



▲ A number of traditional representations of dragons portray them as having a worm-like or snake-like form, as seen here.

Photo courtesy ChameleonsEye/ www.shutterstock.com

➤ Explorer Ivan Mackerle holding a wooden carving of a death worm-like creature, which is in the collection of the Gobi Museum near Dalanzagad in Mongolia. Photo courtesy Ivan Mackerle.



Indeed, its local names, 'allergorhai-horhai' and 'allghoi-khorkhoi', both translate as 'intestine worm', as it is likened by the nomads to a worm that resembles an animate intestine.

But is it conceivable that Tolkien could have heard of such an entity, especially way back in the 1930s? After all, Western cryptozoology itself did not become aware of the Mongolian death worm until the 1990s, when Czech explorer Ivan Mackerle began searching for and writing about the Gobi's reputed vermiform inhabitant after having researched its history in Russian and Mongolian documents.

Nevertheless, Tolkien, as a highly erudite, eclectic reader, may indeed have known of such a beast, thanks to the publication in 1926 of *On the Trail of Ancient Man*, written by eminent American palaeontologist Prof. Roy Chapman Andrews. This best-selling book concerns the American Museum of Natural History's famous Central Asiatic Expedition of 1922 to the Gobi, led by Prof. Andrews, in search of dinosaur fossils. However, it also

includes a mention of the Mongolian death worm – which, as far as I am aware, is the earliest such mention of it in any Western publication.

Support from the highest level

In order to obtain the necessary permits for the expedition to venture forth into the Gobi, Andrews needed to meet the Mongolian Cabinet at the Foreign Office in London. When he arrived, he discovered that numerous officials were attending their meeting, including the Mongolian Premier. After Andrews had signed the required agreement in order to obtain the expedition's permits, the Premier made one final but very unusual and totally unexpected request:

"Then the Premier asked that, if it were possible, I should capture for the Mongolian government a specimen of the *allergorhai-horhai*. I doubt whether any of my scientific readers can identify this animal. I could, because I had heard of it often. None of those present ever had seen the creature, but they all



▲ Prof. Roy Chapman Andrews was unconvinced by the existence of the Mongolian death worm but accepted the Mongolian Premier's request to search for it. Photo courtesy George Grantham Bain Collection/ USA Library of Congress/Wikipedia/PD

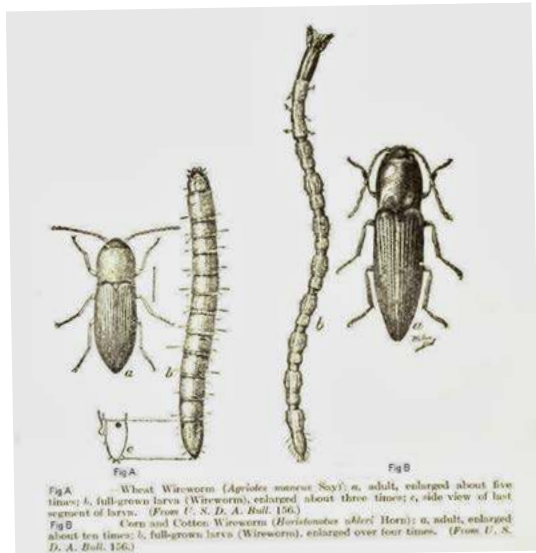


Fig A: Wheat Wireworm (*Agrilus annexus* Say); a, adult, enlarged about five times; b, full-grown larva (Wireworm), enlarged about three times; c, side view of last segment of larva. (From U. S. D. A. Bull. 156.)
Fig B: Corn and Cotton Wireworm (*Hemicolpus villosus* Horn); a, adult, enlarged about ten times; b, full-grown larva (Wireworm), enlarged over four times. (From U. S. D. A. Bull. 156.)

▲ Wire worms are recognised as the larval form in the click beetle's life-cycle, with two different species portrayed in this illustration. Source PD.

firmly believed in its existence and described it minutely. It is shaped like a sausage about two feet (= 60cm) long, has no head nor legs and is so poisonous that merely to touch it means instant death. It lives in the most desolate parts of the Gobi Desert, whither we were going.

To the Mongols, it seems to be what the dragon is to the Chinese. The Premier said that, although he had never seen it himself, he knew a man who had and had lived to tell the tale. Then a Cabinet Minister stated that "the cousin of his late wife's sister" had also seen it. I promised to produce the *allergorhai-horhai* if we chanced to cross its path, and explained how it could be seized by means of long steel collecting forceps; moreover, I could wear dark glasses, so that the disastrous effects of even looking at so poisonous a creature would be neutralized. The meeting adjourned with the best of feeling."

Call me a cynic, but I have the distinct impression that Prof. Andrews did not take the death worm too seriously. In any event, he certainly didn't succeed in finding one, which is probably no bad thing - bearing in mind that he had planned to pick up with steel forceps a creature that had allegedly brought about instantaneous death to a fellow geologist who had prodded it with a metal rod!

More details emerge

During the 1920s, the American Museum of Natural History sent forth several additional Central Asiatic Expeditions to Mongolia and China, and in 1932, a major work, *The New Conquest of Central Asia*, was published, documenting all of them, with Prof. Andrews as its principal author. The first volume in the series, entitled the *Natural History of Central Asia* (edited by Dr Chester A. Reeds), contained a brief

➤ More recent attempts specifically to seek out the Mongolian death worm have been led by Dr Jarda Prokopec and Ivan Mackerie, seen here in the field. Photo courtesy Ivan Mackerie.



section entitled 'The Allergorhai Horhai', which reads as follows:

"At the Cabinet meeting the Premier asked that I should capture for the Mongolian Government a specimen of the *Allergorhai horhai*. This is probably an entirely mythical animal, but it may have some little basis in fact, for every northern Mongol firmly believes in it and will give essentially the same description. It is said to be about two feet long, the body shaped like a sausage, and to have no head or legs; it is so poisonous that even to touch it means instant death. It is reported to live in the most arid, sandy regions of the western Gobi. What reptile can have furnished the basis for the description is a mystery!

"I have never yet found a Mongol who was willing to admit that he had actually seen it himself, although dozens say they know men who have. Moreover, whenever we went to a region which was said to be a favorite habitat of the beast, the Mongols at that particular spot said that it could be found in abundance a few miles away. Were not the belief in its existence so firm and general, I would dismiss it as a myth. I report it here with the hope that future explorers of the Gobi may have better success than we had in running to earth the Allergorhai horhai."

In conclusion

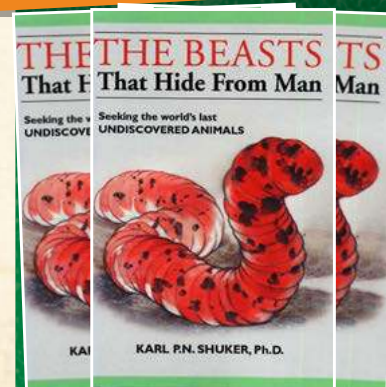
If Tolkien had read either or both of these books, and as someone passionately interested in archaeology, this is by no means an unlikely possibility, then he would indeed have learnt of the dreaded death worm, whose sensational nature might very well have impressed him sufficiently to incorporate a version of this creature in his first draft of *The Hobbit*. Moreover, Andrews's comparison of the death worm's significance to the Mongolian people with that of the dragon to the Chinese may even have inspired Tolkien's otherwise opaque linking of the wild wire worms to the Chinese.

As for why the wild wire worms were replaced in later drafts by wild were-worms, and the Gobi Desert replaced by the Last Desert, who can say? Perhaps Tolkien felt that the latter versions were more compatible with the entirely fictitious Middle-earth than were a real desert and a semi(?)-mythical creature from Mongolian tradition referenced in a real scientific publication.

Of course, this is all very speculative, as there is no firm evidence that Tolkien ever did read or even know of Andrews's above books, but that memorable sentence in Tolkien's original draft of *The Hobbit* remains a compelling enigma. And if nothing else, it conjures up the truly surreal scenario of a hobbit doing battle with the Mongolian death worm - which is surely worthy of a novel in its own right!

* Dr Karl Shuker BSc PhD FRES FZS is a zoologist, author and broadcaster who is pre-eminent in the field of cryptozoology - the study of animals whose existence is not proven.

Discover more



You can read about the Mongolian death worm and many other similar mysteries in Karl's book called *The Beasts that Hide from Man: Seeking the world's last undiscovered animals*. Published by Paraview Press, it is available in hardback (£22.99), paperback (£14.49) and in a Kindle edition (£13.77).



▼ A model of a Mongolian death worm. Courtesy Markus Bühler.

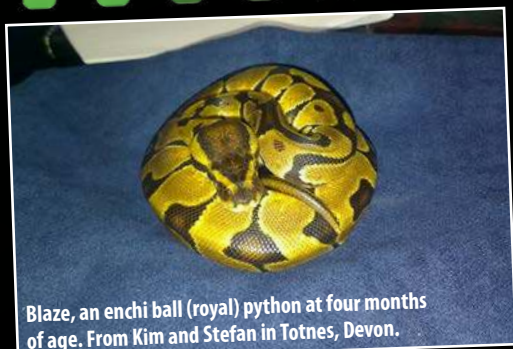
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Robbie, the red-eyed tree frog.
From Michelle in Worksop, Notts.



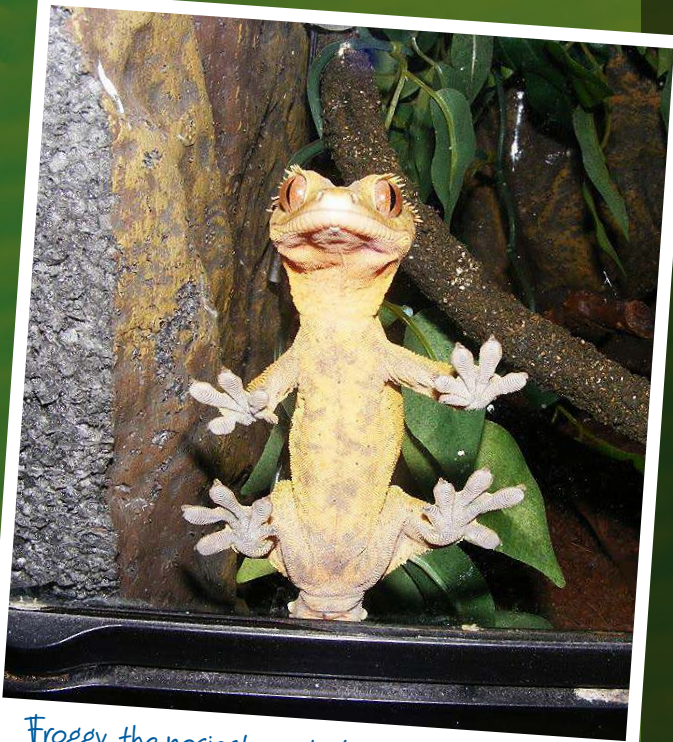
Blaze, an enchi ball (royal) python at four months of age. From Kim and Stefan in Totnes, Devon.



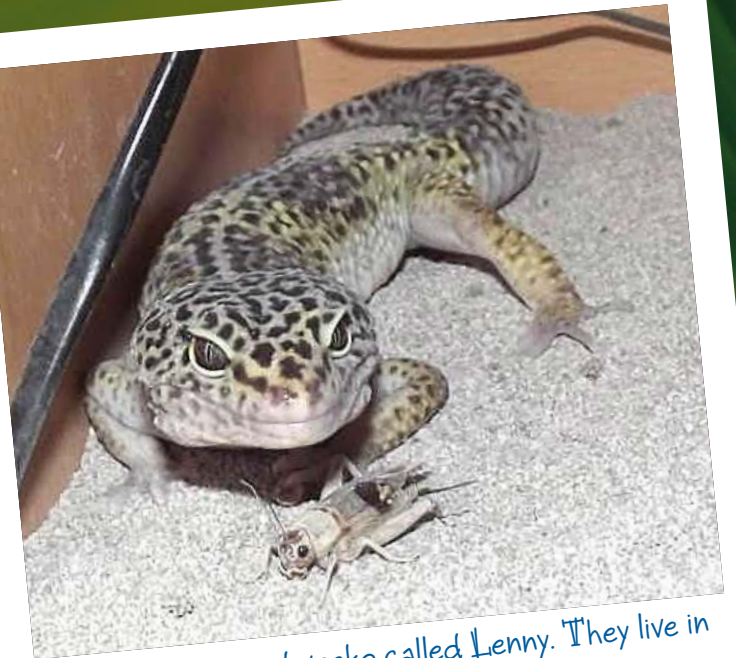
Darwin, the leopard gecko. From Ben in Liverpool.



Goliath the sulcata tortoise, just five minutes after a bath. From Neill who lives in Hyde, Cheshire.



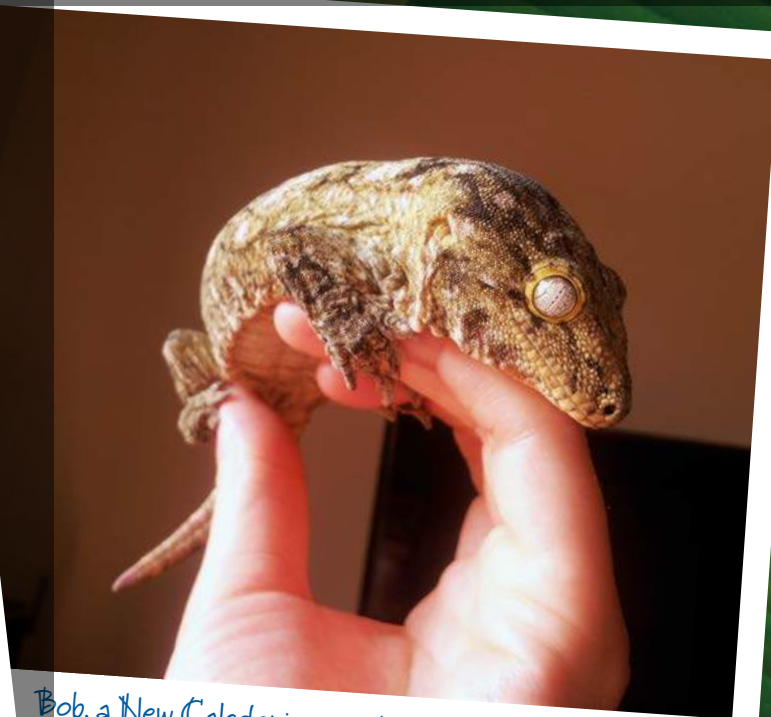
Froggy, the nosiest crested gecko in the world!
From Mandy in Aldershot.



Amanda's leopard gecko called Lenny. They live in
Hatfield, Hertfordshire.



Fluffy - a sub-adult female Mexican red knee
tarantula. From Terry in north Barnsley.



Bob, a New Caledonian giant gecko.
Sent in by Matt from West Malling.



A Kahl albino boa. From Trevor in Cricklade.



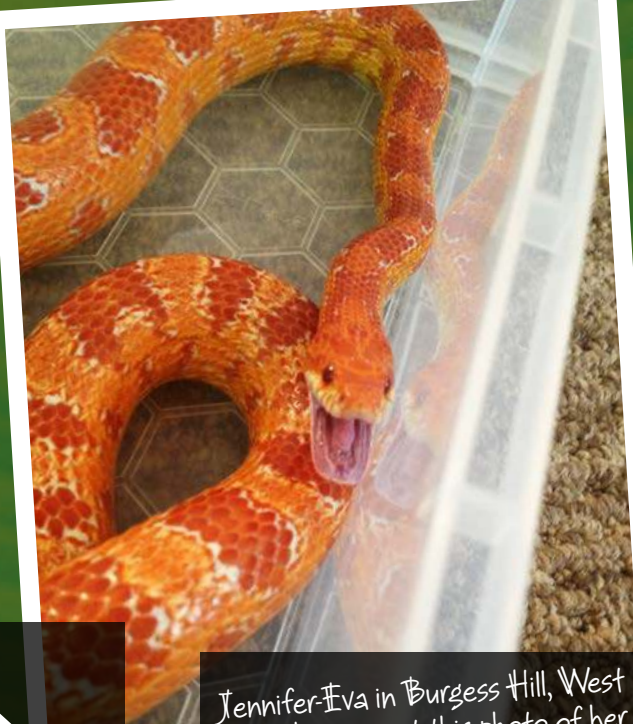
Darren from Rotherham, South Yorkshire, sent this
photo of his crested gecko called Paul.



Bullet and Swift, tokay geckos from James in Surrey.



▲ Chris in Cornwall sent this photo of Rango, his 10 month old male Yemen chameleon called Rango.



Jennifer-Eva in Burgess Hill, West Sussex sent this photo of her amel corn snake called George.



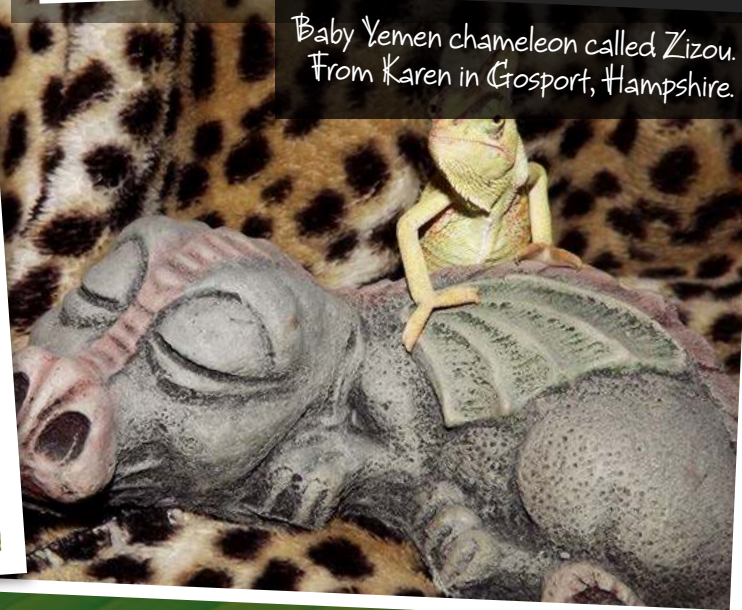
Jada the crested gecko. From Debz in Ashford.

Holli's, a blue tongue skink, on the look-out for snails!



Eric, a nine year old leopard gecko tipping the scales at 124g (4.4oz). From Barry in Cannock, Staffs.

Baby Yemen chameleon called Zizou. From Karen in Gosport, Hampshire.



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