



The bent-toed geckos (*Cyrtodactylus*) of the caves and karst of Thailand.

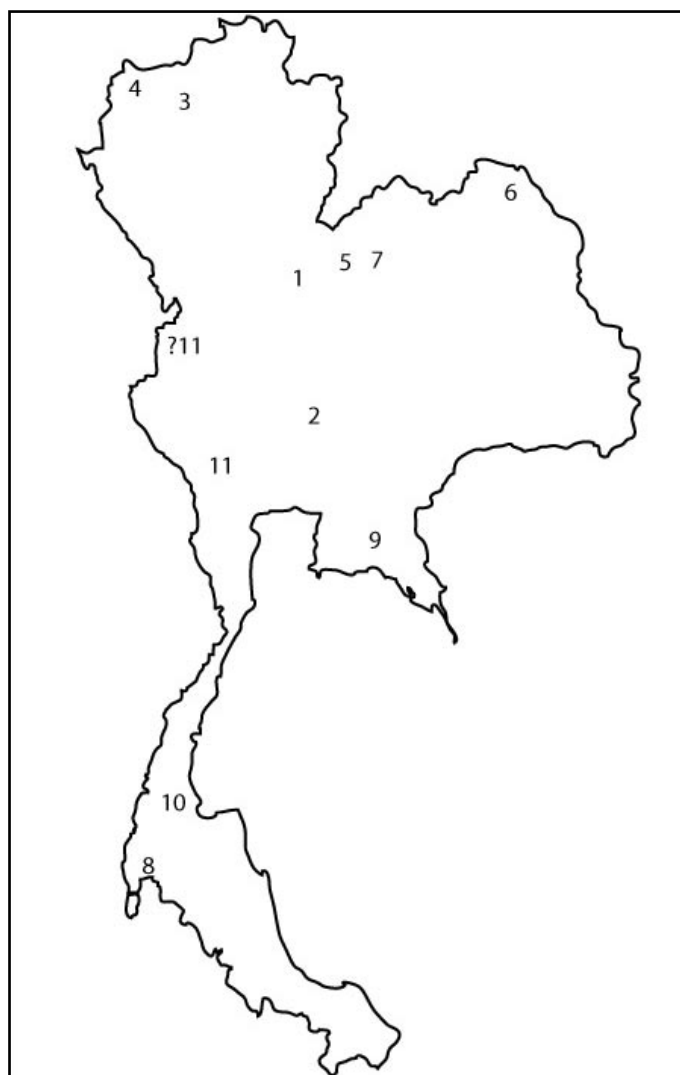
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Abstract: This paper gives a summary of the eleven species of *Cyrtodactylus* bent-toed geckos (Reptilia: Squamata: Gekkonidae) that have been reported from the caves and karst massifs of Thailand. Range extensions for *Cyrtodactylus auribalteatus*, *C. erythropros* and *C. papilionoides* are given. The majority of these geckos have a very restricted geographical distribution and many new species remain to be found and described. Cave explorers can play an important role in helping to populate the inventory of cave geckos.

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There are approximately one hundred and twenty species of *Cyrtodactylus* bent-toed geckos (Reptilia: Squamata: Gekkonidae), of which roughly half have been described during the last ten years. Most of these newly described species are from southeast Asia and many are associated with karst and caves (Bauer *et al.*, 2010). In 2002 thirteen species of *Cyrtodactylus* were recognized in Thailand (Bauer *et al.*, 2002) and since then a further six species have been described, mainly from limestone caves, bringing the number of species in Thailand to nineteen (Bauer *et al.*, 2010).

The six Thai species of *Cyrtodactylus* that have been recorded only from caves, or from near the entrances to caves, exhibit no obvious morphological specializations either to a karst substrate or to the cave environment, and seem to be troglonexes. These six species are *C. auribalteatus*, *C. chanhomeae*, *C. dumnuii*, *C. erythropros*, *C. sumonthai* and *C. thirakhupti*. On-going genetic studies will help to determine whether the limestone-living *Cyrtodactylus* constitute one or more monophyletic groups within the genus, and help to establish whether the amazing diversity of these geckos was generated over a long period or if it represents the results of a relatively recent radiation (Bauer *et al.*, 2009).

Of the eleven *Cyrtodactylus* species that have been found in Thai caves seven species have very limited known distributional ranges. Because of their limited ranges these species are at risk of extinction from various threats, including habitat loss (mainly related to quarrying), uncontrolled collecting by or for the pet trade, and being hunted, in particular by domestic cats (Sumontha *et al.*, 2010). Currently twelve of the nineteen species of *Cyrtodactylus* found in Thailand are listed as protected species under the Thai Wildlife Protection Act of 1992. This list does not include the seven species that have been described most recently (Sumontha *et al.*, 2010).

Although a definitive identification of these lizards requires a specimen in the hand and specialist knowledge, most of the species are very locally distributed and in some cases a tentative identification can be made based on where the animal was seen. Any geckos seen in caves beyond the ranges of the species listed below are possibly representing a new species.

Figure 1: Cave and karst localities for *Cyrtodactylus* species in Thailand: (1) *C. auribalteatus* (2) *C. chanhomeae* (3) *C. dumnuii* (4) *C. erythropros* (5) *C. interdigitalis* (6) *C. jarujini* (7) *C. papilionoides* (8) *C. pulchellus* (9) *C. sumonthai* (10) *C. thirakhupti* (11) *C. tigroides*.

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Taxonomy and distribution

For a detailed taxonomic treatment see the original description of each species. All geographical co-ordinates are on the WGS 84 datum. In the Thai localities names, the Thai word *tham* means cave, the Thai word *wat* means temple, and the northeastern Thai word *phu* means mountain.

Cyrtodactylus auribalteatus Sumontha, Panitvong and Deenin, 2010

Golden-belted bent-toed gecko

Description

Snout to vent length 90mm; total length 205mm.

C. auribalteatus is boldly marked with dark bands of purplish-brown and paler bands of a yellowish-cream with dark purplish-brown dots. The head is pale purplish-brown and the spots are a little darker with yellowish border, and the tail is distinctly brown and yellowish-cream segmented, fading to whitish towards the end of the tail. The eye is greenish brown (Sumontha *et al.*, 2010).

A sub-adult individual was seen by one of us (ME) in Tham Khun Takhan, Phitsanulok Province, on 22 February 2009. This gecko was in a transition phase between the juvenile pattern of yellow dorsal bands and the adult pattern where the bands contain dark brown dots and resemble golden chains.

Distribution and Natural History

Cave localities:

Phitsanulok Province

Tham Phra Wang Daeng (type locality) (Sumontha *et al.*, 2010)

Wat Tham Phra Wang Daeng, Thung Salaeng Luang National Park, Noen Maprang

N16.6787° E100.6875° Altitude 160m

Tham Khun Takhan (Ellis, personal observation, 2009)

Wat Khun Takhan, Thung Salaeng Luang National Park, Noen Maprang

N16.6654° E100.6540° Altitude 136m

Non-cave localities:

None known.

Tham Phra Wang Daeng was visited on three occasions (Sumontha *et al.*, 2010). On the first two occasions, at night, the geckos were observed in the large entrance passage, before the steps down to the streamway, with specimens being caught 15m and 25m from the entrance. Three and four animals were observed on each occasion, respectively, mostly clinging to the side of the cave near holes and crevices, into which they would retreat if approached. On the third occasion, during daytime, none were observed in the entrance section but two were observed in the dark inner section of the cave, 40m from the cave entrance (Sumontha *et al.*, 2010).

Tham Khun Takhan is a short relict cave consisting of a couple of high rift passages. It is 4km westsouthwest of the type locality and falls within the boundaries of the Thung Salaeng Luang National Park. The gecko was seen near the end of one of the rifts, approximately 50m into the cave and just out of sight of the entrance.

Thung Salaeng Luang National Park has an extensive area of karst just inside the park boundary near Noen Maprang and this species is likely to be found in many of the caves. However, the karst is under threat from development, in particular the proposed dam on the Khong Chompu that would raise the base water level in the region and thus would have an effect on the karst hydrology.



Cyrtodactylus auribalteatus Sumontha, Panitvong and Deenin, 2010 – sub-adult from Tham Khun Takhan, Phitsanulok province in situ (Martin Ellis, February 2009).

Cyrtodactylus chanhomeae Bauer, Sumontha and Pauwels, 2003

Chanhome's bent-toed gecko

Description

Snout to vent length 70mm; total length 144mm.

This is a boldly marked lizard with purplish brown dark bands and yellowish cream paler bands, which are a somewhat brighter yellow on the head and tail. The underside is pale brown. The eye is greenish brown (Bauer *et al.*, 2003).

Distribution and Natural History

Cave localities:

Saraburi Province

Tham Phraya Chattan (type locality) (Bauer *et al.*, 2003)

Ban Khun Khon, Phra Phutthabat

N14.7014° E100.8460°

Tham Thep Nimit (Bauer *et al.*, 2003)

Ban Khun Khon, Phra Phutthabat

N14.7014° E100.8460°

Tham Sri Wilai (Konlek and Lauhachinda, 2008)

Wat Tham Sri Wilai, Ban Na Phra Lan, Phu Kae

N14.7106° E100.8795° Altitude 44m

Wat Sap Chaom (Konlek and Lauhachinda, 2008)

N14.6965° E100.8471°

Wat Lublae (Konlek and Lauhachinda, 2008)

N14.6765° E100.8460°

Wat Pu Nan Bap Dtor (Konlek and Lauhachinda, 2008)

N14.7202° E100.8535°

Non-cave localities:

None known.



Cyrtodactylus dumnuui Bauer, Kunya, Sumontha, Niyomwan, Pauwels, Chanhome and Kunya, 2010, from Tham Phra Phutthabat Pang Daeng, Chiang Mai Province (O S G Pauwels).

C. chanhomeae has only been found in and around caves in the Phra Putthabat district, Saraburi Province in central Thailand. Despite extensive surveys in the Saraburi area by Kanokorn Konlek (Kasetsart University) the number of individuals of *C. chanhomeae* has been estimated to be less than one hundred and fifty mature animals, which would make this species one of the rarest lizards in the world. However, to date, *C. chanhomeae* has received no protection of any kind (Sumontha *et al.*, 2010).

Three male specimens of *C. chanhomeae* were found by day on the walls of limestone caves, 10 to 20m from the cave entrance in near total darkness, at heights of 0 to 3m above the ground (where the cave ceiling was 2 to 8m high) (Bauer *et al.*, 2003). At night one female was found inside a cave and a juvenile was found outside the cave entrance. Others were seen inside caves between 22:00 hrs and 00:30 hrs. Several specimens of *C. chanhomeae* have been kept alive in captivity for some time. During this time they readily accepted crickets and meal worms and bit if handled roughly. The species is able to jump quite long distances, but does not run quickly (Bauer *et al.*, 2003).

Extensive limestone quarrying in the Phra Phutthabat district threatens all the known localities, by either the direct physical destruction of the caves or the indirect effects of blasting and dust pollution. The caves that are located in the grounds of Buddhist temples have better protection, but may still be threatened by the development of the cave for worship or tourism.

Cyrtodactylus dumnuui Bauer, Kunya, Sumontha, Niyomwan, Pauwels, Chanhome and Kunya, 2010
Dumnuui's bent-toed gecko

Description

Snout to vent length 80mm; total length 180mm.

This gecko has alternating whitish to greyish-brown and chocolate brown transverse bands on the back. The chocolate bands have paler centres while the greyish-brown bands commonly have darker centres. There are six dark bands between the shoulder and hip and another on the base of the tail. The gecko has green eyes (Bauer *et al.*, 2010).



Cyrtodactylus erythroptus Bauer, Kunya, Sumontha, Niyomwan, Panitvong, Pauwels, Chanhome and Kunya, 2009 – Tham Pakarang, Mae Hong Son Province, in situ (Alice Latinne, February 2009).

Distribution and Natural History

Cave localities:

Chiang Mai Province

Tham Phra Phutthabat Pang Daeng (type locality) (Bauer *et al.*, 2010)

Ban Thakilek, Mae-Na, Chiang Dao District
N19.3463° E099.0255° Altitude 486m

Non-cave localities:

None known.

This recently described species has only been recorded from the type locality, which is in a small, isolated limestone hill about 10km to the east of the large Doi Chiang Dao limestone massif. The type specimens were found inside the entrance and up to 30m into the cave during daylight hours (Bauer *et al.*, 2010). The cave is called Tham Pha Bart Maejon in the reference.

Although Tham Phra Phutthabat Pang Daeng lies just outside the boundary of the Sri Lanna National Park it is in the grounds of a Buddhist temple, which offers some protection against quarrying and hunting threats.

An unvouchered record of *C. variegatus* (Blyth, 1859) from Doi Chiang Dao by Nabhitabhata and Chan-ard (2005) is possibly actually attributable to *C. dumnuui*.

Cyrtodactylus erythroptus Bauer, Kunya, Sumontha, Niyomwan, Panitvong, Pauwels, Chanhome and Kunya, 2009

Red-eyed bent-toed gecko

Description

Snout to vent length 80mm.

This gecko has a more spotted, instead of banded, appearance. The dark markings of the back of the head and body are edged by very pale yellowish borders. A juvenile specimen had a pinkish-grey back with purplish brown markings. Blotches on the back in this specimen had a greater degree of fusion and irregularity than in the adult holotype and the tail exhibited bold alternating banding of very dark brown and opalescent white. The eyes are red, which gives this species its scientific name (Bauer *et al.*, 2009).

Distribution and Natural History

Cave localities:

Mae Hong Son Province

Tham Lod (type locality) (Bauer *et al.*, 2009)

Ban Tham, Lum Nam Pai Wildlife Sanctuary, Pang Mapha
N19.5650° E099.2789° Altitude 640m

Tham Pakarang (Latinne, 2009)

Ban Mae Lana, Lum Nam Pai Wildlife Sanctuary, Pang Mapha
N19.5746° E099.2173° Altitude 690m

Non-cave localities:

None known (but see remarks on *C. variegatus* below).

C. erythroptus has only been recorded from two caves in Pang Mapha district, though it is likely to be more widely distributed in this extensive karst area.

According to Bauer *et al.*, (2009) this gecko feeds by both day and night. Breeding takes place in the winter season, at which time



Cyrtodactylus erythroptus Bauer, Kunya, Sumontha, Niyomwan, Panitvong, Pauwels, Chanhome and Kunya, 2009 – Tham Pakarang, Mae Hong Son Province, in situ (Alice Latinne, February 2009).

males emit advertisement vocalizations to females. The eggs, which are non-adhesive, are oviposited in rock crevices within caves and the incubation period is approximately two months.

The adult male holotype and two juveniles were collected just outside the upstream entrance to Tham Lod (Bauer *et al.*, 2009). While conducting research on the cave rat *Leopoldamys nielli*, Alice Latinne photographed *C. erythroptus* in Tham Pakarang in February 2009 (Latinne, 2009). This large relict cave is about 6.5km northeast of Tham Lod.

Although the two caves are within the Lum Nam Pai Wildlife Sanctuary protected area both sites are tourist attractions, in particular Tham Lod, which sees thousands of visitors every year. The caves are also threatened by forest clearance for farming by local villagers.

The unvouchered record of the rare gecko *C. variegatus* (Blyth, 1859) from Pang Mapha by Nabhitabhata and Chan-ard (2005) is possibly actually attributable to *C. erythroptus*. For a long time *C. variegatus* was only known from two specimens collected from southeastern Myanmar, but it has since been mentioned from northern and western Thailand by Cox *et al.* (1998; all Thai records unvouchered) who state that *C. variegatus* inhabits large caves on mountain slopes, hiding inside during the day and emerging at night to forage around the cave entrance. Besides the records from Chiang Mai and Mae Hong Son Province cited above, Nabhitabhata and Chan-ard (2005) mentioned *C. variegatus* from Kanchanaburi Province (Thong Phaphum), Tak Province (Umphang) and Uthai Thani Province (Huai Kha Kaeng Wildlife Sanctuary). The source of the Thai records of *C. variegatus* in Nabhitabhata and Chan-ard (2005) are unpublished personal observations by Jarujin Nabhitabhata. The actual identity of all these Thai populations should be studied properly; they might represent several species, possibly none of them corresponding to actual *C. variegatus*.

Cyrtodactylus interdigitalis Ulber, 1993

Phetchabun bent-toed gecko; Skin-toe forest gecko

Description

Snout to vent length 80mm.

The ground colour of the back is fawn. Across the back between the neck and tail are six bands, which are rimmed with a slightly darker dark brown that contrasts with the background colour. The tail is banded with some dark brown spots. The underside, with the exception of the tail, is tawny (Ulber, 1993).

Distribution and Natural History

Cave localities:

Phetchabun Province

Tham Yai Nam Nao (type locality) (Ulber, 1993)
Ban Non Chat, Nam Nao National Park
N16.9444° E101.5066° Altitude 700m

Non-cave localities:

Loei Province

Phu Luang National Park (unvouchered record by Nabhitabhata and Chan-ard, 2005; these authors only mentioned that this species lives in evergreen forests, usually on tree trunks, so it can probably be deduced that this Phu Luang observation was not made in or near a cave). Chan-ard *et al.* (1999) illustrated an individual found under the bark of a tree on Phu Luang.

Although not recorded from inside caves *C. interdigitalis* was found near the entrance to a large cave system at the edge of an extensive karst area (Ulber, 1993) and is thus likely to also be found underground.

Jarujin Nabhitabhata, who caught the type series recorded that “*In the daytime this species hides in tree burrows covered with strangling roots of a fig (Ficus) tree. The tree stands in a small clearing in front of a large limestone cave and on the bank of a small stream flowing out of the cave. At night they were seen crawling on the rocks and the tree trunk in the vicinity of their daytime roosts*” (Ulber, 1993). The unvouchered records by Nabhitabhata and Chan-ard (2005) from Phetchaburi Province (Kaeng Krachan National Park), Tak Province (Umphang) and Uthai Thani Province (Huai Kha Khaeng Wildlife Sanctuary and Khao Pla Ra) are most probably based on misidentified *C. brevipalmatus* (see distribution in Thailand as given by Grismer, 2008). *C. interdigitalis* has also been recorded from central Laos (Stuart, 1999) but the exact identity of that Lao population has to be re-evaluated.

The type locality is within the Nam Nao National Park and is a popular tourist attraction, with the clearing near the resurgence cave having many visitors at holiday times. The Phu Luang National Park is a sandstone mountain that has a limited number of visitors and is a less disturbed habitat.



Cyrtodactylus jarujini Ulber, 1993 – Phu Thok, Bueng Kan Province (O S G Pauwels)

Cyrtodactylus jarujini Ulber, 1993

Jarujin's bent-toed gecko

Description

Snout to vent length 90mm; total length 195mm.

The dorsal pattern shows large irregular and asymmetrical dark brown blotches contrasting with the light brown background. The tail is banded with alternate dark brown and light brown. The belly is uniformly whitish (Ulber, 1993). The iris is golden.

Distribution and Natural History

Cave localities:

Bueng Kan Province

Phu Sing (Sumontha *et al.*, 2008)

Sri Wilai District
N18.17° E103.84°

Phu Thok (Sumontha *et al.*, 2008)

Wat Pha Phu Thok, Ban Na Kham Khaen, Sri Wilai District
N18.13° E103.88°

Non-cave localities:

Bueng Kan Province

Phu Wua Wildlife Sanctuary (type locality) (Ulber, 1993)

Nong Dern, Bung Khla District
N18.26° E103.92° Altitude 380m

Jarujin Nabhitabhata, who caught the type series, recorded that, “*at night they were seen crawling on sandstone boulders on the hill top, especially on the steep sides of the rocks; being disturbed by the torch light, they hid under overhanging tangles of vegetation on the top of the rock sides*” (Ulber, 1993). More recently Sumontha *et al.* (2008) found it in two caves on two sandstone hills, Phu Sing and Phu Thok, where it was staying by day on the walls and crevices, going out of the caves at night. Both in Phu Sing and Phu Thok it was found in syntopy with the cave-dwelling agamid *Mantheyus phuwuanensis*. *C. jarujini* has also been recorded from central and northern Laos (Stuart, 1999) but the exact identity of the Lao populations has to be re-evaluated.



Cyrtodactylus jarujini Ulber, 1993 – Phu Sing, Bueng Kan Province (O S G Pauwels).



Cyrtodactylus papilionoides Ulber and Grossmann, 1991 – Tham Yai Wat Pha Sawan, Loei Province, in situ (Steve Smith, December 2009).

Cyrtodactylus papilionoides Ulber and Grossmann, 1991
Butterfly bent-toed gecko

Description

Snout to vent length to 93mm; total length to 178mm.

The upper surface of head is brown with small irregular dark brown spots. The dorsal pattern shows well-defined, transversal, asymmetric dark brown butterfly-shaped marks on a brown background. Small irregular dark brown spots are found within these butterfly-shaped marks. The venter is cream. The iris is golden brown (Ulber and Grossmann, 1991).

Distribution

Cave localities:

Loei Province

Tham Yai Wat Pha Sawan (Ellis, personal observation, 2009)
Wat Pha Sawan, Ban Pha Sawan, Pha Khao
N17.1183° E101.9337° Altitude 420m

Non-cave localities:

Besides the newly-recorded cave locality cited above, the species was previously reported only from non-cave sites, from Chaiyaphum Province (Phu Kieo, Thep Satit, by Nabhitabhata and Chan-ard, 2005; unvouchered), Nakhon Ratchasima Province (Thanon Khao Yai, Pak Chong District, the type locality of the species, by Ulber and Grossmann, 1991) and Roi Et Province (Phu Pa nam tip, by Nabhitabhata and Chan-ard, 2005; unvouchered).



Cyrtodactylus papilionoides Ulber and Grossmann, 1991 – Tham Yai Wat Pha Sawan, Loei Province, in situ (Steve Smith, December 2009)

An adult example of *C. papilionoides* was seen and photographed by one of us (ME) in Tham Yai Wat Pha Sawan, a large, relict limestone cave, at 13:00 hrs on 3 December 2009. The lizard was in a small side passage approximately 70m from the cave entrance, but only 15m from visible daylight.

Cyrtodactylus pulchellus Gray, 1827

Banded slender-toed gecko; Southern banded gecko

Description

Snout to vent length to 115mm; total length to 260mm.

C. pulchellus is a large, spectacularly marked gecko with dark chocolate brown bands ringed with white on a tan background. There is one band on the neck, four bands on the body and another band at the base of the tail (Cox *et al.*, 1998).

Distribution and Natural History

Cave localities:

Phang Nga Province

Tham Phung Chang (Pauwels *et al.*, 2000)

Phang Nga town, Muang District

N08.4429° E098.5126° Altitude 15m

Tham Russi (Pauwels *et al.*, 2000)

Phang Nga town, Muang District

N08.4271° E098.5140° Altitude 5m

In both Thai caves in Phang Nga Province where the species was reported by Pauwels *et al.* (2000), it was common, and eggs were found deep inside the caves. Both of the caves where *C. pulchellus* has been recorded have been developed into show caves and are open to the general public.

Non-cave localities:

Many other localities are known in Thailand, in non-karst sites (see, for example, Chan-ard *et al.*, 1999; Nabhitabhata and Chan-ard, 2005). This species is indeed widely distributed and is not confined to caves or karst environments. It is found in moist evergreen rainforest at altitudes of up to 2,000m in Myanmar, Peninsular Thailand, Malaysia and Singapore (Cox *et al.*, 1998; Das, 2010).

Cyrtodactylus sumonthai Bauer, Pauwels and Chanhome 2002

Sumontha's bent-toed gecko

Description

Snout to vent length 71mm; total length 163mm.

C. sumonthai has a base colour of a pale yellowish white. This is banded with pale brown markings, each of which is outlined by a darker brown border that is more prominent towards the front than the back. There is one dark band across the shoulders, two across the trunk and one across the hips. This pattern on the back fades on the gecko's flanks. The alternating pale and dark pattern of the back continues on to tail, becoming more diffuse towards the end. The eye is golden brown (Bauer *et al.*, 2002).



Cyrtodactylus sumonthai Bauer, Pauwels and Chanhome, 2002 – Khao Wong, Chanthaburi Province (Nonn Panitvong).

Distribution and Natural History

Cave localities:

Chanthaburi Province

Tham Khang Khao (type locality) (Bauer *et al.*, 2002)

Tham Tao (Bauer *et al.*, 2002)

Tham Sing Toh Noi (Bauer *et al.*, 2002)

Tham Sam Mit (Bauer *et al.*, 2002)

Tham Rong Bon (Thooliwan, 2001)

Khao Chamao - Khao Wong National Park, Kaeng Hang Mao
N12.8861° E101.8182°

Non-cave localities:

None known.

Prior to its scientific description, this gecko species was illustrated in a popular article (Thooliwan, 2001), making it known to the biologist Montri Sumontha who then went on site to examine the population and conclude that it was a new species, eventually dedicated to him. *C. sumonthai* is known only from a single mountain, Khao Wong, in Chanthaburi Province, southeastern Thailand, which is riddled with limestone caves. It climbs high on the walls of the caves and is relatively slow moving (Bauer *et al.*, 2002).

Khao Wong is an isolated limestone hill protected by the Khao Chamao – Khao Wong National Park. In the original paper the geographical coordinates for the type locality are given as 16°42'N 104°06'E (Bauer *et al.*, 2002). This error is corrected in Bauer *et al.* (2009).

Cyrtodactylus thirakhupti Pauwels, Bauer, Sumontha and Chanhome, 2004

Thirakhupt's bent-toed gecko

Description

Snout to vent length 80mm; total length 179mm.

The patterning is bright and strongly contrasting. The ground colour of the back is dark brown, with transverse pale yellow bands, each of which is outlined by a very dark brown border. The first band is across the back of the head, forming a collar that joins at the eyes. The second band is on the neck, then four bands on the body and a final band on the base of the tail. These bands are somewhat asymmetrical and broken in places. The colouration on the back gradually fades on lower flanks, becoming whitish on belly, throat and undersides of limbs. The tail has alternating dark brown and pale yellow (base only) or bright white (majority of tail) rings. The eye is dark with diffuse bronze markings and the margins of pupil are bordered by brown (Pauwels *et al.*, 2004).

Distribution and Natural History

Cave localities:

Surat Thani Province

Tham Khao Sonk (type locality) (Pauwels *et al.*, 2004)

Khao Sonk, Tha Chana

N09.5666° E099.1667° Altitude 35m

Non-cave localities:

None known.

C. thirakhupti is currently known only from its type locality, a single cave on a relatively isolated, forested, steep limestone hill (Pauwels *et al.*, 2004). The cave chamber, where the type series was caught, is about 30m wide and 20m high. An adult female was found at 20:15 hrs on the cave wall, 1m above the ground. Another specimen was caught at about 12m from the cave entrance, 1.7m above the ground, while a third specimen was caught at 21:00 hrs, 10m from the cave opening, 1.5m above the ground. On 27 June 2003 only those three specimens and a fourth one (not caught) were seen. The type specimens of *C. thirakhupti* were briefly kept in captivity, but did not thrive (Pauwels *et al.*, 2004).

Cyrtodactylus tigroides Bauer, Sumontha and Pauwels, 2003

Sai Yok bent-toed gecko

Description

Snout to vent length 85mm (male) 75mm (female); total length 200mm (male) 180mm (female).

This is a very boldly marked gecko, hence its scientific name of 'resembling tiger'. The base colour is mid brown with yellowish-cream bands that have well-defined dark brown borders. The top of the head is yellowish-cream with well-defined symmetrical mid brown markings with darker brown borders (Bauer *et al.*, 2003).

Distribution and Natural History

Cave localities:

Tak Province

Umphang (unvouchered record by Nabhitabhata and Chan-ard, 2005; see remark below)

Non-cave localities:

Kanchanaburi Province

Ban Tha Sao, Sai Yok (type locality) (Bauer *et al.*, 2003)
N14.2294° E099.0673°

The type specimens of this species were found after dark (20:00 hrs) along a dry stream at the foot of a limestone hill covered by bamboo forest. Individuals were walking on, or hiding in, exposed limestone, 1 to 1.5m above the ground (Bauer *et al.*, 2003).

Bauer *et al.* (2009) stated that this species is only associated with limestone and has not yet been found inside a cave. However Nabhitabhata and Chan-ard (2005) reported that this species has also been recorded from the Umphang District, Tak Province, 200km north of the type locality, and that it is found in evergreen forest and nearby limestone caves. The identity of the Umphang population identified by Nabhitabhata and Chan-ard (2005) as *C. tigroides* should be verified; it seems zoogeographically possible, but without a morphological study no conclusions can be drawn.

In the original description (Bauer *et al.*, 2003) the geographical co-ordinates for the type locality are given as N14.1000° E99.4167°, which would place it near Ban Lat Ya in Muang Kanchanaburi district, 40km southeast of Ban Tha Sao, Sai Yok district.

Discussion

The *Cyrtodactylus* geckos are an inadequately investigated and surveyed group. As they are nocturnal and mostly live in undisturbed habitats they are difficult to study and are thus poorly documented (Sumontha *et al.*, 2010). More research is required to come to a true understanding of the ecology, taxonomy and distribution of these animals. Work on this group is currently being carried out by a small group of Thai students and biologists (e.g. Konlek and Lauhachinda, 2008) as well as foreign herpetologists. A deliberate effort has been made to focus fieldwork on cave surveys (Bauer *et al.*, 2003; Pauwels *et al.*, 2004) and this has been reflected by the discovery of several cave dwelling species. During the day it is easier to find these nocturnal animals in a large cave passage than by searching on the surface under boulders, holes, vegetation, etc. Thus the currently known geographical distribution may reflect recording effort instead of the true distribution. Based on the limited amount of data available it is possible to make some general observations.

The cave dwelling *Cyrtodactylus* geckos do not display any morphological adaptations for life in the cave environment so may be considered more as substrate specialists rather than true cave specialist species (Bauer *et al.*, 2002). Being nocturnal with the ability to climb rock walls geckos are pre-adapted to make use of caves as a refuge. Of the eleven species of *Cyrtodactylus* that have been recorded from caves or karst habitats in Thailand four species (*C. interdigitalis*, *C. jarujini*, *C. papilionoides* and *C. pulchellus*) have also been recorded in non-karst environments and thus cannot be considered karst specialists (Ulber, 1993; Ulber and Grossmann, 1991; Cox *et al.*, 1998). The only confirmed record for *C. tigroides* is on the surface in a karst area (Bauer *et al.*, 2003).

Of the species recorded from caves there is evidence that they commute from inside the cave to feed outside at night and, apart from the widely distributed *C. pulchellus*, no specimens have been seen more than a few metres deeper into a cave than the end of the threshold zone (the region of the cave to which daylight can penetrate). Sumontha *et al.* (2008) state that *C. jarujini* leaves the sandstone caves to feed outside of the caves at night. Two other species (*C. chanhomeae* and *C. erythrops*) have been captured outside the entrance to a cave, with the *C. chanhomeae* specimen being taken in the evening (19:20 hrs) (Bauer *et al.*, 2003; Bauer *et al.*, 2009). There is evidence that *C. auribalteatus*, *C. dumnuui* and *C. thirakhupti* move from within the cave to outside, or at least to the cave threshold area, at night. On two visits in the evening to Tham Phra Wang Daeng *C. auribalteatus* was seen 15m and 25m from the large entrance (19:30 hrs). However, on a day time visit four days later specimens were only found 40m into the cave in the dark zone (10:30 hrs) (Sumontha *et al.*, 2010). In Tham Khun Takhan the single *C. auribalteatus* was found at midday approximately 5m from visible daylight. *C. dumnuui* has been seen just inside the cave entrance (Bauer *et al.*, 2009) and *C. thirakhupti* has been captured within 10m of the entrance (Pauwels *et al.*, 2004). *C. papilionoides* was observed at 13:00 hrs 70m from the cave entrance, but only 10m from visible

daylight (Ellis, pers. obs.). There is no information on how far into in to the caves *C. sumonthai* was found, but the type series was collected between 12:00 hrs and 17:00 hrs (Bauer *et al.*, 2002).

C. papilionoides and *C. pulchellus* are widely distributed in Thailand, which suggests they may be found in a range of habitats and the populations are not geographically isolated (Nabhitabhata and Chan-ard, 2005). *C. interdigtalis* has been reported from two localities, one a non-karst mountain, which are 20km apart. This species is probably forest dwelling rather than cave dwelling as the type specimen was found in burrows on a tree and under bark at the second location (Ulber, 1993) (Nabhitabhata and Chan-ard, 2005). The forest cover between the two localities has been lost within the last 50 years. *C. jarujini* has been recorded from sandstone substrates from three localities on two low mountain ranges in northeast Thailand (Ulber 1993; Sumontha *et al.*, 2008).

There are seven species of *Cyrtodactylus* that have only been recorded from karst areas. In many regions of Thailand the karst has been heavily eroded resulting in isolated limestone hills and outcrops that are surrounded by alluvial plains that are not suitable habitat for *Cyrtodactylus* geckos. This has resulted in isolated populations, which appears to have promoted speciation (Bauer *et al.*, 2009). *C. tigroides* has a single confirmed karst locality and a second, unvouchered, record from another karst area 200km to the north (Bauer *et al.*, 2003) (Nabhitabhata and Chan-ard, 2005). There is nearly continuous karst between these two locations. Two species have been found at two different caves a few kilometres apart: *C. auribalteatus* has been recorded at two caves that are separated by 4km of continuous karst. This species is probably widely distributed within the karst of the Thung Salaeng Luang National Park (Sumontha *et al.*, 2010). *C. erythropros* has also been recorded at two different cave locations that are 6.5km apart, again with continuous karst between the localities (Bauer *et al.*, 2009; Latinne, 2009). There are four species that have only been recorded from localities on isolated limestone hills: *C. chanhomeae* has been found at six sites on the same limestone hill, but there are other karst hills nearby (Bauer *et al.*, 2003; Konlek and Lauhachinda, 2008); *C. dumnuui* has only been found at one cave located in an isolated limestone outcrop that is 10km from the nearest major karst area (Bauer *et al.*, 2010); *C. sumonthai* has been seen in five caves that are in the same large, but isolated, limestone mountain (Bauer *et al.*, 2002; Thooliwan, 2001); *C. thirakhupti* has only been recorded from a single cave in a small, isolated, limestone hill (Pauwels, *et al.*, 2004).

The majority of the caves where *Cyrtodactylus* have been found are dry, relict, remnant caves that do not have active streams. This may be due to survey work being limited to these types of caves, not a true ecological preference. Although *C. auribalteatus* occurs in Tham Phra Wang Daeng, Thailand's longest known cave with a long (10km) stream passage, the geckos were found within 40m of a dry entrance (Sumontha *et al.*, 2010). Tham Lod, the type locality for *C. erythropros*, is a 1.5km-long stream through cave, but again the geckos were found close to the upstream entrance (Bauer *et al.*, 2010). *C. pulchellus* has been recorded from deep inside a 1km-long stream cave, Tham Phung Chang, which passes through a limestone hill (Pauwels *et al.*, 2000). All of the caves have populations of bats and an invertebrate fauna (crickets, millipedes, spiders, etc.), but none of the caves have exceptionally large bat colonies or extensive guano deposits.

In the literature it is suggested that some of the cave dwelling *Cyrtodactylus* species may be capable of completing their life cycle within the cave environment with the adults able to feed on cave crickets, insect larvae, etc. and thus could be considered to be troglophiles (Bauer *et al.*, 2002; Bauer *et al.*, 2009; Bauer *et al.*, 2010). However, there are no published observations of geckos feeding within the caves so these animals should be described as troglonexes, using the caves for shelter and breeding, but feeding outside of the cave. Some of *Cyrtodactylus* species can breed inside caves with eggs of *C. erythropros* and *C. pulchellus* (Bauer *et al.*, 2010; Pauwels *et al.*, 2000) and juveniles of *C. auribalteatus* and *C. erythropros* (Ellis, pers. obs.; Bauer *et al.*, 2009) having been recorded from caves.

Genetic studies into the relationships between the *Cyrtodactylus* geckos are on-going (Bauer *et al.*, 2009), but unpublished work on nuclear and mitochondrial DNA suggest that the Thai cave geckos are closely related to each other and that they are part of a larger group of *Cyrtodactylus* that have affinities to Malaysian and Indonesian geckos rather than those in Myanmar. However, the taxa found near the Myanmar border, such as *C. erythropros* and *C. dumnuui*, will require careful study as it is expected that species of both the Indochinese and Myanmar *Cyrtodactylus* groups could occur in this region (Bauer *et al.*, 2010).

Many additional forms of *Cyrtodactylus* still awaiting description are known from throughout Thailand, several of them from limestone caves or karst areas (Bauer *et al.*, 2009).

Conclusions

Professional and amateur cave explorers can play a crucial role in the inventory of cave geckos by communicating their photographs and ecological and other observations of cave geckos to herpetologists. General laterodorsal views of the body, close lateral views of the head and close ventral views showing both lower legs and the lower belly will commonly allow herpetologists to identify the species if it is already known, or to conclude it might be a new one and then organize dedicated study trips to examine further the morphology of the population. While being photographed, geckos should be handled gently to avoid stress and caudal autotomy. Given the limited distribution of many cave geckos and the various threats caves have to face, such as, for example, quarrying and excessive touristic exploitation, it has become urgent to accumulate data on distribution, ecological requirements and conservation status for all species. The authors would be very grateful to receive any photographs or reports of geckos from the caves of southeast Asia.

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