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Front cover illustration. St Paul's Island wall lizard (*Podarcis filfolensis kieselbachi*). © A. Sciberras. See article on page 28.

Amphibians and reptiles of the Suez Canal University campuses, Egypt

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ABSTRACT – A herpetological survey was carried out on campuses of the Suez Canal University (SCU) located in the Suez Canal zone (Port Said, Ismailia and Suez) and North Sinai (Al-Arish). Research Center in St. Catherine and the university rest house at Sharm Ash-Sheikh, both in southern Sinai were also checked. A total of 21 herpetofaunal species was recorded during the period 1999–2007, including two amphibians and nineteen reptiles (14 lizards and 5 snakes). The largest number of species was recorded on the campus of Al-Arish, comprising one toad and 12 reptile species. This was followed by the number of herpetofauna inhabiting the Ismailia campus. Distribution of amphibians and reptiles on campuses of the Suez Canal University according to habitat was analyzed. The impact of the change in campus structure on the herpetofaunal community is also discussed.

THE Suez Canal University was founded in 1976, when the region of Suez Canal and Sinai were seeking to meet the needs of the community and the aspirations of their citizens for education and development. Suez Canal University was inaugurated with five faculties, but has grown to encompass twenty-four faculties distributed in four governorates, Bur Saïd (Port Said), Al-Isma'ileyya (Ismailia), As-Suways (Suez) and North Sinai. In addition, the university has specialized research centers in the cities of Sharm Ash-Sheikh and St. Catherine in South Sinai. In 2006–2007 academic year, the university enrolled 47784 undergraduate students.

Herpetological studies at Suez Canal University started two decades ago when the Al-Arish campus was surveyed. Lizards were frequently observed on buildings, fences and on the ground, snakes were captured from cultivated fields, and at night, frogs and geckos were heard calling. Ghobashi et al. (1990) reported one species of amphibian, eight species of lizards and one snake from the Al-Arish campus out of 21 species reported from the Al-Arish area. At that time, the campus consisted of a few buildings and a small garden, in an area of sparse desert vegetation and a few trees. Later, ecological studies were carried out on the commonest lizards on the Al-Arish (Ibrahim, 2002 & 2007) and Ismailia (Ibrahim, 2004) campuses, respectively. However, the total number of herpetofaunal species inhabiting university campuses and their distribution remain little known.

The objectives of this study are: (1) to compile a checklist of amphibians and reptiles inhabiting Suez Canal University and Research Centers as a guide for students and researchers, and (2) to study the impact of the short-term changes on the structure of our university campuses on the herpetofaunal community.

MATERIALS AND METHODS

Study site. Observations were made on the Suez Canal University campuses sporadically from 1999–2007, and on the Al-Arish campus from 1987–2007.

1- Al-Arish Campus (31° 08' 04" N, 33° 49' 41" E) occupies a total area of 0.36 km² and is surrounded by walls. There are 32 buildings of different ages and sizes and one building under construction on campus. Natural vegetation is very mainly composed of Artemisia sparse, monosperma. There are also fruit and olive fields, ornamentals and green houses for edible vegetables, and large trees such as Eucalyptus globosus, Casuarina equisetiforme, Salix tetrasperma and Ficus retusa. The campus is approximately 57% green area, 34.7 % desert and 8.3% buildings.

2- *Port Said Campus*. The campus includes five faculties distributed in Port Said City (31° 15' 55")

N, 32° 17' 85" E) and Port Fouad City east of the Suez Canal (31° 14' 73" N, 32° 18' 90"). The latter is the largest, occupying about 0.12 km² with seven buildings, a dormitory and two other buildings under construction. The green area is about 20% of the total area of campus. This campus was visited only during summer.

3- *Ismailia Old Campus* (30° 36' 19" N, 32° 18' 22" E). The campus occupies 0.5 km² with 24 buildings (2–15 m high). The whole complex is surrounded by a brick wall. Buildings and fences take up approximately 51% of the total campus area. Vegetation on campus is well-formed and covers about 15% of the campus area. The cultivated plants on the Old Campus include mostly ornamental trees, herbs and native plants.

4- Ismailia New Campus (30° 38' 32" N, 32° 16' 17" E) was constructed on an area of about 1 km² in the Ismailia desert and includes 10 faculties, in addition to administration buildings and dormitories. These collectively have more than 60 buildings and annexes of 2–10 m height, in addition to six buildings under construction. These buildings occupy about 23% of the total area of campus; the green occupies at least 30% of the campus and has ornamentals, green houses, orchards in addition to a herbarium.

5- *Suez Old Campus* (29° 58' 33" N, 32° 31' 67" E) is a small campus, occupying about 0.05 km² and consisting of two faculties. A few trees are found on campus. This site was surveyed throughout the year.

6- *Suez New Campus* (29° 59' 73" N, 32° 29' 98" E) was established on an area of about 0.35 km² on the Suez-Cairo desert highway in 2002. It consists of three faculty buildings, two dormitory buildings with two other buildings under construction. Buildings collectively occupy about 20% of the total area of campus. The green area is very small (less than 5%); most of the campus is firm reddish sand desert. The campus was visited throughout the year.

7- *St. Catherine Research Center* (28° 33' 11" N, 33° 56' 51" E) is situated at the mouth of Wadi Al-Arba'ien near St. Catherine monastery and occupies about 243 m² in an extremely arid zone, with a few planted trees. This campus was visited in March, May and July.

8- *Sharm Ash-Sheikh Rest-house* (27° 51' 48" N, 34° 18' 04" E): was visited once during April.

Sampling methods. Lizards were captured by hand and with rubber bands by day and night. Snakes were captured by hand while surveying and by grounds workers and some were collected by students. Verbal reports are not included in this report.

RESULTS

A total of 21 herpetofaunal species were sampled on the university campuses, including two toads, 14 lizards and five snakes (Table 1). Pictures of living amphibians and reptiles are provided in figures 1–15. The Al-Arish campus had the highest number of reptiles (13 species) followed by the Ismailia New Campus. The following is a checklist of amphibians and reptiles inhabiting the university campuses with ecological notes when available.

CLASS: AMPHIBIA

Order: Anura

Family: Bufonidae

(1) *Bufo regularis* (Reuss, 1834); Egyptian toad. Figure 1. This toad is most common on the Ismailia Old Campus and Port Said Campus. As a result of greening the new campus at Ismailia, populations of this toad have been observed in different places, around buildings and heard calling in cultivated areas.

(2) *Bufo viridis viridis* (Laurenti, 1768); Green toad. Figure 2. This is a common species in North Sinai. A fairly small population was found around an old well on Al-Arish campus. The numbers of this toad seem to have been decreasing due to the increase in campus constructions.

CLASS: REPTILIA Order: Squamata Suborder: Sauria Family: Agamidae

(3) *Laudakia stellio* (Linnaeus, 1758); Starred agama. Figure 3. On the Al-Arish campus, the subspecies is assigned to *vulgaris*. It is diurnal, heliophilous and active almost the entire year. In summer and early autumn, these lizards exhibited a bimodal activity pattern, extending their activity as the day lengthened. Activity peaked in May and decreased in August. Daily and seasonal activity

Species	Ismailia Ol	d Ismailia Nev	v Suez Old	Suez New	Port Said	Al-Arish	St. Catherine	Sharm Ash-
	Campus	Campus	Campus	Campus	Campus	Campus	Research	Sheikh
							Center	Resthouse
Buto regularis	*	*			*			
Bufo viridis viridis						*		
Acanthodactylus boskianus						*		
Acanthodactvlus scutellatus						*		
Mesalina olivieri						*		
Cyrtopodion scabrum				*				
Hemidactylus flaviviridis			*	*		*		
Hemidactylus turcicus	*	*		*	*	*		
Ptyodactylus guttatus							*	
Ptyodactylus hasselquistii								*
Tarentola a. annularis	*	*						
Stenodactylus sthenodactylus						*		
Laudakia stellio						*	*	
Chalcides ocellatus	*	*	*		*	*		
Mabuya quinquetaeniata	*	*						
Chamaeleo chamaeleon	*	*				*		
Coluber rhodorhachis							*	
Platyceps rogersi				*				
Psammophis schokari	*					*		
Psammophis sibilans						*		
Spalerosophis diadema	*	*				*		
Total	8	7	2	4	3	13	3	1

decreased in August. Daily and seasonal activity patterns of males did not differ from those of females. The percentage of lizards that perched in direct sunlight or in shade differed seasonally and fluctuated with air temperatures. These lizards used all available microhabitats on campus, but were found most frequently on fences and on the ground. Adults occupied higher perches than juveniles and subadults. Lizards were found in areas of both sparse and dense plant cover, but showed no preference for any particular plant.

A single individual was seen on the stony fence surrounding the Research Center at St. Catherine area during May 2001. The right and left transverse rows on dorsum have large scales with small scales in between.

Family: Gekkonidae

(4) *Cyrtopodion scabrum* (Heyden, 1827); Keeled-skinned gecko. This gecko is very common on building walls and on the ground on the Suez New Campus, in sympatry with *Hemidactylus turcicus* and *H. flaviviridis*. It seems to be most active in summer. Many gravid females with two eggs shimmering through the skin were observed during June. On 25 June 2007, a nest of eight eggs (one smashed) was found under debris **Table 1.** Amphibians and reptiles recorded in the SuezCanal University campuses.

near the Faculty of Education building. In captivity, two eggs hatched on 8 July and one on 22 July, the hatchlings were more brightly colored than adults and measured 19 and 20 mm SVL. After 3 days, one of these geckos developed ecdysis.

(5) Hemidactylus flaviviridis flaviviridis (Rüppell, 1835); Indian leaf-toed gecko. This gecko is common on the Suez campuses. One lizard was observed running on the ground during the day on 11 February 2000 on the Suez Old Campus. On the Al-Arish campus, only a single young specimen was recorded during 2000. Another individual was observed at the university rest house at Al-Arish near campus during 2002. In the Ismailia Governorate, these lizards were active from March through November with activity peak in summer. Individuals were generally more active during the period from sunset to midnight than from midnight to sunrise. Diurnal activity of this species was evident in most seasons. H. flaviviridis is a sit-andwait forager, with Lepidoptera and Diptera as the most important food items. The breeding season

extends from early March to the end of May. The smallest adult male measured 60 mm SVL. Testicular size and mass considerably declined during summer. Gravid females appeared in spring and early June. Juveniles appeared at the end of June and were abundant through July.

(6) Hemidactylus turcicus turcicus (Linnaeus, 1758); Turkish gecko. On the Al-Arish campus, these lizards were often encountered on fences and buildings from March to November and on warm nights in winter. Activity generally started after complete darkness and displayed a unimodal activity pattern. but varied seasonally. Lepidopterans were the most important food items volumetrically. Food types differed according to habitat type. The reproductive season extended from March through August. The first reproductively active females appeared in March and the last in August. Testes of adult males were enlarged from March to July with maximum size and mass during May and minimal during August.

(7) *Ptyodactylus guttatus* (Heyden, 1827); Spotted fan-toed gecko. This gecko is common in St. Catherine Research Center (1500 m above sea level). Several individuals were observed during May when they appeared immediately after dark.

(8) *Ptyodactylus hasselquistii hasselquistii* (Donndorff, 1798); Fan-toed gecko. Figure 4. This species is frequently observed on the Rest house buildings in Sharm Ash-Sheikh. A few individuals were captured, with obvious reddish and white marbling on the head.

(9) *Tarentola annularis annularis* (Geoffroy De St. Hilaire, 1827); White-spotted gecko. Figure 5. This gecko is very common on the Ismailia campuses. It is active throughout the year, with a peak in autumn. In hot months, it showed an irregular activity pattern, while in other months a unimodal one. *T. annularis* is an opportunistic sit-and-wait predator, feeding upon a wide variety of prey primarily cockroaches and grasshoppers, but plant materials and spiders were also found in stomachs. These lizards occasionally showed an active foraging behavior and a tendency to cannibalism. They used different microhabitat types but, as a scansorial gecko, were mainly found on walls and fences. Some lizards occupied the same perches

for weeks or months. The breeding season mainly extended from March through July. In this season, the smallest gravid female measured 69 mm SVL and the smallest adult male with enlarged testes measured 60 mm SVL.

(10) *Stenodactylus sthenodactylus* (Lichtenstein, 1823); Elegant gecko. Figure 6. These were uncommon, reported only from the Al-Arish campus. A nocturnal gecko, it commences activity immediately after sunset. During the day, it could be found under stones, leaf litter or garbage. This gecko seems to have disappeared or become very rare on campus.

Family: Lacertidae

Three species of lacertid lizards were only found on the Al-Arish campus. They are:

(11) Acanthodactylus boskianus (Daudin, 1802); Bosc's fringe-toed lizard. This lizard was found in firm sand with sparse vegetation. Construction and cultivation of a vast area of campus has resulted in the reduction of habitats of this species, so that it is now rare on campus.

(12) Acanthodactylus scutellatus (Audouin, 1809); Nidua lizard. Figure 7. This species was observed in soft sandy areas of campus. The lizards showed a unimodal activity during most months of the year, but in June, bimodal activity pattern was documented. Basking usually occurred between 07:00 h and 12:00 h, and between 15:00 h and 20:00 h. Lizards assumed both sit-and-wait and actively foraging strategies. Coleoptera; larvae, Hymenoptera and plant materials were the main food items in lizard stomachs. Males and females of SVL 40–50 mm consumed prey items of 2–3 mm and 1–2 mm respectively.

(13) *Mesalina olivieri* (Audouin, 1829); Oliver's lizard. Although not uncommon, this lizard has become very rare. In the Al-Arish desert, activity of these lizards peaked during spring and decreased during summer. Lizards commenced activity after 08:00 h and ended about 19:00 h, showing an irregular daily activity rhythm in most months. Basking took place between 08:00–11:00 h and 16:00–19:00 h. Although activity was affected by soil temperature, some individuals were observed running on the ground when soil temperature reached 51.8°C in July. The most



Figure 1. Bufo regularis. All phiotographs © A. Ibrahim.



Figure 3. Laudakia stellio.



Figure 5. Tarentola annularis.



Figure 6. Stenodactylus sthenodactylus.



Figure 2. Bufo viridis viridis.



Figure 4. Ptyodactylus guttatus



Figure 7. Acanthodactylus scutellatus.





Figure 8. Chalcides ocellatus.

Figure 9. Chamaeleo chamaeleon.



Figure 10. Platyceps saharicus.



Figure 11. Platyceps rogersi.



Figure 12. Psammophis sibilans.

important food items taken by these lizards were Hemiptera, spiders, Hymenoptera, and Coleoptera. This terrestrial lizard was observed climbing bushes during the day and occasionally resting on vegetation during night. Lizards were mainly observed in direct sunlight; however, a few individuals were deployed in plant shade.

Family: Scincidae

(14) *Chalcides ocellatus ocellatus* (Forsskål, 1775); Ocellated skink. Figure 8. This skink was common in green areas on Port Said, Ismailia and Al-Arish campuses, usually observed during morning hours, especially from 09:00 to 11:00 h. Part of a dead lizard (including the head) was found on the Suez New Campus under debris in June 2007.

(15) *Trachylepis quinquetaeniata* (Lichtenstein, 1823); Bean skink. Figure 13. This lizard was observed almost all year on the Ismailia campuses. No data on the ecology of this skink in the Suez Canal zone are available.

Family: Chamaeleontidae

(16) *Chamaeleo chamaeleon musae* (Steindachner, 1900); Chameleon. Figure 9. Several individuals were captured on the Al-Arish campus. These chameleons were strictly diurnal, arboreal and camouflaged. A total of 65 chameleon observations were made over a year. Of these, only eight were active during the day from March through July, the remainder were found on trees during the night. Chameleons of different age groups did not assume different heights on trees whilst observed active during the day or inactive during the night. Meanwhile, juveniles did not differ significantly from adults or subadults in assuming different heights on trees.

Suborder: Serpentes

Family: Colubridae

(17) *Platyceps saharicus* (Schätti & Mc Carthy, 2004); Saharan cliff racer. Figure 10. Only once was a single snake of this species captured while entering one of the Research Center's rooms at St. Catherine area in July 2001.

(18) *Platyceps rogersi* (Anderson, 1893); Spotted racer. Figure 11. A freshly road-killed snake of this species was found at the front of the faculty of education building on the Suez New Campus in



Figure 13. Mabuya quinquetaeniata.



Figure 14. Psammophis schokari.



Figure 15. Spalerosophis diadema.

May 2007.

(19) *Psammophis schokari schokari* (Forsskål, 1775); Schokari sand snake. Figure 14. Several individuals were collected from cultivated areas on the Al-Arish campus during the study period. One individual was found beneath some garbage in May 1999. Another snake was caught while basking at 11:00 h in June 2001. A dead snake was

found on the Ismailia Old Campus.

(20) *Psammophis sibilans sibilans* (Linnaeus, 1758); African beauty snake. Figure 12. A single adult male was captured by a student from inside a building on the Al-Arish campus during May 2007.

(21) *Spalerosophis diadema cliffordi* (Schlegel, 1837); Clifford's snake. Figure 15. This snake was most common on the Al-Arish and Ismailia campuses, in sandy areas, cultivated farms, and orchards. A large number were captured from Al-Arish in different months of the year except during winter. In June 2007, a shed skin was collected from an underground electricity box on the Ismailia New Campus.

DISCUSSION

The herpetofaunal survey found a diversity of species on Suez Canal University campuses. This diversity is probably due to the species richness in these areas and to the variety of habitats available. In North Sinai and the Suez Canal region, university campuses were generally constructed outside of town on desert plains with natural vegetation. Enclosing each campus with a brick wall may have isolated the existing reptiles within a specific range.

The reptile species reported herein are known to occur in the Suez Canal zone and Sinai (Werner, 1982, Ghobashi et al., 1990, Saleh, 1997, Ibrahim, 2005, Baha El Din, 2006), except for three species which are recorded for the first time from Al-Arish City and the Suez Canal zone. (1) One specimen of the Indian Leaf-toad gecko, Hemidactylus flaviviridis was collected on the Al-Arish campus; this species is thought to have been introduced to the area which would extend its range by 160 km from Qantara East (Ibrahim, 2003) to Al-Arish. (2) The African beauty snake, Psammophis sibilans was recently discovered on the Al-Arish campus. This specimen may have been translocated from outside Al-Arish City with animal fodder or garden materials, or may have come from a grainery about 500 m from campus where two individuals were captured a few years ago (Adel Ibrahim, unpublished data). Baha El-Din (2006) reported this species from Wadi Al-Arish just

south of Al-Arish City. (3) The Spotted racer, *Platyceps rogersi* was found on the Suez New Campus. This snake is known to inhabit hilly areas, gravel plains, rocky plateaus and sandy areas of the Eastern Desert and Sinai (Baha El-Din, 2006).

The Egyptian toad, *Bufo regularis*, is believed to have been introduced or to be a recent migrant to the university campuses because of the increase in green spaces and a continuous water supply. At the Suez New Campus, no anurans were found as most of the campus is still desert with very few green patches. In the future, it is expected that, *B. regularis*, which is the commonest frog in the Suez Canal area (Ibrahim, 2005), will be found on the Suez New Campus.

The high incidence of reptiles on the Al-Arish campus compared to the other campuses may be attributed to the species diversity of reptiles already found in the area, especially around dwelling species. The presence of scattered boulders and ruins of man-made structures has encouraged scansorial species such as the Turkish gecko, *Hemidactylus turcicus* and the Starred agama, *Laudakia stellio* to flourish. The degradation of reptile habitats on the Al-Arish campus is slow so that a vast area of the campus has retained its natural vegetation. These factors, plus public awareness, may play a role in maintaining a high number of reptile species.

The changes in the structure of campus by continuous construction and forestation seem to have had both positive and negative impacts on the herpetofaunal community structure. For example, on the Al-Arish campus, the lacertids have been negatively affected, simply because of the degradation and diminution of their habitats. No quantitative data on how the species have been affected are available, but the number of these lizards has obviously been decreased (person. observ.). It is expected that the Elegant gecko (Stenodactylus sthenodactylus) on the Al-Arish campus as well as Spotted racer (Platyceps rogersi) on the Suez New Campus will disappear when their habitats are entirely destroyed due to campus construction.

By contrast, such species as Laudakia stellio

and Hemidactylus turcicus are positively affected due to presence of their suitable habitats. increasing Similarly. Bufo regularis is dramatically on the Ismailia New Campus. The continuous increase in green farms has encouraged some lizards and snakes including the chameleon (Chamaeleo chamaeleon) and Clifford's snake (Spalerosophis diadema) to flourish. А considerable number of the latter were captured by workers during the past few years. Availability of food particularly insects and rodents encountered on university cultivated areas may attract this species as well.

No taxonomic problems were found among the university reptile species. However, there was a variation in lizard morphology (scalation or coloration) between some lizards inhabiting the Suez Canal University and Sinai. For example, *Laudakia stellio* in South Sinai differs morphologically than its conspecific *L. stellio vulgaris* in North Sinai. According to Lachman *et al.* (2006), the southern agamid may be assigned to subspecies *salehi*. Also, the taxonomy of the Turkish gecko, *Hemidactylus turcicus* in Sinai and the Canal region needs verification.

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Crotalus aquilus in the Mexican state of México consumes a diverse summer diet

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ABSTRACT – We report observations of the summer diet of *Crotalus aquilus* (Querétaro dusky rattlesnake) from an agricultural region near San Pedro de los Metates, municipality of Acambay, state of México, Mexico. We recovered the remains of 12 individual prey items from 11 different snakes. Eleven of 38 (29%) snakes observed contained prey remains, including 6 mammals, 3 lizards, and 3 snakes. These observations suggest that *C. aquilus* consumes a diverse diet and that they may be more ophiophagous than many other rattlesnakes.

BASIC information describing the natural history and ecology of most Mexican snakes remains fragmentary, particularly for species endemic to the country. Despite recognition of the importance of dietary studies to both conservation efforts and snake evolutionary ecology, relatively few detailed studies of snake diets have been published (Holycross et al., 2002). In the absence of detailed studies, most available dietary information is anecdotal. Available dietary surveys often provide little information beyond a list of prey items consumed across the range of a species. While valuable, these studies provide little information about the dietary preferences of specific populations. In the case of many snakes endemic to Mexico, even less information is available (Campbell & Lamar, 2004). For example, we are aware of only one author who has provided information concerning the diet of Crotalus aquilus: Klauber (1997) mentioned a preponderance of lizards, particularly Sceloporus sp. among a group of C. aquilus (exact number of snakes unknown). Here, we provide detailed records of the summer diet of C. aquilus, a moderately small rattlesnake endemic to the central Mexican Plateau (Campbell & Lamar, 2004).

We collected snakes from an agricultural region near Acambay, state of México (ca. 2500 m elevation). The population of C. aquilus at this site occurs near the southern range limit for this species (Meik *et al.*, 2007), and individuals in this population may achieve larger sizes than those in more northern populations (Mociño-Deloya *et al.*, 2007). The climate is cool, subhumid, and relatively aseasonal, with rainfall concentrated in June–September. Most vegetation in this valley has been converted to agricultural use, and *C. aquilus* persists along margins of crop fields, in pastures, and remnants of more natural vegetation (Meik *et al.*, 2007).

We obtained faecal samples from C. aquilus encountered during June, July, and August of 2006. Most snakes were found in the morning or early afternoon, and were processed the same day that they were found. All snakes were anesthetized with isoflurane (Setser, 2007), sexed, weighed, measured, and marked with subcutaneous PIT tags. We obtained faecal samples by expressing faeces during processing, and from snakes which naturally voided faeces. Additionally, we palpated some snakes with recent food boli: food items were gently pushed to the snake's mouth for identification, and when possible, pushed back to the snake's stomach following identification. We preserved faecal samples in 96% ethanol for subsequent identification. We identified lizard and snake remains to the greatest resolution possible using morphological (remains from palpated snakes) or scale (remains from faeces) characters. We identified mammal remains based on a microscopic examination of hairs (Moore et al.,

1974), and by examination of tooth and bone characters (Whorley, 2000).

We obtained prey remains from eleven adult or subadult (346–618 mm SVL) snakes (five females and six males). These snakes constituted 29% of the 38 C. aquilus which we captured, and 39% of adult and subadult snakes. We did not detect prey remains in any of the 10 neonates (164-193 mm SVL) we examined. We found mammal hair and/or bones in six samples; four of these samples were identified as Microtus mexicanus, one was identified as a Sylvilagus sp., and one was too completely digested to be identified. All three lizards consumed were Sceloporus torquatus, the only lizard we have observed alive at the site. We encountered three snakes that had consumed other snakes. Of these, one snake contained a mediumsized, partially digested Pituophis deppei (Fig. 1). Two other snakes contained Thamnophis sp. scales. We have observed T. eques, Т. melanogaster and T. scaliger at this site, however we do not rule out the possibility that the prey items may have been T. scalaris (not observed, but possibly present based on known range; Rossman et al., 1996).

In only one case were we able to obtain a precise measurement of a prey item's mass, a *S. torquatus* weighing 25.5 g (37% of the snake's mass). In four other instances, it was possible to roughly estimate prey mass by subtracting the snake's post-defecation mass from its initial mass (Table 1). In these cases, prey items weighed ca. 37% (*P. deppei*), 31% (*M. mexicanus*), 16% (*S. torquatus*), and 10% (*M. mexicanus*) of each snake's post-defecation mass. Other prey items were too digested to allow estimation of their original masses.

A single snake contained more than one prey item, a small (346 mm SVL) female contained a freshly ingested *S. torquatus*, and also deposited faeces containing *M. mexicanus* hairs. We recovered pieces of arthropod exoskeletons from one snake's faeces; however, like Prival *et al.* (2002), we consider it likely that these were secondarily ingested as the gut contents of a lizard prey item.

Mammals represented a much higher proportion of our sample than they did in the sample reported by Klauber (19 lizards and 2 rodents; 1997). Many



Figure 1. Adult male *Crotalus aquilus* from the state of México regurgitating the partially digested remains of a *Pituophis deppei*.

smaller rattlesnakes increasingly consume rodents at larger sizes (Holycross et al., 2002 and citations therein). Although Klauber did not itemize the sizes or localities of the snakes from which he obtained records, we suggest that it is likely that his samples were taken from smaller individuals from more northern populations. Snakes in the population we discuss may attain larger sizes than do snakes from more northern populations (Mociño-Deloya et al., 2007), and may also consume higher proportions of rodents. Despite this conjecture, we point out that the smallest (346 mm SVL) animal from which we recovered prey remains had consumed a M. mexicanus, and that many rodent species smaller than M. mexicanus are present in this area.

Perhaps most intriguingly, we encountered repeated evidence of ophiophagy by *C. aquilus*. All three *C. aquilus* that had consumed other snakes were large (524, 556, and 618 mm SVL) adult males. Ophiophagy is rare among rattlesnakes, although numerous anectodal reports exist (Campbell & Lamar, 2004). Although our data are limited, the frequency of ophiophagy in our small sample is notable and suggests that snakes may be an important element of the diet of this population during summer months.

Despite the inclusion of relatively large prey species in their diets (e.g. *Pituophis*, *Sylvilagus*, *Microtus*), none of the prey items we report constituted an unusually high proportion of the snake's mass (Pough & Groves, 1983). This reflects that *C. aquilus* is a relatively stocky snake,

that larger prey items were taken by large snakes, and that most prey items found were already partially or nearly completely digested. In particular, the Svlvilagus was likely a large meal for the snake which consumed it. While we were unable to directly estimate the size of the cottontail, it is possible to infer a minimum size based on hair characters. Based on the presence of identifiable guard hairs, the cottontail ingested had attained juvenile or adult pelage. Negus (1958) asserts that the molt from nestling fur to juvenile pelage in eastern cottontails in Ohio occurs when rabbits are at least 7.5 weeks old and weigh a minimum of 241 g. Cottontails occurring near Acambay may molt at younger ages or lighter masses, nonetheless, it is probable that the rabbit eaten was of equal or greater mass than the snake that ingested it (154.6 g). Pough and Groves (1983) mention that viperid snakes can swallow and digest prey nearly three times larger than themselves; hence it is not unreasonable that a large C. aquilus could swallow a juvenile cottontail.

All of the prey species recovered exhibit diurnal or crepuscular habits. Relatively cool summer night temperatures at this high elevation site may limit nocturnal foraging during the summer (rainy) season, although *C. aquilus* may forage more extensively at night at other sites or during warmer seasons at our study site.

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Effect of timing of egg collection on growth in hatchling and juvenile American alligators

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ABSTRACT – Many crocodilians are raised commercially for their valuable hides and meat. Stock is often obtained by collecting eggs from the wild, a practice known as egg ranching. Hatchlings are then obtained after incubating these eggs in a controlled setting. Alligators are raised in commercial facilities in Louisiana, and growth rates of hatchlings and juveniles can be an important economic factor for the producer. In this study we demonstrate that alligator eggs collected soon after deposition, and incubated at optimum temperatures for the majority of the incubation period produce hatchlings that are heavier (p = 0.029) and longer (p = 0.0072) than clutch mates collected later, and subjected to fluctuating diurnal temperatures in the wild. This accelerated growth associated with early egg collection can be an economic benefit to the alligator producer, and may reduce the impact of potential natural mortality factors (such as flooding, predation, and lightning fires) that eggs would otherwise be exposed to if not collected.

THE American alligator (Alligator I mississippiensis) occurs in the southeastern United States and field studies have examined nesting in this species (Joanen, 1969; Deitz & Hines, 1980; Platt et al., 1995). Alligators begin courtship and breeding in spring, and nest in early summer, with nest construction usually occurring in June followed by hatching in late August and into September (Joanen, 1969). Alligators construct a mound nest of vegetation with eggs deposited within the nest cavity; average clutch size in a five year study of 315 nests was 38.9 eggs (Joanen, 1969). Alligators are valuable commercially for their hides and meat, and alligator eggs are often collected from the wild and incubated in controlled settings, to avoid natural mortality factors such as predation and flooding (Elsey et al., 2001). The practice of egg "ranching" has led to an intensive alligator culture program, which in Louisiana is valued at approximately US \$60 million yearly for the hides and meat alone. In recent years some 350,000 alligator eggs have been collected annually in Louisiana, while in peak years over 500,000 eggs have been collected (Elsey et al., 2006). Notably potentially high embryo mortality from Hurricanes Katrina and Rita was avoided as a

result of prior egg collections for ranching operations.

Sex in all crocodilians studied thus far is determined by incubation temperature (Lang & Andrews, 1994). Additionally, hatchling and juvenile alligator growth can be affected by the temperature at which the eggs are incubated; growth rates are greatest when eggs are incubated at intermediate temperatures, rather than at the extremes needed which determine sex (Joanen et al., 1987). In Caiman latirostris, hatchlings obtained from eggs incubated at 31°C were larger than those incubated at 29°C or 33°C; and growth after one year was best for those incubated at 29°C and 31°C than at 33°C (Pina et al., 2007). A small study (six eggs each at 28°C and 30°C, seven eggs each at 32°C and 34°C) of Caiman crocodilus vacare (Miranda et al., 2002) likewise showed growth at intermediate incubation faster temperatures (caiman monitored for 120 days at the temperatures noted above, after the initial 20 days of incubation at 30°C).

The incubation period of alligator eggs can vary from 63 days at constant high incubation temperatures (33°C) to 84 days at constant low (29°C) incubation temperatures (Lang & Andrews, 1994). Temperatures in natural nests in the wild fluctuate (range of 23.3°C-32.8°C in Joanen, 1969) and may have varying levels of exposure to sun or shade based on geographic location. Various types of nesting vegetation from which nests are constructed may affect incubation temperatures as well (Elsey et al., unpubl. data). High and low incubation temperatures can cause developmental abnormalities (Ferguson, 1985) and embryo mortality in alligators (Lang & Andrews, 1994). In crocodiles, Webb & Cooper-Preston (1989) similarly noted more abnormal embryos developed at high incubation temperatures in Crocodylus porosus. The effect of incubation temperature on reptilian phenotype has recently been reviewed in detail (Rhen & Lang, 2004); references therein note the effects of incubation temperature on crocodilian hatchling morphology, pigmentation, egg dynamics, thermal responses, and growth. Another recent review specific to crocodilians noted temperature affects hatchling size, pigmentation patterns, posthatching growth rates and thermoregulation in juveniles (Deeming & Ferguson, 1989).

This study was initiated to determine if collecting alligator eggs early in the incubation period (so they can be incubated at the optimum steady incubation temperature for the maximum amount of time) leads to more rapid growth after hatching than eggs left in a natural setting and collected much later, and having longer exposure to fluctuating (and possibly sub-optimal) temperatures in the wild. If growth rates are accelerated, this information could be of great importance to commercial alligator farmers and ranchers. Harvest size could be attained sooner, thereby reducing the costs and time needed for rearing alligators to a commercially marketable size.

MATERIALS AND METHODS

This study was conducted on portions of Rockefeller Wildlife Refuge in Cameron Parish, Louisiana USA. The refuge boundaries were previously described (Joanen, 1969) although habitat losses due to saltwater intrusion and erosion are such that current land mass is estimated at 72,600 acres. This study was conducted in two phases, with a small pilot study done in 1999–2000 and an expanded study in 2003–04. Alligator nests were generally located by helicopter and ground survey. Because posthatching crocodilian growth can be strongly influenced by clutch of origin (Garnett & Murray 1986; Webb *et al.*, 1992; Pina *et al.*, 2007) each clutch was divided to serve as its own control. Half the clutch was collected early in incubation [to be incubated at optimum temperatures for posthatchling growth (~ $31-32^{\circ}$ C as per Joanen *et al.*, 1987) in a controlled environmental chamber] and the remaining eggs were left in the nest and collected just prior to hatching. The latter eggs were subjected to fluctuating temperatures under natural conditions.

During the pilot study, the experimental group (collected early) of the eggs from two of the three clutches (clutches A and C) were collected on 2 July 1999. Half the eggs from the third nest (clutch B) were collected on 7 July 1999 and treated as above. Near the estimated time to complete incubation, the control eggs remaining in the field were collected (clutch C collected on 5 August, and the remainder of clutches A and B were collected on 11 August).

During the follow up study, all six nests were visited and eggs divided into control and experimental groups earlier in incubation (18 June 2003), at which point the experimental half of each clutch was placed in the field laboratory incubator. The control group from each clutch was collected on 12 August 2003.

Two days after hatching, all hatchlings were weighed to the nearest 0.01 g and total length (TL) was measured to the nearest 0.1 cm. Hatchlings were permanently marked with removal of one or more tail scutes to indicate treatment and clutch of origin. Web tags were placed in the rear feet for individual identification. Hatchlings were maintained under identical conditions in grow-out chambers (Joanen & McNease 1976) with control and experimental alligators from each clutch kept in the same chamber, and fed a dry pelletized commercial ration approximately five days a week. Alligators were weighed and measured approximately every three months during the pilot study, and every two months for the duration of the 2003-04 study.

A mixed model analysis of variance was used to test for effects of collection time on the length and

			Mass (g)		
		Hatching	1 December 1999	28 February 2000	19 May 2000
A	Experimental	39.20 +/- 1.17 (10)	225.30 +/- 9.74 (10)	638.90 +/- 57.91 (10)	1126.60 +/- 95.50 (10)
	Control	37.10 +/- 1.07 (10)	206.88 +/- 25.55 (8)	586.50 +/- 90.61 (8)	991.75 +/- 148.19 (8)
В	Experimental	46.60 +/- 1.72 (14)	281.36 +/- 10.40 (14)	765.07 +/- 34.86 (14)	1272.64 +/- 54.38 (14)
	Control	48.55 +/- 1.49 (13)	252.15 +/- 33.13 (13)	675.69 +/- 87.52 (13)	1131.23 +/- 145.44 (13)
С	Experimental	49.77 +/- 1.75 (14)	232.25 +/- 17.45 (12)	559.23 +/- 41.17 (13)	795.69 +/- 76.53 (13)
	Control	47.98 +/- 2.04 (16)	206.07 +/- 17.33 (15)	502.94 +/- 53.96 (16)	795.19 +/- 158.92 (16)
			Total Length (cm)		
A	Experimental	23.9 +/- 0.4 (10)	42.3 +/- 0.7 (10)	58.9 +/- 1.4 (10)	73.5 +/- 1.9 (10)
	Control	23.5 +/- 0.5 (9)	40.9 +/- 1.7 (8)	56.6 +/- 2.8 (8)	70.6 +/- 3.0 (8)
В	Experimental	25.7 +/- 0.4 (14)	46.4 +/- 0.6 (14)	63.2 +/- 1.0 (14)	77.5 +/- 0.9 (14)
	Control	26.3 +/- 0.3 (13)	44.2 +/- 2.6 (13)	60.2 +/- 2.6 (13)	74.3 +/- 3.5 (13)
С	Experimental	25.6 +/- 0.8 (14)	42.4 +/- 1.5 (12)	56.1 +/- 1.8 (13)	66.3 +/- 2.5 (13)
	Control	24.9 +/- 0.7 (16)	39.8 +/- 1.0 (15)	52.7 +/- 1.7 (16)	63.0 +/- 2.3 (16)

weight of alligators, using the individual nests as random blocks. Means are presented as +/-1 SE. Results considered significant at p < 0.05.

RESULTS

In the initial pilot study in 1999–2000, two of the early half sets of eggs hatched three days prior to the eggs from the same clutch which were collected later in incubation; in the remaining clutch three additional days were required for the experimental group to hatch compared to the control group. In the expanded study of 2003–04, all the experimental half clutches collected early hatched sooner (one to six days earlier; average 3.5 days earlier for hatchlings to pip/emerge) than their control counterparts (late collected) from the same nest.

In the pilot study in 1999, at the time of hatching two of the three clutches produced hatchings that were heavier and longer when collected earlier than their controls collected close to hatching (Table 1). However, when the alligators were again weighed and measured on 1 December, 28 February, and 19 May the experimental hatchlings were heavier and longer in all cases than their paired control clutch mates (Table 1). By the last measurement, the sets from clutch "C" had nearly equal masses, but the experimental early collected half averaged 3.3 cm

Table 1. Mass and total length (TL) of alligator hatchlings from a pilot study conducted 1999 - 2000. Values presented as mean +/-1 SE (n). A, B, and C designate three specific clutches.

longer than their controls. Of note, the SEMs for the final two measurements (particularly for mass) were often greater for the controls, suggesting the experimental groups collected early were more uniform in size with less occurrence of runting, wherein some animals are smaller than clutch mates and growth remains poor despite aggressive husbandry practices.

In the larger study involving six clutches, experimental hatchlings were heavier than their control clutch mates; similar results were seen when they were weighed on 27 October 2003 (Table 2). By 17 December the control alligators from clutch B slightly exceeded the mass of those from the experimental half (454 g vs. 449 g). Similar findings were noted for clutch B and clutch E at the final measurement on 16 February 2004; although the additional masses were only 19 g for clutch E and 36 g for clutch B. In the other four clutches, the experimental alligators were heavier than their control counterparts by masses of 7 g, 85 g, 102 g, and 167 g (Table 2).

In the 2003–2004 study, the TL of experimental hatchlings were longer at the initial time of

			Mass (g)	
		Hatching	27 October 2003 17 December 2003 16 February 2004	
A	Experimental Control	45.73 +/- 0.79 (14) 43.14 +/- 1.24 (12)	211.57 +/- 13.62 (14) 454.78 +/- 43.32 (14) 815.93 +/- 94.89 (14) 193.08 +/- 13.85 (12) 441.08 +/- 30.55 (12) 808.75 +/- 60.03 (12)	
В	Experimental Control	52.19 +/- 1.25 (17) 50.08 +/- 2.91 (13)	205.41 +/- 14.45 (17) 449.35 +/- 29.56 (17) 776.24 +/- 55.26 (17) 205.08 +/- 15.47 (13) 454.23 +/- 44.89 (13) 812.46 +/- 95.47 (13)	
C	Experimental Control	53.79 +/- 0.97 (21) 50.91 +/- 1.68 (18)	255.29 +/- 10.63 (21) 547.52 +/- 33.12 (21) 920.43 +/- 70.85 (21) 232.39 +/- 18.42 (18) 489.94 +/- 42.33 (18) 835.39 +/- 81.69 (18)	
D	Experimental Control	53.85 +/- 0.90 (16) 51.26 +/- 0.98 (12)	271.81 +/- 14.67 (16) 594.50 +/- 39.85 (16) 1156.50 +/- 83.64 (16) 231.27 +/- 9.61 (11) 517.27 +/- 31.01 (11) 989.09 +/- 50.83 (11)	
E	Experimental Control	52.78 +/- 1.44 (23) 52.58 +/- 1.56 (22)	249.18 +/- 11.13 (22) 532.41 +/- 30.80 (22) 988.77 +/- 63.64 (22) 248.00 +/- 11.66 (22) 527.63 +/- 25.64 (22) 1007.82 +/- 40.85 (22)	
F	Experimental Control	55.82 +/- 1.35 (11) 53.18 +/- 1.20 (8)	250.91 +/- 15.64 (11) 553.18 +/- 42.42 (11) 945.36 +/- 91.54 (11) 229.63 +/- 22.37 (8) 501.00 +/- 57.45 (8) 843.50 +/- 130.03 (8)	

Table 2. Mass of hatchling alligators from six clutches of eggs, 2003-04. Values presented as mean +/- 1 SE (n). A - F designate six different clutches.

measurement as well as the third measurement (17 December 2003) in five of the six groups. In the other clutch the average lengths were the same whether collected early or late (Table 3, Clutch B). At the second measurement on 27 October 2003



the experimental sets had average totals lengths greater than their control clutch mates in all six cases. At the time of the final measurement, four of the experimental sets were longer than their controls for each clutch (Table 3, Figure 1).

Statistical analyses indicated there was a significant difference in weight between experimental and control collection (p = 0.029), with alligators from experimental eggs being heavier than those from control eggs. Similarly, there was a difference in average length of alligators obtained from experimental eggs as compared to the control counterparts (p = 0.0072) with greater lengths corresponding to experimental eggs collected and incubated early.

DISCUSSION

These results indicate that alligator size at hatching and post-hatching growth rates can be affected by the timing of egg collection, provided that maximum exposure time to optimum incubation temperatures is allowed. Early timing of egg collection might also allow egg ranchers to avoid natural mortality factors such as flooding (Platt *et*

Figure 1. Two alligators from the same clutch of eggs that were raised under identical conditions. The larger alligator (right) was hatched from an egg that was collected early and incubated at optimum temperatures while the smaller alligator (left) was from an egg collected later, just prior to hatching, and exposed to fluctuating temperatures in a natural nest.

			Total Length (cm)		
		Hatching	27 October 2003	17 December 2003	16 February 2004
Α	Experimental	24.4 +/- 0.3 (14)	42.1 +/- 1.0 (14)	53.0 +/- 1.7 (14)	63.2 +/- 2.8 (14)
	Control	23.3 +/- 0.5 (12)	39.9 +/- 1.0 (12)	51.2 +/- 1.3 (12)	61.9 +/- 1.4 (12)
В	Experimental	25.2 +/- 0.5 (17)	42.6 +/- 1.1 (17)	53.6 +/- 1.4 (17)	63.6 +/- 1.5 (17)
	Control	25.2 +/- 0.5 (13)	42.2 +/- 1.0 (13)	53.6 +/- 1.6 (13)	64.0 +/- 2.1 (13)
С	Experimental	26.1 +/- 0.3 (21)	45.6 +/- 0.7 (21)	56.6 +/- 1.0 (21)	66.9 +/- 1.4 (21)
	Control	24.8 +/- 0.3 (18)	43.6 +/- 1.4 (18)	54.1 +/- 1.9 (18)	64.5 +/- 2.3 (18)
D	Experimental	26.0 +/- 0.4 (16)	46.0 +/- 1.0 (16)	57.8 +/- 1.5 (16)	70.6 +/- 1.9 (16)
	Control	25.2 +/- 0.3 (12)	43.1 +/- 0.5 (11)	54.7 +/- 0.9 (11)	67.2 +/- 1.3 (11)
Е	Experimental	25.3 +/- 0.4 (23)	44.9 +/- 0.8 (22)	55.6 +/- 1.1 (22)	67.2 +/- 1.4 (22)
	Control	24.9 +/- 0.3 (22)	44.5 +/- 0.7 (22)	55.5 +/- 0.8 (22)	67.5 +/- 0.9 (22)
F	Experimental	25.6 +/- 0.4 (11)	44.8 +/- 1.2 (11)	57.0 +/- 1.7 (11)	67.2 +/- 2.4 (11)
	Control	25.2 +/- 0.4 (8)	42.4 +/- 1.8 (8)	53.6 +/- 2.7 (8)	63.4 +/- 3.7 (8)

al., 1995; Elsey *et al.*, 2006), predation, and lightning fires (Elsey & Moser, 2002), all of which are more likely to occur the longer the eggs are left in the field and exposed to these factors. Indeed, Platt *et al.* (1995) noted all alligator nests on his study site in southeastern Louisiana were lost to flooding from tropical storm Beryl in August 1988. We also received reports from several alligator ranchers noting losses of hundreds to thousands of alligator eggs from tropical storm Bill in late June/early July 2003 (Elsey, unpubl. data).

Accelerated growth of even a portion of an alligator rancher's crop could lead to a significant economic benefit for the business operation. The more rapidly an alligator reaches market size, the lower the costs incurred for continued heating, feeding, and labor for daily care and maintenance of the alligators. In Louisiana, alligator farmers must return a portion of juveniles back to the wild to the area from which wild eggs were collected, as part of a "head start" program (Elsey et al., 2001). The larger the alligators are, the fewer that need be released to the wild to ensure recruitment. Thus, a few inches of additional growth could also allow Louisiana alligator farmers to complete their "release to the wild" obligations with fewer juvenile alligators, and allow them to harvest more for the valuable hides and meat (Elsey et al., 2001). These juvenile alligators released to the wild have been shown to have accelerated growth rates relative to their wild counterparts (Elsev et **Table 3.** Total length (TL) of hatchling alligators from six clutches of eggs, 2003–04. Values presented as mean +/-1 SE (n). A - F designate six different clutches.

al., 2001), this may in part be due to optimal egg incubation temperatures under which they were incubated and maintained by the alligator farmer.

The large numbers of eggs collected by some commercial alligator farmers/ranchers necessitate that some eggs must be collected later in incubation, due to the relatively limited alligator nesting period (approximately 2-2.5 months). It is sometimes more efficient to conduct aerial helicopter surveys only when all nests have been constructed, rather than surveying too early, and missing nests yet to be constructed (for alligators in Louisiana, there is perhaps a two - three week period of time between the earliest and latest nests being completed). However, this study demonstrates the accelerated growth seen in hatchling and juvenile alligators simply by collecting eggs early (to maximize exposure time to optimum incubation temperatures) could be used to increase the profit margin in some commercial alligator ranches and avoid many natural mortality factors that limit nest success in the wild.

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Data on the distribution of amphibians and reptiles from North and West Africa, with emphasis on *Acanthodactylus* lizards and the Sahara Desert

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TORTH and West Africa support large numbers of amphibian and reptile species (Schleich et al., 1996; Chippaux, 2001; Trape & Mané, 2006). Morocco and Western Sahara are undoubtedly the North African regions best explored with comprehensive atlases available on the distribution of these taxonomic groups (Bons & Geniez, 1996; Geniez et al., 2004). However, the inhospitality and remoteness of the Sahara desert mean that there is a paucity of knowledge of most taxa in this area. Social and political instability have long hampered access to certain areas, such as Niger's Ténéré or Libya's Fezzan. Despite the classical works (e.g. Duméril & Bibron, 1839), French and Italian exploratory missions in the first half of the 20th century (e.g. Witte, 1930; Pellegrin, 1931; Angel, 1933, 1938; Scortecci, 1937; Roux, 1939), several works concerning the most studied countries -Morocco, Tunisia and Western Sahara (Domergue, 1959a,b; Blanc, 1986; Nouira & Blanc, 1993; Bons & Geniez, 1996; Geniez et al., 2004), country checklists (Padial, 2006), and occasional expeditions (Papenfuss, 1967; Böhme, 1978; Joger, 1981; Böhme et al., 1996; Ineich, 1996; Joger & Lambert, 1996; Böhme, 2000; Böhme et al., 2001; Brito, 2003), the geographic distribution of many species in the Sahara is poorly known. Within the scope of a research project on phylogenetic relationships of Acanthodactylus lizards, two of us (JCB & HR) had the opportunity to travel through North and West Africa. This note reports

observations of amphibians and reptiles for this region, with emphasis on *Acanthodactylus* lizards and the Sahara desert.

The study area covered North and West Africa (Figure 1) and data were collected in an overland expedition of 96 days, between September, 9 and December, 13 of 2004. The sampling strategy involved a transect covering in the following order: Tunisia, Libya, Niger, Burkina-Faso, Mali, Senegal, Mauritania, Western Sahara and Morocco (Figure 1). The transect crossed North and West Africa ecosystems diversity and specific biotopes, such as sand deserts (erg) and firm ground deserts (reg), banks of salt lakes (chott) and temporary ponds (daya), rocky plateaus (hammada) and dry river beds (oued). Sampling points were selected along transect based on the diversity of biotopes, and visual encounter surveys were used to detect specimens. A total of 13 localities for three amphibian species and 213 localities for 52 reptile species were recorded (see Appendix). From almost all specimens, a tissue sample was collected and photographs with a digital camera were taken. The spatial location of specimens was georeferenced using a Global Positioning System (GPS), using the WGS84 coordinate system, and downloaded into a database with an interface for a Geographical Information System (GIS). Remarks are made when the observations expand distribution limits or when they contribute to the knowledge of the natural history of the species (confront localities marked with ** in Appendix).



Figure 1. Geographic locations of all observations collected during fieldwork.

Amphibians

Bufo xeros Tandy, Tandy, Keith & Duff-McKay, 1976 - Guelta of Timia, Niger (record D368): from a total of 14 active specimens found, nine (65%) had skin ulcers on the dorsum. These lesions were perfect circumferences with a radius of about 2.5mm or less and presented, to some extent, a pale aspect above the muscle as well as pale borders. Possible causes for the lesions include parasitic as well as fungus or viral infections, but secondary opportunistic infections, caused by fungus or bacteria, could also be responsible for the damaging of the cutaneous tissue (for details see Brito et al., 2005). Researchers heading for this remote region should be observant for this situation as well as in other populations also. In the Aïr massif, Bufo xeros is a Sahelian relict and occurs in isolated populations, probably with small population size (Joger, 1981).

Reptiles

Tropiocolotes cf. steudneri (Peters, 1869) - Timia, Niger (record D386): Tropiocolotes steudneri is currently known from southern Algeria, Libya, Sudan and Egypt with an isolated record from Mauritania (Baha el Din, 2006), suggesting that it could also occur until the southern limit of the Sahara desert (see also Schleich et al., 1996). The present record confirms this suggestion and as far as it was possible to determine, this is the first record for Niger. The specimen from Timia differs obviously in several features form typical steudneri from Egypt, pointing to the necessity of further research on the systematics of the central and western populations currently assigned to this species.

Agama cf. impalearis Boettger, 1878 - Aïr populations (records D367 to D384): populations of northern Aïr (Arlit) and the nearby Algerian Hoggar Mountains are sometimes assigned to Agama agama (e.g. Le Berre, 1989) or to A. impalearis (Joger, 1981; Le Berre, 1989 who mentions both species). Their systematics is still currently unresolved: while they are similar to A. impalearis in several features (6 to 7 supralabial scales before the anterior border of the eye) they also differ in other characters (pers. obs.). In the Aïr mountains, typical Agama agama have been reported from the south (Joger, 1979; Kriska, 2001) while animals similar to the Hoggar specimens and currently designed as Agama cf. impalearis are found in the north (Arlit; Joger, 1981).

Acanthodactylus aureus Günther, 1903 – Between Dakhla and Fort Guerguerat, Western Sahara (record A376 to A392): Crochet *et al.* (2003) and Geniez *et al.* (2004) noted a possible disjunction in the range of this lizard in the area between Dakhla and the border with Mauritania. The present records fill out the gap between El Argoub and Fort Guerguerat. In addition, one of us (PAC) has observed several specimens in this area, PK.207 before Lagwera coming from Dakhla [22.4688°N / 16.4434°W] on September 11, 2006.

Acanthodactylus boskianus (Daudin, 1802) – Birni N'Konin, Niger (record A207): sub-Saharan populations of this lizard are rare and were previously known from two localities in Niger, Tahoua and Dogondoutchi (Joger, 1981; Salvador, 1982), and to a few localities in extreme northern Nigeria (Papenfuss, 1969; Salvador, 1982). The present record further suggests that a fragmented population of this lizard occurs in the Sahelian regions of southern Niger and northern Nigeria.

Acanthodactylus cf. busacki Salvador, 1982 sebkha Oum Dba, Western Sahara (record A433): the specimen observed in this locality was an adult male with vivid red coloration in the ventral side of the tail. This tail coloration pattern is unreported for this species since juveniles have a bluish tail and adults generally have a dull coloration (Geniez et al., 2004). Phylogenetic analysis of 12S and 16S rRNA sequences demonstrated that this specimen was very divergent from two other samples from Morocco (oued Massa), making A. busacki paraphyletic (A433 in Fonseca et al., 2007). Indeed, northern populations of the species (eg. Tamri, Souss valley and Souss-Massa National Park) exhibit a different general aspect compared with those of Western Sahara (M. Geniez pers. com., own observations, compare also photo 108 and 109 in Geniez et al., 2004). The taxonomic status of southernmost populations of this species should thus be further investigated.

Acanthodactylus dumerili (Milnes Edwards, 1829) – Zuara (record A129), Nalut (records A139–140) and Fezzan regions (record A169 to A155), Libya: the two records south of Nalut and the three observations in the Fezzan increase the previously known range in Libya (Salvador, 1982) and suggest that the contact zones between *A. dumerili* and *A. scutellatus* should be broader than previously suspected (Crochet *et al.*, 2003). In fact both species were found in sympatry in the costal dunes east of Zuara.

Acanthodactylus longipes Boulenger, 1921 – Between Choum and Nouadhibou, Mauritania (records A310 to A334): observations in the Azeffâl and Akchâr dune fields fill the previously apparent gap between the Adrar Atar and coastal areas (Crochet *et al.*, 2003; Geniez *et al.*, 2004; Padial, 2006). Nevertheless, at local scale the species occurs in fragmented populations restricted to sand dunes.

Acanthodactylus maculatus (Gray, 1838) – Nefza and Cap Serrat, Tunisia (records A71–72): populations from northern costal areas of Tunisia were described as Acanthodactylus mechriguensis Nouira & Blanc, 1999 based on morphological characters (Nouira & Blanc, 1999). Phylogenetic analysis of 12S and 16S rRNA sequences demonstrated that these coastal populations form a monophyletic group with typical maculatus, that there was no genetic support for the species status of mechriguensis and that this form should be included in A. maculatus (A71 and A72 in Fonseca et al., 2007). Therefore, the records for coastal northern Tunisia belong to A. maculatus.

Acanthodactylus cf. maculatus – Hamadath al Hamrah plateau, Libya (records A151–152): two specimens were observed in extremely fragmented and vulnerable populations. They were restricted to small patches of soft sand (about 100 x 100 m) covered with herbaceous vegetation which were very isolated on the flat rocky plateau. Only two specimens were observed, thus population size should be extremely low, rendering these populations susceptible to extinction. The two specimens formed a distinct clade in a phylogenetic analysis of 12S and 16S rRNA sequences (A151 and A152 in Fonseca *et al.* 2007). In one of the patches *Trapelus mutabilis* was also found.

Acanthodactylus senegalensis Chabanaud, 1918 – Tazolé, Niger (record A191), and Atar and Choum, Mauritania (records A287 to A295): the record for central Niger expands the range 1400 km inland. The most inland localities previously known were in the Malian regions of M'Bouna and Goundam (Salvador, 1982). Records for south-western Adrar Atar and in the area of Choum also expand the known range of the species in Mauritania (Crochet *et al.*, 2003; Geniez *et al.*, 2004; Padial, 2006).

Mesalina pasteuri (Bons, 1960) – Between Choum and Nouadhibou, Mauritania (record D526): few localities are known for this lizard and they are scattered along southern Morocco, Algeria, Western Sahara (Auhaifrit and Aouadi), and Mauritania (near F'dérik) (Schleich *et al.*, 1996; Geniez *et al.*, 2004; Padial, 2006). The present record increases the range of the species in Mauritania.

Psammophis aegyptius Marx, 1958 - Dirkou and Bilma, Niger (records D340-341): previously know from Egypt and Libya (Schleich et al., 1996; Baha el Din, 2006), it has been reported recently from Niger and Algeria (Trape & Mané, 2006). The present records in two Ténéré oases confirm the presence of this poorly known species south of its classic range. Although this snake occurs in the Aïr and Hoggar Mountains, the hyper-arid character of the Ténéré renders populations fragmented and restricted to humid habitats of oasis. These two specimens show all the typical features of the species (as seen in Egypt, pers. obs.), especially the dorsal pattern and the uniform brick red ventral coloration. These specimens formed a distinct clade from Psammophis schokari specimens in a phylogenetic analysis of ND4 rRNA sequences (D340 and D341 in Rato et al. 2007).

Psammophis schokari Forsskål, 1775 – South of Dakhla, Western Sahara (records D538 to D545), and Nouakchott, Mauritania (record D491): Geniez *et al.* (2004) noted a possible disjunction in the range of this snake in the area between Dakhla and the border with Mauritania. The present records for Western Sahara fill out the gap between El Argoub and Fort Guerguerat. Sequencing of ND4 rRNA showed that *P. schokari* specimens from Western Sahara together with Morocco form a distinct genetic lineage and differentiated from the individual of Nouakchott (D491 in Rato *et al.*, 2007).

Psammophis sibilans (Linnaeus, 1758) – Fada N'Gourma, Burkina-Faso (record D421), Fama, Mali (record D432), and east of S. Louis, Senegal: the systematics of this complex of sand-dwelling sand snakes is still unresolved and West Africa populations could belong to *P. phillipsi* or *P. rukwae* (Chippaux, 2001). However, these specimens from Sahelian Senegal, Mali and Burkina-Faso conform well to the general features of *Psammophis sibilans* from Egypt (cf. Baha El Din, 2006; pers. obs.) and agree with the geographical distribution given by Trape & Mané (2006). Also, specimens from Burkina-Faso and Mali formed a distinct clade from *Psammophis schokari* specimens in a phylogenetic analysis of ND4 rRNA sequences (D421 and D432 in Rato *et al.*, 2007).

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Table 1. Geographic location (WGS84 datum), code of tissue sample and photo availability for the specimens observed. BFA: Burkina-Faso; LIB: Libya; MAL: Mali; MAU: Mauritania; MOR: Morocco; NIG: Niger; SEN: Senegal; TUN - Tunisia; WSA: Western Sahara. Observations with particular comments are marked with (**).

Species	Latitude	Longitude	Locality	Country	Tissue sample code	Image
Amphibia						
Bufo viridis	N 32 988367	E 9 639800	4km SE of Ksar Ghilane	TUN	D317	Ves
Bufo voros	N 11 062333	E 0.302783	10km S Eada N'Gourna	REA	D417	yoc
Buio xeros	N 11.902333	L 0.392703		DIA	D417	yes
	N 12.060333	E 0.369333	Fada N'Gourma	BFA	D423	
	N 14.504000	E -11.090983	20km W of Kayes	MAL	D460	yes
	N 14.505667	E -9.633000	220km E of Kayes	MAL	D445	yes
	N 14.511500	E -9.702700	210km E of Kayes	MAL	D452	ves
	N 14 545417	F -11 943033	60km W of Kaves	MAI	D462	
	N 14 683100	E 10.38/017	120km E of Kayos	MAL	D455	VOC
	N 12 474900	E - 10.304917			D455	yes
	N 12.474600	E 2.427600	lapoua NiG	D410	D 000	
(**)	N 18.094950	E 8.761267	Air: Guelta of Timia	NIG	D368	yes
	N 16.178167	E -13.997233	300km SE of S.Louis	SEN	D473	yes
Rana saharica	N 33.487500	E 8.925017	10km W of Douz	TUN		
	N 35.582150	E 8.482633	3km E of Haidra	TUN	D310	ves
						,
Bontilio						
	N 40 000047	E 0 001000		DEA	D 100	
Ptyodactylus ragazzii	N 12.220017	E 0.301900	20km N Fada N Gourna	BFA	D422	yes
	N 12.060333	E 0.369333	Fada N'Gourma	BFA	D418	yes
	N 12.113683	E 0.170033	Diapango	BFA		
	N 12.353250	E -1.527017	Ouagadougou	BFA	D429	ves
	N 14 555833	E -10 999817	60km E of Kaves	ΜΔΙ	D458	,
	N 12 474900	E -10.333017	Teneuro		D400	
	N 12.474800	E 2.427600	Tapoua	NIG	D409	yes
	N 16.773333	E 7.553300	50km SW of Agadez	NIG	D396	yes
	N 16.951667	E 8.674133	Tourayet	NIG	D345	yes
	N 17.219600	E 8.099783	Air: 30km N of Agadez	NIG	D350	yes
	N 17.710817	E 8.274167	Air: 5km S of Elmiki	NIG	D387	ves
	N 17 929183	E 8 823067	Air: 25km S of Timia	NIG		,
	N 19 009292	E 9 766722	Air: Ekm S of Timio	NIC	202	
	N 10.090303	E 40 000000		NIG	D302	yes
Tarentola annularis	N 21.251400	E -13.282933	20km VV of Choum	MAU	D523	yes
	N 18.091667	E -16.030000	Nouakchott	MAU	D504	yes
	N 20.982917	E -16.512167	90km S of Nouadhibou	MAU	D532	yes
	N 21.303300	E -16.366767	90km E of Nouadhibou	MAU	D531	ves
Tarentola chazaliae	N 28 191900	F -11 824500	60km S Tan-Tan Plage	MOR	D564	Ves
	N 27 502267	E 12 125000			D561	yes
	N 27.502307	E -13.135900	40km N OI Laayoune	WSA	D201	yes
			in coastal dune field			
	N 26.713600	E -13.545133	70km S of Laayoune	WSA	D559	yes
Tarentola parvicarinata	N 14.448650	E -11.438700	Kayes	MAL	D461	yes
	N 20.747567	E -13.140867	35km N of Atar	MAU	D521	ves
Tropiocolotes	N 17 816667	E 8 228333	Air: S of Timia	NIG	D386	Ves
of stoudpori (**)	1111010007	L 0.220000		NIO	2000	yes
Transis a slata a tria slita ava	NI 22 000022	E 0 750500		TUN	1/240	
Tropiocolotes tripolitanus	SIN 32.908233	E 9.752533	17km SE Ksar Ghliane	TUN	V318	yes
Chamaeleo africanus	N 13.787150	E 4.969133	20km W Birni N'Konin	NIG	D401	yes
Chamaeleo chamaeleor	1N 28.230783	E -11.701650	50km S Tan-Tan Plage	MOR		yes
Agama agama	N 12.102083	E 0.248050	15km W Fada N'Gourma	BFA	D425	
	N 14.511500	E -9.702700	210km E of Kaves	MAL	D451	ves
	N 14 522000	E -9 550067	240km E of Kaves	ΜΔΙ	D443	,
	N 14 509522	E 5 276067	Enkm & of Tabour		D300	
	N 14.506555	E 3.370907		NIG	D399	yes
Agama boueti	N 17.392733	E -16.062067	80km S of Nouakchott	MAU	D489	yes
	N 13.785933	E 5.012817	15km W of Birni N'Konin	NIG	D400	yes
	N 13.787150	E 4.969133	20km W of Birni N'Konin	NIG	D402	yes
	N 17.710817	E 8.274167	Air: 5km S of Elmiki	NIG	D389	ves
Agama of impalearis (**)	N 18 012517	E 8 741033	Air: 10km of Timia	NIG	D367	Ves
(**)	N 16 051667	E 9.67/133	Touravet	NIC	D342	yoo
	N 10.951007	L 0.074133		NIG	D342	
(***)	N 17.302500	E 8.1/0200	AIT: 50KM N of Agadez	INIG	0353	yes
(**)	N 17.522100	E 8.667200	Air: Abardokh	NIG	D355	yes
(**)	N 17.985600	E 8.765067	Air: 20km S of Timia	NIG	D361	
(**)	N 17.998417	E 8.753983	Air: 15km of Timia	NIG	D366	ves
(**)	N 18.098383	E 8.766733	Air: 5km S of Timia	NIG	D384	ves
Agama impoloaria	N 20 100867	E -9 466700	6km W of Taggit	MOR		,
	N 20 100717				D220	
Trapelus mutabilis	IN 29.128/1/		IT OKT SE OF Derj	LIB	0330	yes
Uromastyx acanthinura	N 29.879317	E 10.757183	45km SE of Derj	LIB	D328	yes
	N 29.155433	E -8.593267	60km W of Akka	MOR	D575	yes
Uromastyx geyri	N 17.555333	E 8.748783	110km NE of Agadez	NIG	D357	
Uromastvx gevri	N 17.219600	E 8.099783	Air: 30km N of Adadez	NIG	D351	
		· · · · · · · · · · · · · · · · · · ·		-	-	

	N 17 302500	E 8 170200	Air: 50km N of Agadez	NIG	D352	Ves
	N 17 303833	E 8 175600	Air: 50km N of Agadez	NIG	D354	Ves
	N 17.000000	E 0.175000	Air. Sokin N Or Agadez	NIC	D304	yes
	N 17.010007	E 0.220333	Air. S of Timia	NIG	D365	yes
	N 17.845817	E 8.216933	Air: S of Elmiki	NIG		
Acanthodactylus aureus	N 21.218250	E -16.843233	40km S of Nouadhibou	MAU	A369	yes
	N 20.801583	E -17.053233	4km N of Cape Blanc	MAU	A370	yes
	N 21.097867	E -16.699867	70km S of Nouadhibou	MAU	A365	ves
	N 28 744733	F -10 743850	25km S of Aoreora	MOR	A435	ves
	N 28 873167	E -10 702733	15km E Aoreora -	MOR	A443	VOS
	N 20.075107	L -10.702755	Diago Diagoho	WOR	A445	yes
			Plage Blanche			
(**)	N 21.981350	E -16.877600	70km N of Fort	WSA	A376	yes
			Guergerat			
(**)	N 22.370967	E -16.471050	240km S of Dakhla	WSA	A382	ves
(**)	N 22 820467	F -16 251933	190km S of Dakhla	WSA	A391	ves
(/ / / / / / / / / / / / / / / / / / /	N 23 133017	E -16.08/333	140km S of Dakhla	WSA	A302	Vec
()	N 22 625050	E 16.004000			A204	yes
	N 23.025050	E -15.652067		WSA	A394	yes
	N 23.890017	E -15.823950	20km N of Dakhia	WSA	A395	yes
	N 24.497533	E -15.033050	100km N of crossroad	WSA	A409	yes
			for Dakhla			
	N 25,198317	E -14.827067	110km S of Bouidour	WSA	A410	ves
	N 26 713600	E -13 5/5133	70km S of Laavoune	W/SA	A423	VAS
	N 27 502267	E 12 125000			A420	yes
	N 27.302307	E -13.135900	40km N OI Laayoune,	WSA	A432	yes
			in coastal dune field			
	N 27.587633	E -13.018967	NW margin of sebkha	WSA	A434	yes
			Oum Dba			
Acanthodactvlus blanci	N 37 206900	E 10 190733	Siouine: 2km N of	TUN	A69	ves
		2 101100100	Raf-Raf		,	,
Accepthodoctylus	N 20 076592	F 10 CCEC92			A140	
Acanthodactylus	N 30.076583	E 10.005083	22km SE of Derj	LIB	A149	yes
boskianus	N 25.762667	E 12.166467	Wadi Matendous;	LIB	A166	yes
			145km SW of Tesawa	I		
	N 25.992383	E 12.693117	Messak Mallet;	LIB	A168	ves
			95km W of Tesawa			
	N 28 511733	F 12 812083	Hamadath al Hamrah:	LIB	A153	VAS
	N 20.511755	L 12.012303	120km N of Idri	LID	A155	yes
	N 47 400007	E 40.000007			4007	
	N 17.403267	E -16.069967	80km S of Nouakchott	MAU	A237	yes
	N 29.052467	E -9.345883	4km E of Taggit	MOR	A447	yes
	N 29.052950	E -9.373850	3km E of Taggit	MOR	A446	yes
	N 29 056033	F -9 334883	6km E of Taggit	MOR	A449	ves
	N 29 880167	E -6 711900	30km E of Fourm Zouid	MOR	A455	Vec
(**)	N 40 707407	E 4 000000		NICIC	A-007	yes
	N 13.707107	E 4.900903		NIG	A207	yes
	N 14.903433	E 5.392900	15km NE of Tahoua	NIG	A206	yes
	N 17.164200	E 8.093217	20km N of Agadez	NIG	A199	yes
	N 33.451583	E 11.080483	7km S of Zarzis	TUN	A128	ves
	N 33.615833	E 9.007033	18km N of Douz	TUN	A97	ves
	N 34 809733	E 8 513583	15km S of Eeriana	TUN	A85	Ves
A contradicate dura burgada	N 09.000700	E 10 702722			A00	yes
Acantriodactylus busacki	N 20.073107	E-10.702733	ISKIII E OI AOreora -	MOR		
			Plage Blanche			
	N 28.744733	E -10.743850	25km S of Aoreora	MOR		
(**)	N 27.595650	E -12.998367	NW margin of sebkha	WSA	A433	yes
			Oum Dba			
Acanthodactylus	N 25 992383	F 12 693117	Fezzan:	LIB	A169	ves
dumerili (**)		2 .2.000	95km W of Tesawa	2.0	,	,
(**)	N 00 070000	E 40 000067			A 1 E 4	
(***)	N 28.378083	E 12.832267	Fezzan:	LIB	A154	yes
			105km N of Idri			
(**)	N 28.276650	E 12.882750	Fezzan: 95km N of Idri	LIB	A155	yes
(**)	N 31.299567	E 10.624650	72km S of Nalut	LIB	A140	yes
(**)	N 31 789533	E 10 955800	10km S of Nalut	LIB	A139	ves
(**)	N 32 896867	E 12 153600	ladi Resort	LIB	Δ129	Ves
<u> </u> '	11 02.030001	L 12.133000	7km E of 7	210	1120	yes
		E 10 011222				
	N 17.785217	E -16.041683	30km S of Nouakchott	MAU	A238	yes
	N 18.145250	E -16.028867	10km N of Nouakchott	MAU	A247	yes
	N 18.169783	E -16.028217	12km N of Nouakchott	MAU	A255	yes
	N 18.215017	E -16.034317	15km N of Nouakchott	MAU	A264	ves
	N 21 011117	F -16 290633	160km S Nouadhibou	MAU	A337	ves
	N 21 267150	E 15 055617	250km E Nouadhibou	MALL	A207	100
	UCI 1021.207 100			MAU	MJ21	yes
	IN 21.2///33	E -15.4/031/		IVIAU	A331	yes
1	N 21.303300	E -16.366750	90km E Nouadhibou	MAU	A333	yes
Acanthodactvlus	N 29.850700	E -6.621967	40km E of Four Zauid	MOR	A456	ves
dumerili	N 30 184933	F -5 146600	60km E of Tagounite	MOR	A476	Ves
1		_ 0.110000	seam E or ragounite			,00

r	11 15 000007	E 10 E10 100	<u> </u>		
	N 15.969967	E -16.512433	S.Louis peninsula SEN	I A215	yes
	N 32.908917	E 9.758167	Pipeline track, TUN	I A121	yes
			20km SE of Ksar Ghilane		,
	N 00 007400	E 10 007050		4407	
	N 32.997433	E 10.607950	TITEM INE OF TATAOUINE TUN	A127	yes
	N 33.074750	E 9.615983	Ksar Ghilane at the TUN	I A115	yes
			Roman fort		
	N 22 106792		Dipolino trook TUN		
	N 33.100763	E 9.769667	Pipeline track, I UN	I AII4	yes
			22km NE of Ksar Ghilane		
	N 33 148767	F 9 760833	Pipeline track TUN	L A108	Ves
		E 0.1 00000	20km NE of Koor Chilone	71100	yoo
			ZZKIII INE OI KSAI GIIIIAIIE		
	N 33.338933	E 9.725000	Pipeline track, TUN	I A107	yes
			40km N of Ksar Ghilane		
	N 33 487350		11km NW of Douz TUN	1 402	VOC
	N 33.407330	L 0.900330		A 400	yes
	N 33.615833	E 9.007033	18km N of Douz IUN	I A102	yes
	N 33.900000	E 8.048883	7km W of Tozeur TUN	I A91	yes
Acanthodactvlus longi	nes N 26 120233	F 14 904333	Crossroad to Al Katrun: LIB	A170	Ves
, iou ni iou doty iuo iongi		2	100km E of Murzug	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	jee
			TOOKITI E OI MUIZUQ		
	N 26.804833	E 13.540067	Lake Gabrun LIB	A161	yes
	N 27.493000	E 13.227617	17km E of Idri LIB	A160	ves
	N 30 176150	E 9 441067	7km NW of Ghadames LIB	A148	VAS
	N 30.170130	2 3.44 1007		A140	yes
	N 18.318667	E -15.798717	20km NE of Nouakchott MAL	J A274	yes
	N 19.043167	E -15.116183	100km SW of Akjoujt MAL	J A286	yes
	N 19 104850	F -16 261983	Akchar dunes: MAI	Ι Δ271	VAS
	11 10.104000	L 10.201300	14Elve N of Nevel-1-		yes
			I I SKM IN OF NOUAKCHOT		
	N 20.508083	E -16.238067	15km S of Bir el Gareb MAL	J A344	yes
(**)	N 21 194050	F -13 618433	60km W of Choum MAL	J A310	
(/ / / / / / / / / / / / / / / / / / /	N 21 104492	E 14 120117	100km W of Choum MAL		1/00
()	N 21.194403	E -14.130117	TOOKITI VV OF CHOUTH IMAC	J ASTI	yes
(**)	N 21.198583	E -14.160617	100km W of Choum MAL	J A317	yes
(**)	N 21.261200	E -14.617200	140km W of Choum MAL	J A318	ves
(**)	N 21 261867	E -13 392400	50km W of Choum MAL	Ι Δ302	,
	N 21.201007	E -15.552400		, ,,,,,,	
(**)	N 21.277733	E -15.470317	200km E of Nouadhibou MAL	J A332	yes
(**)	N 21.303300	E -16.366750	90km E of Nouadhibou MAL	J A334	yes
. ,	N 29 854567	F -6 225583	Fra Mhazil - MOF	Α462	Ves
	14 20.004007	E 0.220000		11402	yes
			oukin E of Fourn Zgula		
	N 18.155867	E 11.611333	Fachi NIG	A187	yes
	N 18.788233	E 12.886033	15km North of Bilma NIG	A184	ves
	N 19 371683	E 12 864567	40km N Dirkou NIG	A183	Ves
	19.571005	L 12.004307		AIOS	yes
	N 21.945767	E 13.658117	Madama NIG	A181	yes
	N 33.074750	E 9.615983	Ksar Ghilane at TUN	I A116	yes
			the Roman fort		,
	NI 00 107050	E 0 000550			
	N 33.487350	E 8.906550	TIKM INVV OF DOUZ I UN	I A94	yes
Acanthodactylus	N 35.583317	E 8.482633	3km E of Haidra; TUN	I A80	yes
maculatus			W of Thala		
(**)	N 26 072492		Couth of al Dorrold dome TUN	470	
	N 30.972103	E 9.000750	South of el bellak dalli, 101	I AIZ	yes
			6km W of Nefza		
(**)	N 37.214883	E 9.246183	Cape Serrat beach TUN	I A71	ves
Acanthodactylus	N 29 060550	E 11 95//83	Hamadath al Hamrah: LIB	Δ152	VAS
Acaminouaciyius	N 23.000330	L 11.334403		A102	yes
ct. maculatus (^^)			190km SE of Derj		
(**)	N 29.128717	E 11.785150	Hamadath al Hamrah; LIB	A151	yes
			172km SE of Deri		-
Aconthodootyluo	N 22 906967	E 12 152600	Indi Report: LIR	A 122	1/00
Acantinouactylus	11 32.090001	E 12.10000		A133	yes
scutellatus (**)			7km E of Zuara		
Acanthodactvlus	N 17.392733	E -16.062067	80km S of Nouakchott MAL	J A226	ves
seneralensis	N 17 785217	F -16 0/1683	30km S of Nouskebott MAL	Δ2/3	100
Concyalensis	N 40 4 45050	E 40.000003			усэ
	N 18.145250	E -16.028867	TUKM IN OF NOUAKCHOTE MAL	J A248	yes
	N 18.169783	E -16.028217	12km N of Nouakchott MAL	J A252	yes
1	N 18.215017	E -16.034317	15km N of Nouakchott MAI	J A263	ves
	N 10 702617	E 15 600700	70km NE of Nevelshett MAL	1 4200	,00
	IN 10.703017	E - 13.009700	/UKITI NE UI NOUAKCHOTT MAL	J A280	
(**)	N 20.062450	E -13.808700	110km SW of Atar MAL	J A287	yes
(**)	N 20.164300	E -13,651650	90km SW of Atar MAI	J A288	ves
(**)	N 21 251400	F -13 282033	40km W of Chourn MAL	Δ205	Vee
<u>()</u>	N 20 500000	E 40 000007			усэ
	N 20.508083	E -16.238067	15km S of Bir el Gareb MAU	J A348	yes
	N 20.905100	E -16.402917	110km S of Nouadhibou MAL	J A357	yes
(**)	N 17 228267	E 9 066383	Tazolé well NIG	A191	VAS
<u>``</u>	N 45 700450	E 46 404007		1 4000	you
	IN 15.799150	E -10.494367	Piste S.Louis - Louga; SEN	A220	yes
			PN Langue Barbarie		
	N 15 810700	E 16 509/67	Pisto S Louis - Lougo: SEN	1 4240	1/00
	11 13.012/00	E -10.306407	FISIE S.LOUIS - LOUGA, SEN	AZ 19	yes
			PN Langue Barbarie		
	N 16.509417	E -14.732483	200km of S.Louis SEN	A212	ves
1					,

Latactia langiaguda	N 12 220067	E 1 97/167	60km S Niemov	NIC	DE01	1/00
Lalaslia iongicauda	N 13.229907	E 1.0/410/	OUKITI S INIAITIEY	NIG	D361	yes
	N 15.795867	E -16.494183	Piste S.Louis - Louga;	SEN	D585	yes
			PN Langue Barbarie			
Mesalina guttulata	N 28 443267	E 12 770083	Military checkpoint	LIB	D331	VAS
wesalina gullulala	N 20.443207	L 12.779903		LID	0331	yes
			300km SE of Derj			
	N 29.100867	E -9.466700	6km W of Taggit	MOR	D571	ves
Mesalina olivieri	N 32 908917	E 9 758167	Pipeline track:	TUN	D595	Ves
	102.000017	E 3.7 00 107			DOOD	yes
			20km SE of Ksar Ghila	ane		
	N 33.451583	E 11.080483	7km S of Zarzis	TUN	D321	yes
	N 34 000883	F 8 284733	Cedada at NE of	TUN	D312	ves
	11011000000	2 0.20 11 00	Chatt al Jarid		2012	900
			Choll el Jena			
	N 35.582150	E 8.482633	3km E of Haidra	TUN	D308	yes
	N 25 984100	F -14 489317	10km S of Bouidour	WSA	D555	Ves
Magalina pagtauri(**)	N 21 277722	E 15 470217	200km E of Nouadhibou	MALL	D526	y00
Nesalina pasteun()	N 21.2///33	E -15.470317	200km E ol Nouadhibou	IVIAU	D526	yes
Ophisops occidentalis	N 35.587783	E 8.489767	4km E of Haidra	TUN	D307	yes
Timon pater	N 37.206900	E 10.190733	Raf-Raf	TUN		
Sphonons boulongori	N 20 880167	E 6 711000	30km E of Fourm Zauid	MOP	D570	VOC
Sprienops boulengen	N 29.000107	L -0.711900			0379	yes
Sphenops	N 18.169783	E -16.028217	20km N of Nouakchott	MAU	D498	yes
sphenopsiformis						
Trachylopic offinic	N 14 511500	E 0 702700	210km E of Kayos	MAL	D/53	VOC
	N 14.311300	L -9.702700			D433	yes
Trachylepis perrotetii	N 12.468933	E 1.49511710km W of	border BFA	D412	yes	
	N 16.510050	E -15.479383	120km of S.Louis	SEN	D483	ves
Trachylopic	N 11 846067	E 1 517017	30km S of bordor	REA	D/31	VOC
Tracitylepis	N 11.040907	E -4.517917	SUKITI S UI DUIDEI	DFA	D431	yes
quinquetaeniata	N 11.961417	E 0.393383	10km S Fada N'Gourna	BFA	D420	yes
	N 12.113683	E 0.170033	Diapango	BFA		
	N 12 468033	E 1 405117	10km W of bordor	REA	D/11/	VOC
	N 12.400955			DIA	D414	yes
	N 17.164183	E 8.092983	Air: 20km NE Agadez	NIG	D346	yes
	N 17.710817	E 8.274167	Air: 5km S of Elmiki	NIG	D388	ves
Varanus avanthomaticus	N 16 515600	E 14 673067	210km of S Louis	SEN	D/81	100
	N 10.515000	E -14.073007			D401	yes
Varanus griseus	N 17.402750	E -16.065367	80km S of Nouakchott	MAU	D492	yes
	N 18.169783	E -16.028217	20km N of Nouakchott	MAU	D499	
	N 19 020283	E -15 175617	120km SW of Akiouit	ΜΔΠ	D505	VAS
	N 13.020200	E 10:170017			DUCC	yes
varanus niloticus	N 14.509633	E-9.770600	210km E of Kayes	MAL	D454	yes
	N 16.486117	E -16.297083	35km E of the border	MAU		yes
	N 15 932100	E -16 470267	Piste S Louis - Louga:	SEN	D466	Ves
	10.002100	E 10.470207	Philip C.Eouis Eouga,	OLIN	D-+00	ycs
			PN Langue Barbarie			
Gongylophis muelleri	N 14.521117	E -9.557850	240km E of Kayes	MAL	D444	yes
	N 14 543883	E -9 496033	25km W of Diema	ΜΔΙ	D439	VAS
	N 14.040003	E 40 74407			D400	yes
	N 16.049067	E-13.741167	330km SE of S.Louis	SEN	D469	yes
Crotaphopeltis	N 12.495950	E 2.408617	10km of Tapoua	NIG	D408	yes
hotamboeia						
Notriv mouro	N 25 592450	E 0 400600	2km Γ of Lloidro	TUNI	D200	
Naux maura	N 35.562150	E 0.402033	SKITLE OF HAIDTA	TUN	D208	
Psammophis	N 18.976233	E 12.895933	2km SE of Dirkou	NIG	D340	yes
aegyptius (**)						
(**)	N 40 000047	E 10 000 100	Dilas a sasia	NIC	D044	
()	N 10.090017	E 12.922433	Biima oasis	NIG	D341	yes
Psammophis elegans	N 13.735567	E -8.019500	15km S Didieni	MAL	D434	yes
Psammophis	N 17.392733	E -16.062067	80km S of Nouakchott	MAU	D491	ves
aabalkari (**)						,
SCHOKAH ()						
(**)	N 22.078217	E -16.688433	280km S of Dakhla	WSA	D538	yes
(**)	N 23.126300	E -16.068033	S of Dakhla	WSA	D545	
(**)	N 23 170767	E 16 11/283	150km S of Dakhla	10/90	D5/3	VOC
()	N 23.179707	E -10.114203	ISUKIII S UI DAKIIIA	VV3A	D343	yes
	N 25.043983	E -14.805800	120km S of Boujdour	WSA	D551	yes
	N 26.434667	E -13.994750	60km N of Bouidour	WSA	D557	ves
Psammonhis	N 12 220017	E 0 301900	20km N of Fada	REA	D/121	VAS
	N 12.220017	L 0.301300	ZURININ UTT aua	DIA	0421	yes
sibilans (**)			N'Gourna			
(**)	N 12.758400	E -7.191750	20km W of Fama	MAL	D432	ves
(**)	N 16 120917	F -13 963483	310km SE of S Louis	SEN		,
	N 10.120317	E -10.000400			5540	yes
Scutophis mollensis	N 19.667633	E -14.469400	TUKM SW of Akjoujt	MAU	D513	yes
1	N 20.248900	E -13.336283	45km SW of Atar	MAU	D518	ves
1	N 29 085000	E _8 680850	80km SW of Akka	MOR	D57/	,
1	N 07 500007				D500	усэ
1	IN 27.500867	E -12.97305	TUKM IN OT Dawra	WSA	D062	yes
Spalerosophis diadema	N 33.487350	E 8.906550	12km W of Douz	TUN	D315	ves
Cerastes cerastes	N 31 299567	E 10 624650	73km S of Nalut	LIB	D325	VAC
	N 40 070400				D5020	усэ
Cerastes vipera	IN 18.979133	E -16.209900	TOKM S AKChar dunes	MAU	D503	yes
1	N 21.261867	E -13.392400	40km W of Choum	MAU	D524	ves
1	N 25 758483	E -14 600000	40km S of Bouidour	WSA	D553	,
Estate lawa	N 40 040000				D 470	усэ
Echis leucogaster	IN 16.318333	E -14.21100/	∠rukm ⊨ of S.Louis	SEN	D478	yes
Echis ocellatus	N 11.961417	E 0.393383	10km S Fada N'Gourna	BFA	D419	ves
	N 12 495950	F 2 408617	10km of Tapoua	NIG	D407	VAS
					_ 101	y03

Conservation status of the St Paul's Island wall lizard (Podarcis filfolensis kieselbachi)

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ABSTRACT – The population of the endemic Maltese wall lizard, *Podarcis filfolensis*, on the small island of Selmunett (10.9 ha), off the northeast coast of the island of Malta, has been described as a distinct subspecies *P*. *f. kieselbachi*. Selmunett is a protected site and its lizard is a protected species. Reports of a pronounced decline in the Selmunett lizard population were investigated by systematic visual estimates of lizard population density started in 1999. Since August 1999, population counts declined from a high of 18 individuals observed per hour to zero by August 2005. The rate of decline was greatest for juveniles and females. Numerous cases of predation of the lizards by rats were observed and such predation seemed to be the cause of the decline in lizard population; visual counts of daytime-active rats, also started in 1999, showed a large rat population on Selmunett. In turn, the rat population programme implemented in 2006–2007 exterminated rats from Selmunett by the summer of 2007, when a few lizards captured in 2004 and kept in captivity since were released back on the islet to augment what remained of the population there (some lizards were spotted by casual observers, even if none were recorded during the actual counts). It remains to be seen if this attempt at saving the Selmunett wall-lizard population has been successful.

THE only living lacertid on the Maltese Islands is the Maltese wall lizard, *Podarcis filfolensis* (Bedriaga 1876), a species endemic to the Maltese Islands and the Pelagian Islands of Linosa and Lampione (Lanza, 1972). Four races of this lizard have been named from the various islands of the Maltese group and one race from the Pelagian Islands: filfolensis on the island of Filfla, maltensis (Mertens, 1921) on Malta, Gozo and Comino, generalensis (Gulia in Despott, 1915) on Fungus (= General's) Rock, *kieselbachi* (Fejervary, 1924) on Selmunett (= St. Paul's) Islands, and laurentiimuelleri (Fejervary, 1924) on Linosa and Lampione (Lanfranco, 1955; Lanza, 1972; Baldacchino & Schembri, 2002). Savona Ventura (1983) regards the population on the island of Cominotto (= Kemmunett) as a distinct subspecies, which he did not name, while Bischoff (1986) has suggested that the lizards of Pantelleria, which most workers considered to belong to Podarcis sicula, might actually be Podarcis filfolensis. According to the immunological data of Lanza & Cei (1977) Podarcis filfolensis is closely related to Podarcis

wagleriana, a species endemic to Sicily, however, the genetic investigations of Capula et al. (1988), suggested a closer relationship to Podarcis sicula, a predominantly southern European species, and possibly to *Podarcis melisellensis*, a species of the east Adriatic coast. Recent molecular genetic work (Capula, 1994) has confirmed that the Podarcis filfolensis of the Maltese Islands is a welldifferentiated species most closely related to Podarcis sicula than to any other lizard, that the lizard of Pantelleria is not Podarcis filfolensis but *Podarcis sicula* as originally thought, and that the lizards of Linosa and Lampione belong to Podarcis filfolensis and, surprisingly given the long time the Pelagian Islands have been cut off from the Maltese Islands, that they are very similar to the Maltese populations. All in all this suggests that Podarcis filfolensis is most probably derived from mainland populations of Podarcis sicula which became cut off when the various islands of the Maltese and Pelagian groups finally became separated from the Sicilian mainland. However, the great similarity between the Pelagian and Maltese population of Podarcis filfolensis may



mean that the Pelagian Islands were colonised much more recently by *Podarcis filfolensis* from the Maltese Islands by natural means or through human agency (Capula, 1994).

The named subspecies of Podarcis filfolensis differ mainly in mean body size and coloration, especially of the gular region of males and in the degree of dark markings on the back, flanks and ventral region of the neck (Ferjervary, 1924; Lanfranco, 1955; Lanza, 1972; Savona Ventura, 2001; Baldacchino & Schembri, 2002). However, there are no consistent morphological differences between the various subspecies, and the different subspecies can only be securely named on the basis of provenance, since each isolated population includes a range of forms that overlap with those of other populations. No definitive molecular studies have as yet been made to establish the taxonomic status of the various populations, although unpublished preliminary sequencing of mitochondrial 12S and 16S rDNA from the named subspecies and other isolated populations of Podarcis filfolensis from the Maltese Islands have demonstrated only small and almost negligible genetic differences between the populations (D James Harris, AS & PJS, unpublished data), conforming to the results

Figure 1. Map of Selmunett islet and insets showing its location off the northeast coast of the island of Malta.

obtained by Podnar & Mayer (2005) in their phylogenetic study of central Mediterranean species of Podarcis, including Podarcis filfolensis. However, even if the various named subspecies of Podarcis filfolensis have a very low degree of genetic differentiation between them, these populations may nonetheless be considered as 'evolutionarily significant units' (ESUs) sensu Waples (1986)(populations that are reproductively separate from other populations and have unique or different adaptations), certainly as far as reproductive isolation is concerned, since the named subspecies occur on isolated islets. In this respect, the different microinsular populations of Podarcis filfolensis are of intrinsic interest.

Podarcis filfolensis kieselbachi was described by Fejervary (1924) as Lacerta muralis var. kieselbachi. This race has a mean snout to vent length of 54.4 \pm 4.9mm (Borg, 1989) and is brownish grey with small black patches or reticulations on the back, especially in males; the ventral surface is yellowish with the gular region becoming a bright yellow or orange yellow in males during the breeding season. This subspecies is limited to Selmunett, also known as St Paul's Islands, located off the northeastern coast of the island of Malta and separated from it by a channel that is some 100m wide at the point of closest approach (Fig. 1). Selmunett is an elongated block of limestone rock with a narrow neck of land (100m long and 20-25m wide) that defines a larger western 'island' (440m long and 184m wide) from a smaller eastern 'island' (344m long and 132m wide); this neck of rock is only about 1m above mean sea level such that it is frequently inundated in rough weather, giving the appearance that Selmunett is actually two islands (and hence the reason why this islet is sometime referred to in the plural). The western 'island' has an area of approximately 7 hectares and is just over 23m above mean sea level at its highest point; the eastern 'island' is about 3.9 hectares in area and its highest point lies 8m above mean sea level.

In the past, the land in the central and eastern parts of the west 'island' was cultivated by a farmer who also kept a number of domestic animals and who lived in a small farmhouse on the central-northwestern coast of the larger 'island'; farming activity was abandoned in the 1940s (Farrugia Randon, 2006) and today only the ruined farmhouse and the remnants of the dry-stone walls that formed the field boundaries remain, together with a statute of the Apostle Paul close to the ruins of the farmhouse (Fig. 1). The vegetation of the larger 'island' consists of an impoverished maritime garigue on the low-lying coasts, rupestral assemblages on the cliff coasts, and a low garigue dominated by Pine spurge (Euphorbia pinea), Seaside squill (Urginea pancration), and Golden samphire (Inula crithmoides) on the inland parts with the addition of Common ferule (Ferula communis), Cardoon (Cynara cardunculus) and Prickly pear (Opuntia ficus-indica) on the previously cultivated higher ground at the top of the island (Lanfranco, 1983). Due to its exposure to sea spray, the east 'island' is only vegetated by the same maritime assemblage that is found in the lower lying coastal regions of the west island, consisting of Shrubby glasswort (Arthrocnemum glaucum), Crystal-plant (Mesembryanthemum nodiflorum), Zerapha's sea-lavender (Limonium zeraphae, endemic to the Maltese Islands) and

Maltese sea-chamomile (*Anthemis urvilleana*, also endemic to the Maltese Islands) (Lanfranco, 1983).

Selmunett was originally declared a 'nature reserve' in 1993 under the Environment Protection Act 1991. This designation fully protected all species of flora and fauna on the Island and also restricted access to Selmunett to between sunrise and sunset, and visitors to designated footpaths only. Selmunett was subsequently declared a 'Special Area of Conservation - Candidate Site of International Importance', which is the designation given to sites proposed by the Government of Malta for inclusion in the Natura 2000 network of the European Union's 'Habitat Directive'.

Podarcis filfolensis kieselbachi was first declared a protected species in 1992 with the enactment of the Reptiles (Protection) Regulations, 1992. These regulations prohibit the pursuing, capture, killing, possession, sale, import, export or exchange of all Maltese reptiles. It is presently listed as a 'species of national interest whose conservation requires the designation of Special Areas of Conservation' under the Flora. Fauna and Natural Habitats Protection Regulations, 2006. The Maltese wall lizard (and therefore including the population on Selmunett) is protected internationally by the Habitats Directive (listed in Annex IV 'species of Community interest in need of strict protection') and by the Bern Convention (listed in Appendix II 'strictly protected species of fauna').

One of us (AS) had been observing the reptiles of Selmunett since 1999 and in the summer of 2003 noted a remarkable decline in the population of Podarcis filfolensis kieselbachi on the islet, compared to the situation in previous years. This confirmed anecdotal reports that the other of us (PJS) had received in 2002-2003 from persons who visited Selmunett for the specific purpose of photographing the lizards and who either did not see a single specimen or else saw very few. In order to assess whether the apparent decline in the Selmunett lizard population was a real phenomenon and if so, to quantify it, we developed the observations initiated in 1999 into a census of the lizards on Selmunett that is still ongoing. Here we report on our results for the period 1999-2007.

METHODS

At the time we were alerted that the *Podarcis* populations on Selmunett may be declining, we already had five years worth of data collected as part of a general study on the reptiles of Selmunett. Since this was the only quantitative data on the lizard populations of the island that existed, we were constrained to use this as our baseline and to use the same sampling protocol that had been used since 1999, even it this was not specifically designed to census the *Podarcis filfolensis kieselbachi* population.

Selmunett was visited during spring or summer (when lizards are most active) at least once every year since 1999, and in most years, the island was visited more than once in spring-summer and sometimes also in autumn and winter during sunny periods (when lizards are also active). When the island was visited multiple times in the same month of a particular year, the data for the different visits during that month were combined. For surveying, Selmunett was divided into six sections and during each visit, an observer visited each section in turn and took a fixed position at the boundary of the section, then used binoculars to scan the area within the section. Any lizards or other reptiles or mammals that were spotted within the section were identified and recorded, and note was taken of their behaviour. In general, each section was scanned for one hour, however, when this was not possible due to logistic difficulties, each section was scanned for a shorter period, that was however never less than 30 minutes. On some occasions, each sector was scanned for 1.5 h and sometimes for longer. Because of the variable time of each survey, the abundance data were standardised to 'individuals per hour'. Because the lizards are territorial and they could be identified individually due to their markings, no lizards were counted twice during the same survey.

RESULTS

During the period 1999–2007, Selmunett was visited on 39 separate occasions, grouped in 26 months: 20 months in spring-summer and seven months in autumn-winter. The relative abundance of *Podarcis filfolensis kieselbachi* estimated as described above is plotted in Fig. 2. It is clear that



Figure 2. Variation in population density of *Podarcis filfolensis kieselbachi* on Selmunett, estimated as number of individuals counted per hour of observation, for the period 1999-2007.

starting from August 1999 (the first of our summer population counts; 18 ind. h⁻¹), the population has suffered an exponential decline such that by August 2005 we did not count any individuals, a situation that persisted in 2006 and 2007. The plot of the spring-summer abundances of males, females and juveniles (juveniles are most active in spring-summer) (Fig. 3) shows that by April 2004, no more juveniles were spotted during the surveys while the sex ratio became heavily skewed suggesting a differential towards males. disappearance of the small-sized individuals (juveniles and females, which are smaller than males: mean snout to vent length of males = 56.7 \pm 2.9mm, females 48.3 \pm 2.3mm; Borg, 1989).

In the July 2001 survey we recorded two carcasses of *Podarcis* and one of the gecko

Figure 3. Variation in population density of male, female and juvenile *Podarcis filfolensis kieselbachi* on Selmunett, estimated as number of individuals counted per hour of observation, for summer counts in the period 1999-2007.





Figure 4. Variation in population density of daytimeactive rats on Selmunett, estimated as number of individuals counted per hour of observation, in the period 1999-2007.

Hemidactylus turcicus in the central part of the eastern Selmunett 'island' while during the course of four separate visits in August of the same year we recorded four Hemidactvlus carcasses, 1 carcass of the gecko Tarentola mauritanica, and two carcasses of the Leopard Snake Elaphe situla, one of which was missing the head, and another injured Elaphe; on five occasions we recorded dead Podarcis being eaten by rats (Rattus sp.) and we witnessed three chases of *Podarcis* by rats, which were unsuccessful. These observations suggested that a possible cause of the decline in the lizard population was predation by rats. Since we had already been recording the density of rats spotted during the surveys, we continued to record rat abundance and these results are given in Fig.4. Note that since rats are mostly active by night while our surveys were made during the day, rat abundance is probably grossly underestimated; however, the results are nonetheless indicative of a large and thriving rat population on Selmunett. Predation of Podarcis was confirmed by direct observation on at least four occasions: in August 2003 we observed a rat with a live juvenile Podarcis in its mouth; in February 2004 we witnessed a successful chase and capture of a Podarcis by a rat, and in April of the same year, the capture of the female of a courting pair; and in November 2004 another successful chase and capture of a female Podarcis by a rat. Apart from the observations reported above, we came across

half-eaten carcasses of *Podarcis* in August 2002 (2 carcasses), August 2003 (1 carcass) and October 2003 (3 carcasses), and May 2004 (1 carcass). We also noted carcasses of *Hemidactylus turcicus* and *Tarentola mauritanica* on numerous occasions as well as the capture by a rat of one individual of each species (in October 2003 and April 2004, respectively). On one occasion only (August 2002), we witnessed the successful predation of a juvenile *Podarcis* by a Spanish sparrow (*Passer hispaniolensis*).

On the basis of coloration and general morphology, the majority of the rats observed on Selmunett appeared to belong to *Rattus rattus*; however, on at least one occasion, a rat conforming to the description of *Rattus norvegicus* was spotted, so both species may occasionally co-occur on Selmunett, at least temporarily.

Concerned about the rapidly declining population of Podarcis filfolensis kieselbachi on Selmunett, in November 2003 a report on the situation was lodged with the Environment Protection Directorate (EPD) of the Malta Environment and Planning Authority, the agency concerned with the management of protected species and protected areas in Malta, in which a number of recommendations were made, including that the rat population needs to be controlled or eradicated. Such an eradication programme was initiated in April 2006 and by the end of summer 2006. Selmunett was declared rat-free. In the meantime, one of us (AS) keep six individuals of Podarcis filfolensis kieselbachi in captivity with the intention of returning the species to the wild after rats are exterminated from Selmunett: four males and two females were collected in 2004, and five (one senescent male died in captivity) were handed over to the EPD in May 2006 for eventual release. Members of the EPD reported glimpsing some lizards on Selmunett during visits in connection with the rat eradication programme, and in June 2007 the EPD decided to release the remaining lizards back on Selmunett in a last attempt to augment any surviving population of lizards and possibly enable the population to recover in the absence of predation by rats. Our last survey on Selmunett was in March 2007, before the release of the captive lizards and we did not spot any lizards on that occasion.

DISCUSSION

There is no doubt that a large population of Podarcis filfolensis kieselbachi originally existed on Selmunett; while no quantitative population estimates had been made before the present study, Moravec (1993) reports that in August 1986 the population on Selmunett was "very dense", while one of us (PJS), who has visited the islet regularly since the late 1970s, estimates an 'order of magnitude' population density of at least one individual per 100m² up to the early 1990s. Such a density would give a total population of some 1000 individuals for the whole of Selmunett. The highest number of lizards observed in the present study was 127 in 11 hours of observation on 17 August 2001, which even on an order of magnitude basis, is much lower than the estimated pre-2000 population density. Whatever the population density was before the present study, it declined during the period 1999–2007, reaching zero values in 2006 and 2007. This is not to say that the population is extinct, since some individuals were spotted in 2006 and the individuals kept in captivity were released back on the island in 2007, however, whether the population will recover depends on many factors, especially if any of the individuals that remained on the island were female and were still of reproductive age and thus capable of breeding with any resident males or those released. The fate of Podarcis filfolensis kieselbachi is presently unknown, however, if not already extinct, the population will be severely endangered for the foreseeable future.

Predation by rats seems to be the most likely cause of the decline in the Podarcis filfolensis kieselbachi population on Selmunett. Direct predation of lizards by rats was observed on numerous occasions (and of geckoes as well), and carcasses of lizards, geckoes and snakes were frequently encountered. The successful attacks by rats on lizards were predominantly on smaller individuals (juveniles and females) which may explain why as the population declined males started outnumbering females and juveniles, and when six lizards were captured in 2004, these were all large individuals. The differential targeting of small lizards by rats leads to the concern that even if some lizards have survived on Selmunett following eradication of the rats, these are males and post-reproductive females. Juvenile lizards may also be targeted by Spanish sparrows as observed on one occasion. Fornasari & Zava (2000) seem to have observed regular predation of *Podarcis filfolensis laurentiimuelleri* by Spanish sparrows on Linosa; however, while such predation may contribute to the decline of *Podarcis filfolensis kieselbachi* on Selmunett, all evidence points to predation by rats as being far more significant.

Since rats have been present on Selmunett for decades, the question arises as to why predation by rats should suddenly cause a decline in the Podarcis population. We hypothesise that the reason for this is a change in the levels of human presence and in the nature of human activities on Selmunett. When Selmunett was still being farmed, the only human presence on the island was the farmer and his family who occupied the upper room of the (now derelict) three-roomed farmhouse (Farrugia Randon, 2006); from this it can be deduced that the farmer's family could not have been too numerous and in any case, the farmer did not live permanently on Selmunett but resided on Malta (Farrugia Randon, 2006). In 1958, Selmunett was given on a 30 year emphyteusis and the tenants bred rabbits on the island to hunt, and used the farmhouse for weekend stays on the island (Farrugia Randon, 2006) (we never noted any rabbits or their droppings during any of our visits to Selmunett in connection with our surveys). During this period, only fishers and a few visitors frequented the island so human presence was low key. In 1988, Selmunett reverted to the Government of Malta and in 1993 it was declared a 'nature reserve'; visitors were allowed on the island during the daylight hours for swimming and walking on the designated paths, but all other activities were prohibited. However, as noted by Farrugia Randon (2006), these regulations were seldom respected and they were not enforced by the authorities; in particular, the islands became popular with boat owners as a bathing and barbeque spot, and as more people started owning boats during the 1990s so did human presence on the island increase. A direct consequence of this was that a great deal of organic material, including food waste, started to accumulate on the island and it is our opinion that the rat population bludgeoned as a result, and when food became scarce for any reason, predation on the herpetofauna, including the lizard population, increased.

Although there do not seem to be any genetic differences that justify separation of the Semunett population of Podarcis filfolensis as a distinct subspecies, nonetheless, all indications are that this population is reproductively isolated from any other populations in the Maltese archipelago, while it also shows some phenotypic differences. Therefore, the Selmunett population qualifies as a 'management unit' sensu Moritz (1994) (a population that is currently demographically independent from other populations), and possibly also as an ESU. The Selmunett population of Podarcis filfolensis is therefore of conservation as well as of cultural value (Baldacchino & Schembri, 2002) and all efforts should be made to conserve it. Only future monitoring will tell if the efforts made in this respect have been in time and sufficient to achieve this.

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Seasonal activity and reproductive characteristics of an oldfieldgrassland snake assemblage: Implications for land management

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ABSTRACT – We examined the seasonal activity and aspects of reproduction of a snake assemblage during September 2001-September 2004 at the James H. Barrow Field Station in northeastern Ohio. Peak activity for the five species (*Lampropeltis triangulum, Nerodia sipedon, Storeria dekayi, S. occipitomaculata, Thamnophis sirtalis*) captured under cover boards occurred in June and August. June and July were the months with most gravid females, and August was associated with a peak in numbers of juveniles observed for most of these species. The temporally localized peak of activity should be kept in mind when considering mechanisms such as burning, disking, or mowing to maintain the integrity of this vanishing habitat.

NORTH America has lost 80% of grasslands since the 1800s (Brennan and Kuvlesky, 2005). In the East, encroachment of forest is the main cause, whereas in the Midwest fragmentation from agriculture is most responsible for this loss (Brennan & Kuvlesky, 2005). In Kansas, the collapse of a diverse grassland herpetofauna was monitored during an extended period of fire suppression (Fitch, 2006a,b). Only 0.5% remains of Ohio's original 2,591 km² native tallgrass prairie, and secondary grassland habitat, such as pastures and hayfields have declined 61% and 46%, respectively, since 1950 (Swanson, 1996). We undertook a snake monitoring project in secondary grassland sites at a biological preserve in the Glaciated Allegheny Plateau section of northeastern Ohio to understand the seasonal activity patterns and reproductive seasons of this segment of the biota in the context of making sound land management decisions of northeastern grasslands.

STUDY SITE AND METHODS

The James H. Barrow Field Station (JHBFS) is a 121.4 ha reserve that is privately owned and operated by Hiram College and is located in Hiram Township, Portage County, Ohio. Located in the Glaciated Allegheny Plateau region in northeastern

Ohio and founded in 1960, JHBFS contains habitats that range from various stages of oldfield succession and pasture to 67% forest coverage of a primarily Beech-Maple community. Creeks and artificial ponds are present on the property. The station is surrounded by farms and rural residences. This study ran from September 2001 to September 2004. In each of three oldfield sites, 10 1X1 m cover boards of untreated plywood were set 2 m apart from one another along a transect, where they were exposed to direct sunlight for most of the day. Over the course of the study, 30 cover boards were checked on 35 days during May-September. Because, for logistical reasons, cover boards were not checked prior to May, our conclusions speak to the seasonal activity patterns from May onwards. Cover boards were checked in the morning, while the ambient temperature was cool or cold and presumably before snakes became active. In this regard, long term average monthly high air temperatures during Mav-October ranged 15.6–26.7 C and monthly average low air temperatures for this same period ranged 10.0–21.1 C.

Snakes that were captured under the cover boards were identified to species, sexed, and their body lengths were measured in cm as snout-vent length (SVL). A subset of snakes was individually



Figure 1. Seasonal activity of males, females, and juveniles of the Milk snake (*Lampropeltis triangulum*) during May-September at JHBFS.



Figure 2. Seasonal activity of five species of snakes during May-September at JHBFS.



Figure 3. Seasonal distribution of body sizes of males, females, and juveniles of the Milk snake (*Lampropeltis triangulum*) during May-September at JHBFS.

marked with AVID Passive Integrated Transponder (PIT) tags, and a subset of new animals was used for the seasonal distribution of body size scattergrams. All other figures are based on total numbers of individuals observed. Common names follow Collins & Taggart (2002). Means are followed by ± 2 standard deviations, and statistical significance was recognized at p < 0.05.

RESULTS

Lampropeltis triangulum (Lacepede, 1788). With 44 observations, the Milk snake was captured during May-September and most active in June (Figure 1). The snake assemblage generally was active during May-September but appeared to peak bimodally during May-June and again in August (Figure 2). Males were most noticeable in July, whereas females were most noticeable during May-June (Figure 1). Juveniles were captured most in June and again during August-September (Figure 1) with the smallest individuals apparent in July (Figure 3). From a small sample, Mean body size of males (mean = 52.9 ± 8.92 cm SVL; range = 43.0–63.0; n = 5) was significantly different (z =-3.245; p < 0.000) than that of females (mean = 75.3 ± 15.92 cm SVL; range = 55.0–92.0; n = 8).

Nerodia sipedon (Linnaeus, 1758). With 22 observations, the Northern water Snake was captured during May and July–September and was most noticeable in May and August (Figure 4). The snake assemblage generally was active for all five months with two peaks in activity (Figure 2). Males were scarcely captured; however, females peaked in numbers in May and again in August (Figure 4). Juveniles were most apparent in August (Figure 4), the two smallest of which measured 32.5 and 33.0 cm SVL. We measured three males (38.0, 46.0, 69.0 cm SVL) and one female (63.0 cm SVL).

Storeria dekayi (Holbrook, 1836). With 102 observations, the Brown Snake was captured during June–September with generally high numbers of sightings until September (Figure 5). The snake assemblage of JHBFS generally was active during all five months; however, the peak activity for the assemblage was bimodal (Figure 2). Males were more active during the latter part of the season than at the beginning, whereas female activity climbed in June and July and sharply decreased thereafter (Figure 5). Juveniles were evident in June, August and September, and peaked

in August (Figure 5). The smallest gravid female measured 25.0 cm SVL. The gravid condition was most evident during June-July, the incidence of which sharply decreased and ended in August (Figure 6). This pattern to nesting season was similar to that of the snake assemblage generally of the station (Figure 7). The body size distribution of this species indicates that the peak in juveniles at the end of the season (Figure 8) was associated with a peak in parturition in August (Figure 6). The seasonal distribution of Brown Snake body sizes also suggests sexual maturity by the following August, which could explain larger numbers of males at that time in association with fall breeding. The mean body size of males (24.1 \pm 2.9 cm SVL; range = 20.0–31.1; n = 22) was significantly different (t = -6.306; df = 56; p <0.000) than that of females (28.4 + 2.2 cm SVL); range = 25.0-34.0; n = 36).

Storeria occipitomaculata (Storer, 1839). With 19 observations, the Northern redbelly Snake was active during June-September with most observations occurring during June followed by a lesser peak in September (Figure 9). This observed pattern in the Redbelly snake is shorter than that of the snake assemblage generally at the station (Figure 2). Likewise, peak patterns of its activity (Figure 9), although bimodal, are somewhat different than of the entire assemblage (Figure 2). No males of this species were captured in this study; however female activity peaked in June, and juvenile activity peaked in September (Figure 9). In this connection, juveniles ranging 9.5–10.0 cm SVL were taken during August-September. The smallest gravid female measured 25.0 cm SVL, and all females captured during June-July were gravid, which is one month shorter than that reported for the snake assemblage generally at the station (Figure 7).

Thamnophis sirtalis (Linnaeus, 1758). With 321 observations, the Common garter Snake was recorded in all five months of the study, with most observations having occurred during May–June and again in August (Figure 10). Both of these patterns mirrored those of the snake assemblage generally at the station (Figure 2). Males were active in each of the five months studied but especially so during May–June and in August (Figure 10). Females were also active throughout



Figure 4. Seasonal activity of males, females, and juveniles of the Northern water snake (*Nerodia sipedon*) during May-September at JHBFS.



Figure 5. Seasonal activity of males, females, juveniles, and unknown individuals of the Brown snake (*Storeria dekayi*) during May-September at JHBFS.



Figure 6. Seasonal frequency of gravid females of the Brown snake (*Storeria dekayi*) during May-September at JHBFS.

the season but numbers tapered off after a peak during May–June (Figure 10). Juveniles, also active throughout the season, were especially noticeable in May and August (Figure 10). The



Figure 7. Seasonal distribution of gravid females of the Brown snake (*Storeria dekayi*), Redbelly snake (*S. occipitomaculata*), and Common garter snake (*Thamnophis sirtalis*) during May-September at JHBFS.



Figure 8. Seasonal distribution of body sizes of males, females, and juveniles of the Brown snake (*Storeria dekayi*) during May-September at JHBFS.

smallest gravid female measured 45.0 cm SVL, and the highest incidence of gravid females occurred during June-July, after which time gravid females were scarcely present in August and none thereafter (Figure 11); a pattern that was similar to that of the snake assemblage generally (Figure 7). The bimodal peak in male activity could represent two mating periods, between which females were parturient. The May peak in juveniles (Figure 10) represented overwintering juveniles that were born as late as the previous August and September (Figure 12), which was the second peak in activity of juveniles (Figure 10). The seasonal distribution of those body sizes suggests that sexual maturity occurred during the following June in males and as early as the following August for females (Figure 12). This



Figure 9. Seasonal activity of females, juveniles, and unknown individuals of the Redbelly snake (*Storeria occipitomaculata*) during May-September at JHBFS.



Figure 10. Seasonal activity of males, females, juveniles, and unknown individuals of the Common garter snake (*Thamnophis sirtalis*) during May-September at JHBFS.

growth rate would explain the scarcity of juveniles during June–July (Figure 10) replaced by young adults (Figure 12). Mean body size of males (38.5 + 4.9 cm SVL; range = 29.0-53.0; n = 49) was significantly different (t = -13.13; df = 90; p < 0.000) than that of females (53.5 + 6.0 cm SVL; range = 45.0-68.5; n = 43).

DISCUSSION

The snakes of JHBFS adhered to unimodal or bimodal activity patterns that typify temperate zone snakes (Gibbons & Semlitsch, 1987). Strong seasonal pulses of activity are evident in snakes of Indiana (Minton, 2001), northern Ohio (Conant, 1938), Pennsylvania (Hulse *et al.*, 2001), and Connecticut (Klemens, 1993). The same is true in southerly populations such as South Carolina (Gibbons & Semlitsch, 1987) and southern Florida (Dalrymple et al., 1991), where frequency of winter or dry season activity tends to be higher than in northern sites. At JHBFS, the assemblage and three species (Northern water snake, Redbelly snake, Common garter snake) exhibited bimodal peaks in their seasonal activity, and two species (Milk snake, Brown snake) exhibited a unimodal peak in their seasonal activity. Although we do not know the extent to which snakes were active snakes in April, by May activity was pronounced and by September activity had waned in this population. Within this five or six month activity season, reproduction was likewise constrained. For example, the frequency of gravid females among the four species for which we had data peaked in July. For one species, the Redbelly snake, the season also ended in July. For the other two species, the Brown snake and Common garter snake, remaining gravid females were collected in August. The latter two snakes appeared to have given birth as late as September, and the Common garter snake may have mated a second time the previous month. For some species, such as the Redbelly snake, birthing seasons are relatively constant across its geographic range (e.g., Palmer & Braswell, 1995; Dundee & Rossman, 1996; Minton, 2001), whereas for others, like the Brown snake and Common garter snake, birthing seasons seasonally expand as one proceeds southward in their geographic ranges (e.g., Dalrymple et al., 1991; Larsen et al., 1993; Meshaka, 1994; Minton, 2001).

Consequently, it is safe to conclude that aboveground risks to individual snakes are highest beginning at least in May (risks prior to May are unknown this study) and last through August after which time surface activity declined precipitously. In many cases, as in the Northern redbelly snake, the risk is directed to gravid females that are thermoregulating in grass tussocks or under the cover boards. Likewise, the geographic variation among patterns speaks to the importance of region and sitespecific data concerning life history phenologies, such as seasonal activity and reproductive seasons, for predictive power in hypothesis testing and in accuracy of management strategies.

In this connection, a wide range of management options are available to maintain grasslands within which these species occur. With mixed success,



Figure 11. Seasonal frequency of gravid females of the Common garter snake (*Thamnophis sirtalis*) during May-September at JHBFS.



Figure 12. Seasonal distribution of body sizes of males, females, and juveniles of the Common garter snake (*Thamnophis sirtalis*) during May-September at JHBFS.

these include techniques such as burning (e.g., Greenfield et al., 2003; Fynn et al., 2004), disking (Greenfield et al., 2003), and mowing (Fynn et al., 2004). For the grasslands in the Midwest, a diverse program of burning, having, mowing, and grazing has been proposed for management (Swengel, 1998). The former method affects earthworm abundance (James, 1988), an important food item for The Redbelly snake, Brown snake, and Common garter snake, the latter two of which are likewise affected by fire (Wilgers & Horne, 2006). Each of these management protocols can bring with them potential injury to wildlife. In light of our findings, we proffer here that the timing of management techniques, such as those mentioned above, be considered in relation to segments of the faunal community whose phenologies could be subject to negative impacts by summer land

management programs. Thus, for the snake fauna of JHBFS, which we feel represents the fauna of neighboring parts of northeast Ohio, such activities are safest done after September.

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NATURAL HISTORY NOTES

CHIRONIUS EXOLETUS (Common whipsnake): PREY AND POSSIBLE DIET CONVERGENCE. Neotropical colubrid snakes of the genus Chironius inhabit rainforests in Central and South America (Dixon et al., 1993). These snakes are diurnal, terrestrial to arboreal and feed on frogs (Dixon et al., 1993). Arboreal species of Chironius feed mainly on Hylidae anurans (Dixon et al., 1993; Marques & Sazima 2004). Chironius exoletus is a medium-sized snake, with a slender body that forages mainly from shrubs and trees (Marques & Sazima, 2004); its diet is based mostly on treefrogs but it preys on other anurans and lizards as well.

Here I report an unexpected treefrog as prey, *Trachycephalus mesophaeus* (Hylidae), found in the gut of an individual of *Chironius exoletus*. When disturbed, treefrogs of the genus *Trachycephalus* are known to release an abundant poisonous adhesive milky secretion from their skin (Duellman, 1956; Delfino *et al.*, 2002). This provides them with protection against predation, similar to that which occurs in other amphibians such as newts (Arnold, 1982). The snake was an adult male (MNRJ 585, 701 mm SVL, broken tail, 87 g mass) from Santa Catarina state, southern Brazil. The prey (70 mm SVL, male, 8,1 g mass) was ingested headfirst and was intact. The prey/predator mass ratio was 0.09.

Although previous information reported an individual Trachycephalus in the gut of Chironius foveatus (Dixon et al., 1993), this is the first record of Trachycephalus mesophaeus as prey of Chironius exoletus. Besides that, Trachycephalus venulosus has already been reported as having been successfully eaten by snakes of the genus Leptophis (Henderson & Nickerson, 1977; Prado 2003; Albuquerque & Di-Bernardo, 2005) and Liophis poecilogyrus (Silva et al., 2003). However, an adult Drymarchon corais (Leary & Razafindratsita, 1998) and a Leptodeira annulata ashmeadii (Manzanilla et al., 1998) failed to ingest individuals of the genus Trachycephalus. Moreover, Lutz (1973) reported a T. venulosus being dropped by a bird and human injury by Trachvcephalus has also been recorded previously (Duellman, 1956; Janzen, 1962).

The genera *Drymarchon*, *Chironius* and *Leptophis* belong to the subfamily Colubrinae but *Liophis* is a Xenodontinae genus. Therefore having *Trachycephalus* as prey may indicate an ecological diet convergence. Furthermore, these data could indicate an ability of *Chironius* to handle and swallow a dangerous unpalatable prey, similar to that observed for other snakes such as *Liophis epinephalus* and *Heterodon* spp (Greene, 1997).

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CROTALUS TRISERIATUS (Dusky rattlesnake): **BODY TEMPERATURE**. The physiological ecology of rattlesnakes is a new field of research; however recent studies offer intriguing glimpses that have significant bearing on our standing of their ecology and evolution (Campbell & Lamar, 2004). Nowadays, there are few reports about thermal ecology from this species group, specifically from *Crotalus*

triseriatus there are not studies about its thermal biology. Here we present first data of thermal ecology in this species.

From February to October 2007, we conducted field work in Magdalena Petlatalco, Delegación Magdalena Contreras, Sierra del Ajusco, México, Distrito Federal (19°13'15.5''N, 99°17'8.2''W, WGS84; elev. 3500 m). The climate is temperate semihumid (Cw) with a mean annual temperature of 7.5-13.5°C and a mean annual rainfall of 1340 mm (García, 1973). The vegetation is represented by pine forest (Pinus hartwegii) and zacatonal (Muhlenbergia quadridentada, Festuca hephaestophila and Festuca amplissima) (Álvarez del Castillo, 1989). The data presented are based on 15 captures. From each capture, body (T_b), substrate (Ts at the exact point of observation) and air temperatures (T_a at 1 m above substrate) were measured to nearest 0.2°C with a Miller & Weber $(0-50 \pm 0.2^{\circ}C)$ quick reading thermometer. We also recorded microhabitat type for each capture.

Mean body temperature of *C. triseriatus* was $20.83 \pm 5.36^{\circ}$ C (12–31°C; n = 15). Mean substrate and air temperature were $16.64 \pm 5.93^{\circ}$ C (11.1–32°C) and $16.46 \pm 3.64^{\circ}$ C (12–22°C), respectively.

Body temperature and T_s were significantly correlated (Sperman Rank correlation: $r_s = 0.5588$, P = 0.0471), but T_b and T_a were not (Sperman Rank correlation: $r_s = 0.4596$, P = 0.1141). Most snakes were found under trunk (n = 8), the remainder were found on ground (n = 6) and vegetation (n = 1).

Snakes living in temperate areas often encounter large temperature fluctuations and thus many have evolved strategies to maintain a preferred T_b (Peterson, 1987). *Crotalus triseriatus* has a high field body temperature which could be the result of behavioral thermoregulation selecting different microhabitats to maintain their preferred T_b as happens with other species (Graves & Duvall, 1993). Higher T_b may allow snakes to digest prey, speed the recrudescence of reproductive organs, and/or further the development of embryos (Graves & Duvall, 1987). As a result *C. triseriatus* may maintain a strong relation between T_s and T_b , which appears to have a strong effect on activity patterns in other *Crotalus* species (Jacob & Painter, 1980).

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BOOK REVIEWS

Atlas des reptiles du Cameroun

Laurent Chirio and Matthew Lebreton 2007. Muséum national d'Histoire naturelle, IRD, Paris. 688 p.

This "Atlas" is an atlas in both the older, geographic meaning and the more recent use of this term for a volume of photographs. Weighing in at $1\frac{1}{2}$ kg and 688 pages, this treatment of the reptiles of Cameroon is a heavyweight to hold, let alone to carry anywhere! The weight results from the luxuriant production we have come to expect of IRD, with abundant and sometimes superfluous use of colour for diagrams as well

as photographs. An introductory 20 pages provide background on geology, geography, climatology, topography and vegetation with maps of vegetation and administrative districts but not climatology or topography. The core of the book (621 pages) is a systematic listing of Orders and Families and within the latter of each species by its scientific name in alphabetical sequence. The last is a welcome divergence from the usual practice of grouping by supposed affinities which is familiar to none other than a few aficionados. Indexes to scientific and French vernacular names appear at the end (pages 678–685) but not to English vernacular names although these are given in the text.

Each species gets a double page treatment with a left page of text providing information on the known geographic distribution within and without Cameroun, advice on how to identify and where it is to be found, conservation status and a recent bibliographic source; on the right a coloured photograph of the species accompanies a coloured map of Cameroon with locality plots distinguished according to whether they are supported by specimens now in the Paris museum (MNHN) collection or based on published or sight records.

By way of analysis the systematic 'core' is preceded by a geographic analysis (p. 22–24) which attributes the 8500 specimens of 274 species collected from about 1000 localities to half degree squares of latitude and longitude and is followed (p. 658–667) by biogeographic and habitat analyses; unsurprisingly the greatest number of species occur in the western evergreen forests.

It is a revelation that after the collections and publications by many earlier researchers -Sternfeld, Mertens, Monard, Perret, as many as four geckos (of a total of 26), three skinks (total of 33) and two colubrid snakes (total of 90) have been described as new species since the year 2000 and in the present work four agamids (of total of 11), four skinks and three snakes are listed as "n.sp." although it is more than likely that some of these "new" species will be found to have been described from outside Cameroun. A measure of how much our knowledge has increased is to compare Perret's (1961) list of 119 Cameroun snake species with the 152 listed in this work - an increase of more than one quarter. Some species date much earlier but have been treated as variants of other species only to be more recently disinterred from synonomy e.g. Atheris subocularis Fischer, 1888 rescued by Lawson et al. (2001) from synonomy with A.squamigera; others were long considered subspecies but are now given full species rank e.g. Mehelya savorgnani (Mocquard, 1887), treated as a subspecies of M. capensis but given species rank by Broadley (2005).

The only serious criticism of this work is the uneven quality of the photographs which range

from excellent to abysmal! The admirable plan was to illustrate every species with a photograph and in some cases there is little to choose from but in many cases the lighting, focussing or composition of the authors' own photographs are – I regret to say, substandard. Furthermore, the text sometimes contradicts what is to be seen in the photograph eg. *Thrasops jacksonii* is described as "uniformément noire" but in the photograph appears white tinged with yellow! Too often the snakes are obviously posed dead. It is to be hoped that the popularity of this volume will lead to further editions in which inadequate photographs will be replaced.

The price of E58 translates to UK $\pounds 50 + \pounds 10$ postage/packing which is about twice the cost of Bons & Geniez (1996), the Amphibians and Reptiles of Morocco, but that is half the length and covered only 98 species of reptiles; this volume is not as expensive as may first appear and certainly is worth getting.

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