The
HERPETOLOGICAL BULLETIN

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Contents

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The Herpetological Bulletin is produced quarterly and publishes, in English, a range of articles concerned with herpetology. These include society news, selected news reports, full-length papers of a semi-technical nature, new methodologies, natural history notes, book reviews, letters from readers and other items of general herpetological interest. Emphasis is placed on natural history, conservation, captive breeding and husbandry, veterinary and behavioural aspects. Articles reporting the results of experimental research, descriptions of new taxa, or taxonomic revisions should be submitted to *The Herpetological Journal* (see inside back cover for Editor's address).

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Front cover illustration. *Pseudoeurycea leprosa* © Uri Omar García-Vázquez. See article on page 15.

LETTERS

RONALD MAXWELL SAVAGE – AN APPEAL FOR INFORMATION

I am hoping to write a short tribute to R. Maxwell Savage, a pioneering British herpetologist who carried out groundbreaking work on Common Frog ecology in the 1930s. I would be delighted to hear from anyone who knew him, and especially to learn about any surviving relatives (he died in the 1980s). At present I have very little biographical information.

If you can help, please contact Trevor Beebee by:

Tel.   01273 606755 (work)
        01273 305634 (home)
Email: t.j.c.beebee@sussex.ac.uk
Letter: 434 Falmer Rd,
        Woodingdean,
        Brighton,
        BN2 6LG.

Thanks in anticipation.

RESEARCH ABSTRACTS

HERPETOFAUNAL MORTALITY ON ROADS.

In this study 145 points throughout a 353-km highway network were surveyed in New York State, USA, for road kill of reptiles and amphibians. Land cover, wetland configuration and traffic volume data were used to identify features that best predicted hot spots of herpetofauna road mortality. Forty points were resampled over four times over four years to evaluate temporal repeatability. Both amphibian and reptile road mortality was spatially clustered and road kill hot spots of the two taxa overlapped. One survey provided a valid snapshot of spatial patterns of road mortality and spatial patterns remained stable across time. Road kill hot spots were located where wetlands approached within 100 m of the road and the best predictor was a causeway configuration of wetlands (wetlands on both sides of the road).

Causeways proved to be predictors of road mortality by surveying 180 causeways and 180 random points across five regions (17,823 km^2) of northeastern New York. Causeways were three times more likely than random locations to have amphibian and 12 times more likely to have reptile mortality. Causeways had four times as much total number of amphibian road kill and nine times as much reptile roadkill than randomly sampled points. The study clearly concluded that it is possible to identify hot spots of amphibian and reptile road mortality. This is useful when planning for roads to locate priority areas for mitigation.

Langen, T.A., Ogden, K.M. & Schwarting, L.L. (2009). Predicting hot spots of herpetofauna road mortality along highway networks. *J. Wildlife Man.* **73** (1), 104-114.

POPULAR HERBICIDE (ATRAZINE) AFFECTS SEXUAL DEVELOPMENT IN FROGS.

The controversy surrounding the unintended effects of herbicide and pesticide use has intensified as researchers from the University of Ottawa's Department of Biology have identified that atrazine, a heavily-used herbicide, alters sexual development in frogs. There have been numerous scientific and journalistic reports on the detrimental effects of herbicides, including atrazine, yet investigations by other research teams report minimal adverse effects of the popular herbicide.

In an attempt to help resolve differences between the various reports, Dr. Vance Trudeau and his team at the University of Ottawa's Centre for Advanced Research in Environmental Genomics developed a system to evaluate the effects of a commercial formulation of atrazine. Specifically, Ph.D. student Valérie Langlois applied it to outdoor tanks where tadpoles of leopard frogs were kept for an entire spring and summer. Under these semi-natural conditions (in mesocosms), the levels of atrazine were low and comparable to those measured in the Canadian environment. At the end of the summer,

the results showed that atrazine levels in the tanks were at levels within currently acceptable guidelines. However, researchers also found that the herbicide reduced the number of tadpoles reaching the froglet stage. Also noteworthy was that atrazine had a feminizing effect on the frogs, resulting in sex ratios favouring females, with a reduced number of males.

This study raises important questions about the level of atrazine in the environment, and its negative effects on animal development. Atrazine is one of the top selling herbicides used worldwide. It was designed to inhibit weed growth in cornfields. It is so widely used that it can be detected in many rivers, streams and in some water supplies. This has raised the alarm among many conservationists about the possibility of other serious detrimental effects to habitats and their species.

Langlois, V.S., Carew, A.C., Pauli, B.D., Wade, M.G., Cooke, G.M. & Trudeau, V.L. (2009). Low levels of the herbicide atrazine alters sex ratios and reduces metamorphic success in *Rana pipiens* tadpoles raised in outdoor mesocosms. *Environ. Health Perspect.* doi:10.1289/ehp.0901418.

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HOW DO SALAMANDERS GROW A NEW LEG? PROTEIN MECHANISMS BEHIND LIMB REGENERATION.

The most comprehensive study to date of the proteins in a species of salamander that can regrow appendages have provided important clues to how similar regeneration could be induced in humans. Researchers at the School of Science at Indiana University-Purdue University Indianapolis and colleagues investigated over three hundred proteins in the amputated limbs of Axolotls (*Ambystoma mexicanum*) with the hope that this knowledge will contribute to a better understanding of the mechanisms that allow limbs to regenerate.

Comparisons of fish proteins with those expressed in amphibian limbs is shedding light on the mechanisms involved. Limb regeneration in the axolotl occurs when undifferentiated cells accumulate under the wound epidermis at the amputation site, a process known as the establishment of a blastema. These cells are derived by the reprogramming of differentiated cells to a less specialized state, and from resident stem cells. Proteins were found that pointed to several areas that need to be studied. Investigating the proteins found in the axolotl limb, the study noted three findings that appear to have significance in reprogramming cells to grow new limbs:

1. Quantities of enzymes involved in metabolism decreased significantly during regeneration.

2. There were many proteins that helped cells avoid cell death. Because amputation is very traumatic, this is critical.

3. A protein which appears to keep cells from dividing until they are fully dedifferentiated and reprogrammed to begin forming a new limb was expressed at high levels throughout blastema formation.

Rao, N., Jhamb, D., Milner, D.J., Li, B., Song, F., Wang, M., Voss, S.R., Palakal, M., King, M.W., Saranjami, B., Nye, H.L.D., Cameron, J.A. & Stocum, D.L. (2009). Proteomic analysis of blastema formation in regenerating Axolotl limbs. *BMC Biology* **7**, 83, doi:10.1186/1741-7007-7-83.

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GENETIC ANALYSIS OF THE IMPACT OF ROAD-BASED HABITAT FRAGMENTATION ON EASTERN BOX TURTLES.

Historically, the Eastern Box Turtle (*Terrapene c. carolina*) has been found in 31 counties in Michigan's Lower Peninsula, USA, although it has been extirpated from 13 of these in the last ten years. One possible cause of the decline is habitat fragmentation by roads with resulting demographic and genetic consequences. Accurately identifying population structure of the turtles is necessary to determine conservation priorities and aid in the recovery of *Terrapene c. carolina*. In this study

163 turtles were genetically marked at eight microsatellite loci from three locations in southwestern Michigan covering 360 km².

The study found high levels of genetic variation (H = 0.83; A = 16) and low levels of genetic differentiation (FST = 0.006) in the system. The three areas studied exist as a single population and there was a low rate (11%) of misassignment across the sites. There was initial evidence of a genetic bottleneck in two of the three study areas and the system as a whole. However, additional analysis failed to find a mode-shift in allele frequencies and did not detect any further evidence of a bottleneck in any of the populations.

The study concluded that the conflicting genetic indication of a bottleneck, despite the geographic evidence, is most likely due to the long generation time of *Terrapene c. carolina*. The study also suggested that the retention of genetic variation, despite population declines, may allow managers flexibility in dealing with the conservation of such a long-lived species.

Marsack, K. & Swanson, B.J. (2009). A genetic analysis of the impact of generation time and road-based habitat fragmentation on Eastern Box Turtles (*Terrapene c. carolina*). *Copeia* **2009** (4), 647-652.

ECOLOGY OF THE PEAKS OF OTTER SALAMANDER (*PLETHODON HUBRICHTI*).

The Peaks of Otter Salamander, *Plethodon hubrichti*, is found along a 19 km length of the Blue Ridge Mountains, Virginia, USA, often in sympatry with the Eastern Red-backed Salamander, *P. cinereus*. This study was conducted in an area where both species occurred in Bedford County, Virginia. A mark-recapture study was conducted on a 10 × 10 m site.

The results showed that surface densities of salamanders decreased as the number of days without precipitation prior to a collection event increased. This suggested that vertical movements performed by salamanders were in response to surface moisture. When salamanders returned to the surface after rain, individuals appeared to "shuffle" between rocks and likely, leaf litter. The surveyors found they were more likely to find a different individual beneath a particular rock rather than the previous resident during sequential collection periods. There was no significant difference in the results between the species in microhabitat use by adults; adults were primarily found under rocks. However, neonate and young-of-the-year *P. hubrichti* were found beneath rocks more frequently than *P. cinereus*.

Linear movements, home ranges, growth rates and adult survival rates were similar for both species. The densities of *P. hubrichti* in sympatry with *P. cinereus* was 0.6/m², which is lower than previously recorded for *P. hubrichti* in allopatry with another salamander (1.6–3.3/m²). The cumulative ratios of the number of the two species were stable over nine collection events but showed the least change (≤ 2%) after the third collection. The study also recommended using ratios of the two species at a series of sympatric sites as one measure to determine whether *P. cinereus* may encroach upon the distribution of *P. hubrichti*.

Kniowski, A. & Reichenbach, N. (2009). The ecology of the Peaks of Otter Salamander (*Plethodon hubrichti*) in sympatry with the Eastern Red-backed Salamander (*Plethodon cinereus*). *Herpetol. Cons. Biol.* **4** (3), 285-294.

Nocturnal behaviour of American Alligator *(Alligator mississippiensis)* in the wild during the mating season

VLADIMIR DINETS

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THE American Alligator is by far the most studied species of crocodilian. However, previous research on its behaviour has been conducted only in captivity (Garrick et al., 1978; Garrick & Lang, 1977; Vliet, 1989; Huchzermeyer, 2003) or in daytime hours (Watanabe, 1980). In the course of night time observations of alligators in the wild in the spring months of 2006-2009, two undescribed forms of social behavior were observed.

METHODS AND MATERIALS

Regular observations were made at four locations (Fig. 1) in the southern part of the Florida peninsula, at 0-2 m ASL. The locations were selected to represent the wide range of natural habitats occupied by alligators in the area. Each of the four locations was observed for one 16-hour period (approximately 18:00-11:00) each week from March 26 until May 17, 2006, except as noted below. These locations were: 1) Arthur R. Marshall Loxahatchee National Wildlife Refuge (ARMLNWR, 26°30'N, 80°15'W), a network of artificial and natural channels in seasonally flooded marshland; 2) An unnamed lake at the edge of Fakahatchee Strand State Preserve (FSSP, 26°49'N, 81°25'W), surrounded by tropical hardwood forest; 3) A natural stream 3-7 m wide and about 1 m deep in Big Cypress National Preserve (BCNP, 25°47'N, 81°06'W), surrounded by seasonally flooded forest of Bald Cypress (*Taxodium distichum*); 4) An unnamed lake with a network of radiating channels on private land near the northern edge of BCNP (26°15'N, 81°15'W), surrounded by wet marshland.

Water levels at sites 3 and 4 fell dramatically during the observation period. At site 3, the channel dried out completely and all alligators moved elsewhere, so the observations were discontinued on May 5. In May, some observations were conducted for 36 hour periods (two nights and the intervening daylight period). Occasional observations were also made at other locations in BCNP, as well as at Taylor Slough and Shark Valley in Everglades National Park (25°23'N, 80°36'W and 25°39'N, 80°46'W, respectively), and at forest ponds ("gator holes") in Picayune Strand State Forest (PSSF, 26°07'N, 81°31'W).

In 2007-2008, additional observations were made at various locations (Fig. 1) in Ocala National Forest, Florida (ONF, 29°20'N, 81°40'W) and Savannah National Wildlife Refuge, South Carolina (SNWR, 32°11'N, 81°20'W). In 2009, occasional observations were made in Aransas National Wildlife Refuge, Texas (ANWR, 28°15'N, 96°55'W), St. Catherine Creek National Wildlife Refuge, Mississippi (SCCNWR, 31°22'N, 91°42'W), Cat Island National Wildlife Refuge, Louisiana (CINWR, 30°89'N, 91°20'W), and Anacoco Floodplain, Louisiana (AFP, 31°24'N, 93°24'W). Unless specified, all information below refers to 2006 Florida observations.

Total observation time in 2006-2009 was over 1200 hours, including 380 hours of night time observations. Alligators were observed either from the shore or from an inflatable kayak. A small headlamp with a red filter was used on moonless nights. The animals seemed remarkably indifferent to the presence of an observer, often courting, bellowing or mating within 1-2 m of the kayak.

Animals were counted at 20 min intervals and all observed behaviours were recorded. During large gatherings, when recording all behaviours for all animals was impossible, estimates of the frequency of observed behaviours were made by counting the occurrence of a behaviour during an
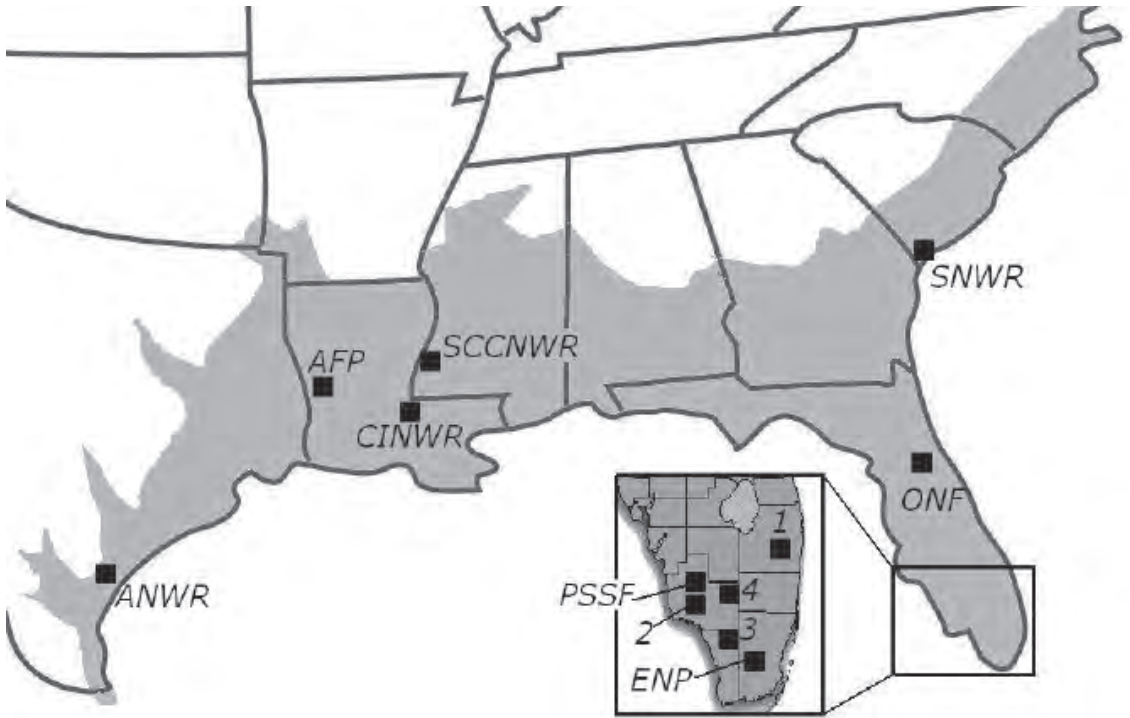
Figure 1. Study sites in the southeastern United States. Sites of regular observations: 1 – Arthur R. Marshall Loxahatchee National Wildlife Refuge, 2 – Foxahatchee Strand State Preserve, 3-4 – Big Cypress National Preserve. Sites of irregular observations: ANWR – Aransas National Wildlife Refuge, AFP – Anacoco Floodplain, ENP – Everglades National Park (Taylor Slough and Shark Valley), CINWR – Cat Island National Wildlife Refuge, PSSF – Picayune Strand State Forest, SCCNWR – St. Catherine's Creek National Wildlife Refuge, SNWR – Savannah National Wildlife Refuge. Approximate range of American Alligator shaded.

arbitrarily selected 5 min interval. Size of animals was visually estimated as belonging to half metre interval size classes of total length: less than 0.5 m, 0.5 to 1 m, and so on. Unless specified otherwise, sizes below are given by the lower limit of the size class. Keeping track of individual animals was usually difficult, so only twelve alligators with easily recognizable features were recorded for more than one night with certainty. The lengths of channel stretches recorded below were all measured by pacing. Areas occupied by gatherings were visually estimated. Video, photographic and audio recordings of various types of behaviour were obtained.

RESULTS

Courtship Gatherings

At all sites, mating-related activities such as bellowing choruses, swimming in pairs, chasing,

and snout touching (Garrick et al., 1978) were first observed during the week of April 9-15. As water levels dropped, alligator numbers at sites 2-4 increased rapidly, from 5-10 in late March to 50-100 in late April, and the animals concentrated in areas with deep water. At site 1, where water levels did not change, the animals also concentrated in one stretch of the main channel, 200±20 m long.

From mid April until mid May, alligators at all four regular study sites and at Taylor Slough gathered in large numbers, apparently for courtship (Fig. 2). The maximum number observed was 80 (at Taylor Slough), mean maximum number per gathering was 28 (Fig. 3). Each gathering occupied a well-defined area, visually estimated to be 100-600 m². The precise location of the gathering changed each night. At sites 2-4 and at Taylor Slough, the animals had limited choice of locations, but at site 1 all their gatherings took place within only

Figure 2. Courtship gathering of American Alligators in Big Cypress National Preserve, Florida. Note two males resting their chins on the backs of females as part of courtship.

one section of the main channel, 100±10 m long, which did not differ in visible features from other sections. At its maximum, the abundance of animals (determined by dividing the total area occupied by the gathering by the number of animals present) exceeded one animal per 10 m². For comparison, the density of alligators in the remaining parts of the lake/channel (determined by dividing the total water area by the number of animals counted during the same night of observation) did not exceed one animal per 100 m², except at site 3 in the last day before it completely dried out.

On some nights gatherings were not observed. One such night was on April 24 the only rainy night during the study period. No significant association of presence/absence of gathering with water temperature (χ^2 0.75; P = >0.05) or lunar phase (χ^2 0.05; P = >0.25) was detected (Chi-squared test).

Each gathering lasted for 4-8 hours (mean duration 6 h 40 min, n = 15), but never for the entire night (Fig. 4). Most gatherings took place between sunset and sunrise, but three had formed before sunset (approximately 10, 10 and 30 min before sunset), and one continued for 15 minutes after sunrise (Fig. 5). At any given time, some animals present in the area were not participating in the gathering and remained in other parts of the lake/channel, where their activity patterns were similar to those observed on the nights with no gatherings. Alligators smaller than 1.5 m joined those gatherings only occasionally, and those smaller than 1 m were never observed to join them. Some alligators were not permanently present in the lakes where gatherings were taking place, but
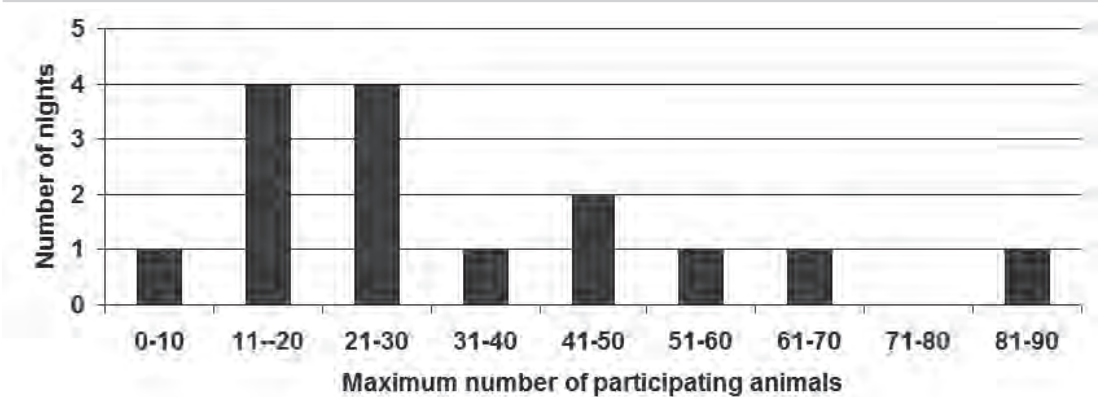
Figure 3. Maximum numbers of alligators participating in courtship gatherings.
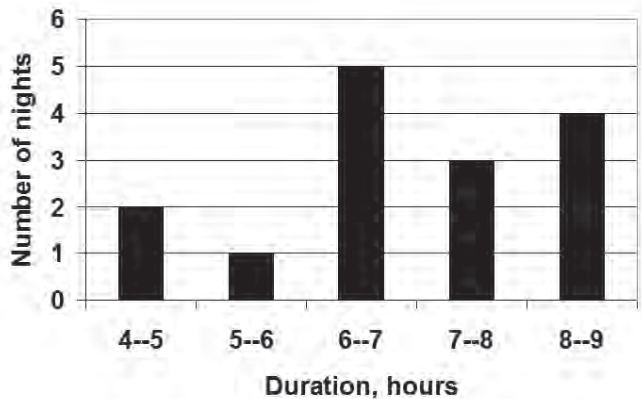
Figure 4. Duration of observed courtship gatherings.

were observed as they moved into the lake from surrounding channels shortly before or after the formation of the gathering, and left it later. Many participants arrived in pairs. Two particularly large and recognizable individuals were observed to participate in gatherings throughout the mating season, even though they were already accompanied by mates by mid April. Three other individually recognizable alligators were not observed to form pairs at all.

The gatherings were characterized by very high levels of activity. Animals spent hours swimming (mostly in pairs and trios), touching each other's snouts, chasing each other, and placing their chins on other alligators' backs. All these behaviours

have been described by Garrick et al. (1978) as part of courtship. Fighting was also observed frequently (at least every ten minutes). Most fights consisted of just one or two jaw slaps and/or light bites, but some lasted for several minutes and resulted in visible injuries. One 1.5 m long alligator had a half of its upper jaw bitten off by a 2.5 m long individual and died two weeks later. Another common behaviour was swimming in circles: two animals would follow each other for a few seconds at a time making 1-3 circles with diameter roughly equal to the larger animal's length, clockwise or counterclockwise. Sounds such as deep grunts, low growls, hisses, coughs, head slaps and tail slaps (as described by Garrick et al., 1978) were
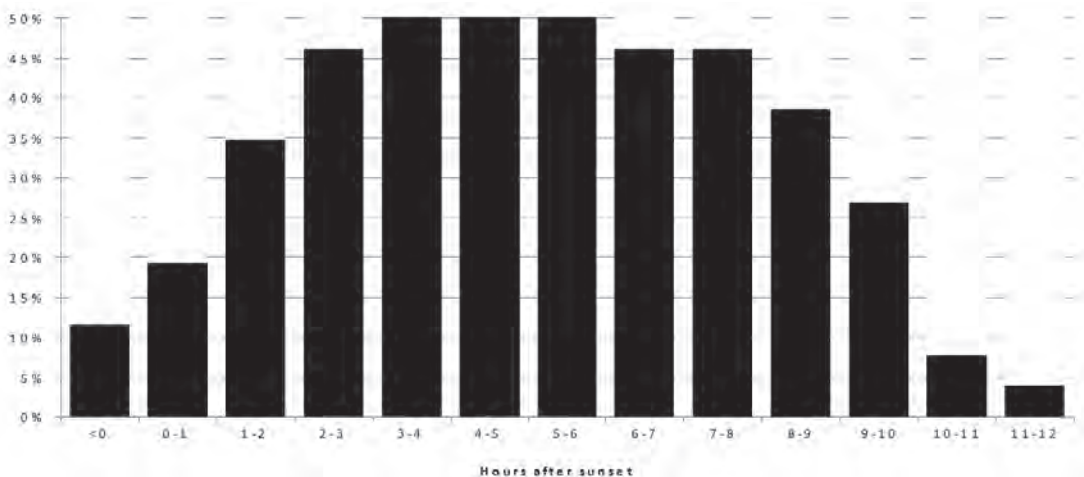
Figure 5. Percentage of nights when courtship gatherings were observed at known gathering sites at different times after sunset.

Figure 6. Cooperative feeding of American Alligators in Everglades National Park, Florida.
One large animal is swallowing a fish.

used frequently (Table 1). In gatherings with more than 20 participants, each sound was heard at least once over all 5 min intervals when frequency of those behaviours was recorded. Large gatherings produced so much noise that they could be easily heard from up to 300 m away. Bellowing was never recorded during gatherings, even if they continued into daylight. Copulation was observed twice during those gatherings. On both occasions the pairs left the gathering and mated nearby away from the group (approximately 15 and 35 m). More often, copulation occurred after the gatherings (three observations before dawn and six observations during morning hours). Bellowing choruses were more than twice as likely to be observed on a morning after a gathering as on a morning that followed a night when no gathering took place (12 bellows recorded after 15 nights with gatherings, 4 after 11 nights without gatherings).

On eight occasions, alligators were observed catching or attempting to catch fish during gatherings, but their level of fishing activity was

very low (in 96 hours of gatherings observed, only six fishing attempts were recorded, less than 0.1 attempt per animal per hour). Animals not involved in any type of gathering made 1-5 such attempts per hour in the water. Once a 2 m long alligator was seen trying to catch a Black Crowned Night Heron (*Nycticorax nycticorax*).

The spring of 2006 was unusual in that many female alligators had very small offspring. Normally the majority of hatchlings in southern Florida appear during the late summer. But in fall and winter months of 2005-2006 many females nested very late in season, probably after having their nests destroyed by hurricanes in 2005. In one remarkable case, a 2 m long female with a recognizable teeth pattern was seen leaving her brood of 30 cm long juveniles and swimming for two miles downstream to a place where a gathering was taking place. This behaviour was observed on one night in April and two nights in May. Each time she would leave her brood at approximately sunset, spend part of the night in the gathering, and

Type of gathering	Fishing attempts per animal per hour	Predominant sounds	Swimming pattern	Water depth at location	Minimum size of animals
Courtship gatherings	Less than 0.1	Deep grunts, low growls, hisses, coughs, head slaps and tail slaps	At least 1/3 of animals swim in pairs and trios	Deeper than 50 cm, if available	1 m
Cooperative feeding	More than 6	Jaw slaps, splashing sounds	No animals in pairs or trios	Less than 50 cm	60 cm

Table 1. Differences between cooperative feeding and courtship gatherings.

return in late morning. Possibly due to predation by Great Blue Herons (*Ardea herodias*), the number of her offspring fell from six to two during that time. She was seen in the gathering three times, but was never observed to find a mate.

In the spring of 2007, courtship gatherings were recorded in other parts of the species range: twice in ONF (at 03:20 on April 28 and at 11:55 on May 5) and twice in SNWR (at 22:20 on May 10 and at 00:12 on May 15). In all cases, the beginning and the end of the gatherings were not observed. The number of individuals present was 16, 11, 5 and six respectively. The relatively small numbers of participating animals at the two SNWR gatherings probably reflects the overall lower density of alligator in South Carolina in the northern part of its geographical range (Neill, 1971).

In the spring of 2008, more gatherings were noticed during occasional observations in ONF (four gatherings, all in pre-dawn hours) and in ENP (two gatherings, one near midnight and one at pre dawn time). One of the gatherings took place at just 10°C air temperature (ONF, April 18), and one was at the latest date ever recorded (ENP, May 25).

In the spring of 2009, courtship gatherings were incidentally observed in the western part of the species' range: five times in ANWR (all with more than 10 animals present), twice at SCCNWR (with six and five animals), once in CINWR (with six animals), and once at AFP (with four animals). The amount of time spent observing alligators at night was approximately the same in all four locations. It appears that such gatherings are not only larger, but also more common in the southern part of the geographical range of the American Alligator.

Cooperative Feeding

Cooperative feeding was observed only in late April and May, and always in places with water depths of less than 50 cm. It was seen once at FSSP, twice at BCNP (once at each site) and five times at Taylor Slough. On each occasion, 10-50 (arithmetic mean 22.5, n = 8) alligators would gather in an area not larger than 250 m^2 or in a small pond about to dry up (Fig. 6). They would then spend 2-6 hours (arithmetic mean 3 h 20 min, n = 8) swimming in circles (usually over 5 m in diameter) in that small area and catching fish, with 2-20 jaw slaps being

heard every minute. The level of fishing activity was roughly estimated as 0.1-3 fish catching attempts per animal per minute, compared to 1-5 attempts per hour in animals not involved in a gathering of any type, and less than 0.1 attempt per hour in animals in courtship gatherings. When fishing occurred on the water surface the method observed was almost always a quick lateral jerk of the head, accompanied by slapping of the jaws. Less than one in ten times, alligators made a frontal attack instead, lunging forward and catching fish with the tips of their jaws. Judging by the plumes of silt rising to the surface, a lot of fish were taken from the bottom mud. On a few occasions the fish could be identified to family as it was caught and eaten. Two fishes were Cichlids (Cichlidae); all others were Catfish (Ictaluridae). Despite the presence of many Florida Gars (*Lepisosteus platyrhincus*) at some sites, alligators were never observed to catch them. All cooperative feeding was observed between 17:00 and 09:00. Most animals were more than 1 m in length, but a few juveniles as small as 0.6 m were also seen.

Cooperative feeding gatherings could be immediately distinguished from courtship gatherings (Table 1). Swimming in pairs never took place, even though some animals arrived to the gathering in pairs. Sound signals were never recorded, except for very few low growls and hisses when one alligator accidentally bumped into another. Fights over fish happened occasionally. It was possible to tell the two kinds of gatherings apart even without seeing them: cooperative feeding produced mostly splashing and slapping sounds, while courtship gatherings were also accompanied by grunts, growls, hisses, and coughs. No gatherings intermediate between feeding and courtship types were ever observed. On one occasion at Taylor Slough, a courtship gathering and cooperative feeding were taking place at the same time within 30 m from one another and a few animals (five in two hours) were seen moving between them.

DISCUSSION

Both cooperative feeding and courtship gatherings occasionally take place during daylight hours and can be watched by hundreds of visitors to Everglades National Park. However, these types of behaviour

apparently have never been described in scientific literature, probably because daytime observers did not recognize them as a distinct and regular type of behaviour. Cooperative feeding of other Crocodilians (see below) has been mentioned in popular literature and shown in TV documentaries but scientific descriptions are also lacking.

It seems reasonable to assume that courtship gatherings are an important part of courtship behaviour in alligators although they are not essential for pair formation (as demonstrated by successful breeding of animals in isolated ponds and in captivity). The purpose of cooperative feeding seems obvious, but the exact mechanism of the increased efficiency of group fishing is not. Sometimes the fishing area is adjacent to deeper water. So why do fish not leave when cooperative feeding begins? One possibility is that the fish (Catfish in particular) are either taken from the layer of mud on the bottom, or flushed out of mud and immediately eaten. In this case, the presence of many alligators possibly causes the remaining Catfish to hide in mud instead of leaving the area immediately. This thus would prompt alligators to flush them out one by one.

Cooperative feeding might be common among most Crocodilians that occur at sufficient population densities. Anecdotal evidence and numerous video recordings suggest that it is used by all species of genus *Caiman*, and also by the Nile Crocodile (*Crocodylus niloticus*), which employ a variety of group tactics for hunting fish and mammals. A documentary called 'Lake of a Thousand Caiman' by National Geographic shows cooperative feeding by hundreds of Black Caiman (*Melanosuchus niger*) in the Amazon. The author has observed cooperative feeding by 12 Mugger Crocodiles (*C. palustris*) that were catching Catfish in Kateraniaghat Wildlife Sanctuary, India, and by three Saltwater Crocodiles (*C. porosus*) catching a domestic pig near the city of Sorong in the Indonesian part of New Guinea.

Courtship gatherings seem to be much less common among Crocodilians. Despite an extensive literature search, interviewing crocodile researchers and professional hunters, and hundreds of hours of night time observations in the wild during the mating seasons of Nile, Mugger, Saltwater,

American (*C. acutus*), Morelet's (*C. moreleti*) and Orinoco (*C. intermedius*) Crocodiles, as well as Black Caiman, no courtship involving more than four animals has been recorded or heard of. One possible explanation is that male crocodiles (Neill, 1971) and Black Caiman (P. Taylor, pers. comm.) are much more territorial than male alligators. Group courtship was observed in captivity among Chinese Alligators (*A. sinensis*) (Wang Xi, pers. comm.) and Indian Gharials (*Gavialus gangeticus*) (pers. obs.), but it is unknown if this behaviour occurs in the wild, where population density is much lower. It was never seen by the author in six nights of observing Indian Gharials in Kateraniaghat Wildlife Sanctuary during the mating season.

Group courtship can be easily observed among Yacare Caiman (*Caiman yacare*) in the Brazilian Panthanal and adjacent parts of Bolivia. During a study of caiman vocalizations in September-November of 2007, caimans were seen engaging in a frenzy of courtship in certain lakes, where 10-50 animals were present throughout the mating season, with densities of 0.5-2 animals per 100 m². Unlike alligators, they did not gather in particular locations at the beginning of each courtship event and dispersed at the end of it. Most individuals remained in a particular lake for weeks and participated in courtship every day from approximately one hour before sunset until sometime between midnight and dawn. Caimans did not congregate in one part of the lake, but used most of its area for courtship activities. However, if the surrounding floodplain was covered with water after heavy rains, the animals did not disperse more than 100 m away from the original lake contour until the end of the mating season. Unlike alligators, individual Yacare Caiman are easy to identify and follow due to unique patterns of facial markings. Courtship behaviour itself was very similar to that of American Alligators, as described by Garrick et al. (1978).

On January 3, 2010, an apparent courtship gathering of six Broad-headed Caimans (*C. latirostris*) was observed for most of the night at Itaipu Reservoir on Paraguay-Brazilian border. Again, the courtship behaviour was very similar to that of American Alligators and Yacare Caimans.

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Notes on body size and natural history of *Enyalioides heterolepis* (Bocourt 1874) in its northernmost population in Panama

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ABSTRACT - We present details of the natural history of the poorly known Bocourt's Dwarf Iguana *Enyalioides heterolepis* from its northernmost population in El Copé, Panama. Three individuals (a subadult, a male and a female) were found during a three day period in April 2007 in a secondary premontane forest near El Copé at about 700 m elevation. These iguanids could best be found at night while they rested on tree trunks and low vegetation. New details on maximum length, colour pattern and pholidosis are described.

Data regarding members of the genus *Enyalioides* is scarce in literature. This might be explained by their secretive natural history, seasonal activities or their rarity in the wild. Whereas the majority of the eight currently known species of this genus inhabit South America, the distribution range of *Enyalioides heterolepis* extends well into Panama, ranging to Parque Nacional (PN) General de División Omar Torrijos Herrera (Lips, 1999).

METHODS AND MATERIALS

Data and observations were obtained between 12 and 14 April 2007, from the area around the biological ranger station of PN General de División Omar Torrijos Herrera in the vicinity of El Copé, Provincia Coclé, Panama (8°40'05.00" N, 80°33'33.30" W) at ca. 700 m ASL (Fig. 1). Snout-vent length (SVL) and tail length (TL) measurements were taken with a ruler and recorded to the nearest millimeter. Scalation characteristics were recorded and representative photographs were deposited in the media collection of the Division of Vertebrate Zoology at the Yale Peabody Museum of Natural History (HER.M.001194a - HER.M.001210). All animals were thereafter released at the same locality.

RESULTS

We found one adult male and one female resting at night on vegetation (Figs. 2 and 3). The female was found oriented horizontally on a plant at a height of approximately 50 cm on two consecutive nights (12-13 April 2007), while the male rested in an upright vertical position on a tree trunk approximately 120 cm off the ground. We observed a sub-adult animal on two consecutive days (12-13 April 2007) underneath a fallen tree trunk, hiding in an existing burrow (Fig. 4). We summarize environmental data and sizes associated with each individual in Table 1.

Only the male possessed enlarged femoral pores and had only one on each hind limb. Overall coloration in both sexes was olive brown to tan interspersed with greenish and yellowish spots and ocelli. All animals displayed a light stripe in the scapular region as well as a black triangular spot with a light caudal margin in the sub-ocular region (originating beneath the eye and widening towards the jaw angle). This latter pattern element was especially prominent in the male, which also showed a beige and brown pattern (without green) between the paravertebrals. Distinct blackish blotches were present on the beige ventral surfaces in the adult animals: one on the gular region of both the male and female, and one on the male's umbilical region (Fig. 5; compare "characters 32-34" in Wiens & Etheridge [2003], Appendix II). All three individuals consistently exhibited the following characters: iris coloration brown to copper with white margin encircling pupil; vertebral scales equal-sized and in a continuous series along neck and body; paravertebrals

Figure 1. Habitat of *Enyalioides heterolepis* at PN General de División Omar Torrijos Herrera, Panama in secondary premontane forest (© T. Eisenberg).

Figure 4. Sub-adult *Enyalioides heterolepis* at PN General de División Omar Torrijos Herrera, Panama; (HER.M.001199: © T. Eisenberg).

Figure 2. Male *Enyalioides heterolepis* at PN General de División Omar Torrijos Herrera, Panama resting vertically on a tree trunk (HER.M.001195: © T. Eisenberg).

Figure 3. Female *Enyalioides heterolepis* at PN General de División Omar Torrijos Herrera, Panama. This specimen was found resting on vegetation on two consecutive nights (HER.M.001205: © N. Pantchev).

Figure 5. Male *Enyalioides heterolepis* at PN General de División Omar Torrijos Herrera, Panama. Ventral aspect; note distinct blackish blotches on gular and umbilical region (HER.M.001194a: © T. Eisenberg).

forming three distinct longitudinal series of enlarged scales on each side of the middorsal line, intermixed with small, strongly keeled scales; dorsal surfaces of body and limbs with granular scales interspersed with large conical scales; ventral scales keeled; caudal scales keeled and imbricate, not projecting; subcaudal scales larger than caudal scales; distinct caudal segments present between intercalaria, each spanning two ventral scale rows and 6-7 dorsal scale rows; tail laterally compressed. Additional morphological values are presented in Table 2.

DISCUSSION

According to Boulenger (1885) *Enyalioides heterolepis* reaches a maximum SVL of 138 mm and a TL of 172 mm. Our data show that these lengths are significantly exceeded even by the smaller females. At a SVL of 182 mm, *E. heterolepis* is currently the largest known species in its genus. Femoral pores were only present in the male, and only one on each side. This is in accordance with the range (1-3) published by Burt & Burt (1931) for six South American specimens but it has not yet been clarified for Panamanian populations. In the species' original description (type locality, Veragua, Panama) as well as a later published key to the genus (Peters, 1967) the average count yielded three to four femoral pores on each side of the body. In addition to Boulenger's description (1885) we found that adult animals of both sexes showed dark markings on the gular pouch, but that only in the male a ventromedial, ventrally-bilobed black blotch was present around the umbilicus. This marking was approximately 20 ventral scales wide (Fig. 5).

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Thermal ecology of *Pseudoeurycea leprosa* (Caudata: Plethodontidae) from Sierra del Ajusco

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ABSTRACT - Many physiological and behavioural processes are temperature dependent in ectothermic organisms. In this study, we evaluated the influence of environmental temperature on the thermoregulation of *Pseudoeurycea leprosa* in a pine forest of Mexico. Mean body temperature was 29.7 ± 13.24°C. Body temperature was correlated with air and substrate temperature. Further study involving more complex aspects of the thermal ecology, together with other biological characteristics, may help to make specific conservation strategies for *P. leprosa*.

Sierra del Ajusco is located within the Transmexican-Volcanic Belt. This region is one of the most important morphotectonic provinces in Mexico because it is located at the transition between the Nearctic and Neotropical biogeographic regions, resulting in great biological diversity (Rzedowsky, 1998). This biodiversity has been subjected to fires, pests, deforestation, erosion and clandestine hunting for many years which has led to the decrease in populations of some species (Granados-Sánchez et al., 2004).

Mexico has 373 species of amphibians, with the salamanders of the family Plethodontidae representing 30 % of the total (Liner, 2007). Additionally, Mexico hosts 40 % of all described species of salamanders in the world (Parra-Olea et al., 2005b).

The genus *Pseudoeurycea* (Taylor, 1944) is one of the most diverse neotropical salamander groups. Species in the genus inhabit pine-oak forests at elevations higher than 2,000 m (Parra-Olea et al., 2004), and represent 12 % of the Mexican amphibian fauna. The genus includes 45 species which occur from northern Mexico to western Guatemala. Of these 41 are endemic to Mexico, one to Guatemala, and three occur in both countries (Windfield-Pérez et al., 2007). Although these salamanders are the most abundant vertebrates in many upland habitats,

their ecology is poorly known (Lynch et al., 1983). Studies on *Pseudoeurycea* include analyses of its geographic distribution (Windfield-Pérez et al., 2007), taxonomy (Lynch et al., 1983; Adler, 1996; Pérez-Ramos and Saldaña-De la Riva, 2003; Parra-Olea et al., 2005a), climate change effects (Parra-Olea et al., 2005b), helminth parasites (Falcón-Ordaz et al., 2007) and ecology (Bille, 2000; García-Vázquez et al., 2006).

Pseudoeurycea leprosa (Cope, 1869) (front cover, this issue) is a terrestrial species associated with pine, pine-oak, and fir forests along the Transmexican-Volcanic Belt at the southern end of the Sierra Madre Oriental (Parra-Olea et al., 2005b). Bille (2000) studied some aspects of microhabitat use and more recently García-Vázquez et al. (2006) made an extensive study of ecological aspects of this species. Nevertheless no studies of its thermal biology have previously been completed.

In this paper we analyze the thermal profile of *Pseudoeurycea leprosa* and describe the relationship of body temperature to substrate temperature. We also record microhabitat use by this salamander.

METHODS AND MATERIALS

This study was carried out in Ejido Magdalena Petlatalco, Delegación Magdalena Contreras, Sierra

del Ajusco, Mexico, Distrito Federal (19.2209° N, 99.2856° W) from 3,500 to 3,930 m. The climate of the study area is temperate semi-humid (Cw) with a mean annual temperature of 7.5-13.5°C and a mean annual rainfall of 1340 mm, less than 5% of which occurs in winter (García, 1973). The vegetation is pine forest (*Pinus hartwegii*) and grassland (*Muhlenbergia quadridentada*, *Festuca hephaestophila* and *Festuca amplissima*) (Álvarez del Castillo, 1989).

We collected 24 salamanders between 09:00 and 14:00 from January-August 2007. Animals were captured by hand and returned to their habitat after taking measurements.

Body temperatures (cloacal = T_b to the nearest 0.2°C), and substrate temperature (Ts on substrate where the salamander was first observed) were obtained using a Miller & Weber (0-50 ± 0.2°C) quick reading thermometer. Snout-vent length (SVL) was measured to the nearest mm with an electronic caliper at the site of capture.

We assessed normality and homoscedasticity with Kolmogorov-Smirnov and Bartlett tests respectively. We calculated residuals from the relationship of T_b to SVL to produce T_b adjusted variables which maintain variation of extrinsic factors and minimize the compounding effect of size related to individual variation in SVL.

We performed non-parametric statistical analysis with JMP statistical software package, Version 7 (SAS, Institute Inc. 2007). A Kruskal-Wallis analysis of variance was used to evaluate body temperature differences among age classes (adult, juveniles and hatchlings). We performed a Spearman rank correlation (r^s) to test the relationship between body (T_b), SVL and substrate temperatures (T_s). All measurements are reported as mean ± standard deviation. Statistical significance was < 0.05.

RESULTS

The mean SVL of all salamanders was 29.7 ± 13.24 (n = 24; range 17.17-60 mm) and the mean body temperature was 12.86 ± 3.77°C (range: 8-18°C). The SVL for adults was 54.33 ± 6.65 mm (n = 3; range 47-60 mm), for juveniles 28.3 ± 8.88 mm (n = 9; range 17.17-40.5 mm) and for hatchlings 20.96 ± 3.23 mm (n = 7; range 17.2-27 mm). Body

temperature of adults (n = 4) was 13.85 ± 3.32°C, (range 8.9-16°C), for juveniles it was of 10.5 ± 3.59°C (n = 9; 8-18°C), and for hatchlings 14.53 ± 3.31°C (n = 9; range 9-18°C). There was no statistical significance between body temperatures of the size classes (H = 5.0024, df = 2, P = 0.082, Fig. 1). As a result, we combined temperature values for subsequent analyses.

Substrate temperature recorded during this study was 10.39 ± 3.37°C (range 6-16°C). There was a significant correlation between body and substrate temperature (r^s = 0.4563, P = 0.0376). Most salamanders were found under tree trunks (n = 22, 91.6 %), meanwhile the remainder were found under stones (n = 2, 8.3 %).

DISCUSSION

Thermoregulation in amphibians is behaviourial (emergence, retreat, selection of temperature, basking etc.) and physiological (acclimation, evaporative cooling etc.) (Brattstrom, 1963). Behaviourial thermoregulation enables ectotherms to use thermally diverse environments and yet control temperature-sensitive physiological processes (Feder, 1982). However, terrestrial salamanders from the Temperate Zone are exceptional because they exhibit seldom behaviourial thermoregulation in the field (Brattstrom, 1979) or do not thermoregulate in a manner that is conspicuous to biologists (Feder & Lynch, 1982).

Our results show that *P. leprosa* frequently occur beneath tree trunks as found by Bogert (1952) for other terrestrial salamanders. The hydric requirements of this secretive terrestrial salamander may also restrict it to microhabitats with high humidity and thermal homogeneity such as tree trunks which have a low thermal heterogeneity that may promote the apparent rarity of behaviourial thermoregulation in these organisms (Tracy, 1976). Consequently, salamanders have a narrow relationship with wet microhabitats which results in similar body and substrate temperatures. Our study suggests that body temperature of *P. leprosa* maintains a strong and positive correlation with substrate temperature in Sierra del Ajusco.

This study emphasizes the extent to which thermoregulation is related to microhabitat used. It
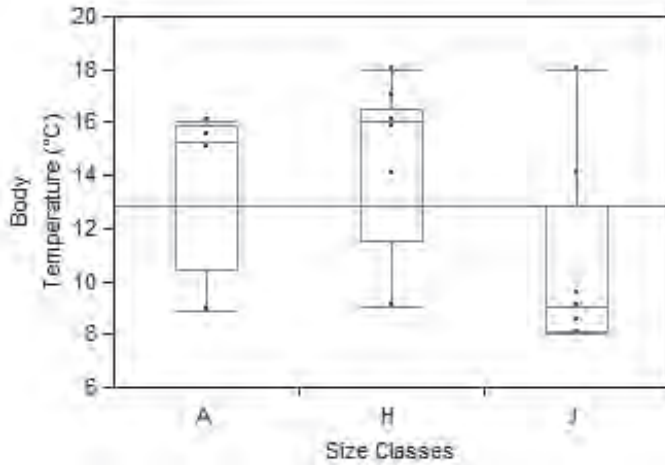
Figure 1. Comparison between body temperature and age classes in *Pseudoeurycea leprosa* in Sierra del Ajusco, Mexico. Adult (A), Juvenile (J) and Hatchling (H) age classes. Horizontal line across the graph is the mean for all animals sampled. Boxes indicate the standard deviation. The horizontal line inside the box is the mean of each sample. Vertical lines are the maximum and minimum values and any points outside the boxes are extreme values.

shows that more detailed studies involving other aspects of the thermal ecology of *P. leprosa* and consideration of habitat composition and other biological characteristics will be necessary for developing specific conservation strategies.

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The Bahian Sand Dunes Whiptail Lizard *Cnemidophorus abaetensis* Dias, Rocha & Vrcibradic 2002 (Reptilia, Scleroglossa, Teiidae), geographic distribution and habitat use in Bahia, Brazil

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ABSTRACT - The Bahian Sand Dunes Whiptail Lizard is probably the most endangered reptile in Bahia, Brazil. It is an endemic lizard with a restricted distribution. Most of its populations are confined to a coastal sand dune vegetation ecosystem in the Atlantic Forest domain. Most of the literature records are disjunct and present occasional reports of the species in its natural habitat. Here we present a discussion of 11 new localities for the species, covering all the eight municipalities where it is originally distributed, and offer two new extensions of its geographic limits to the north and south. Our results indicate that the species has a confirmed contiguous distribution and its main populations are restricted to a single vegetation type. The species is suffering from severe habitat loss and efforts should be taken to address this and prevent the loss of genetic viability within its natural range.

THE genus *Cnemidophorus* comprises ten species of Whiptail Lizard (Bérnils, 2009), most of which occur in a variety of habitats in the Atlantic forest ecosystems in Brazil. Despite study of the ecology of the genus, knowledge on geographic distribution of *Cnemidophorus* in Bahia state, especially in Restinga habitats, is still very scarce. Among the ten known species, four of them, *Cnemidophorus abaetensis* (Fig. 1), *Cnemidophorus littoralis*, *Cnemidophorus nativo*, and *Cnemidophorus vacariensis*, are listed by the National Environmental Agency – IBAMA (Brazilian Institute for Natural Resources) as Vulnerable (Brasil, 2008). Major threats to the species include habitat loss, road and highway construction, environmental pollution and wildlife trafficking.

In Bahia two of the above species exist, *C. abaetensis* and *C. ocellifer*. *Cnemidophorus abaetensis*, the Bahian Sand Dunes Whiptail Lizard, also known as the Abaeté Whiptail, was first described as endemic to the Restinga formation (Fig. 2) on the northern coast of Bahia at Abaeté Dunes (Dias et al., 2002). The region covers eight municipalities; Salvador, Lauro de Freitas, Camaçari, Mata de São João, Entre Rios, Esplanada, Conde, and Jandaíra (Fig. 3). Since its discovery at Abaeté, the species' geographic distribution has progressively extended to several areas surrounding the type locality. These areas include; APA (Environmental Protection Area) Lagoas e Dunas do Abaeté, Salvador, Bahia, Brazil and the northern and coastal areas of the region; Costa Azul, Baixios, and in the Guarajuba districts (Dias & Rocha, 2006), which include three further municipalities, Camaçari, Entre Rios and Jandaíra. Despite such information, there is still a lack of data describing the species geographic distribution and natural history. This creates a requirement for distribution records to fill gaps in territories that

Figure 1. An adult male *Cnemidophorus abaetensis* from the district of Praia do Forte, Mata de São João, Bahia, Brazil. This species has a distinct colour pattern when compared to most other *Cnemidophorus* spp. Although it has colour similarities to *C. littoralis* its supraocular scales differ (Dias et al., 2002). *C. abaetensis* and *C. littoralis* are geographically separated by two major river basins (Photograph © M.Tinôco).

Figure 2. Open sand shrub vegetation, the main habitat of *Cnemidophorus abaetensis*, Entre Rios municipality, Bahia, Brazil. Individuals can be found foraging within scrub on bare sand and soil, next to a nearby leaf-litter cover. When disturbed they retreat into refuges and dug holes. Note in the background, the typical sandy herbaceous beach vegetation with coconut palms, where most of the *C. ocellifer* specimens were recorded (Photograph © M.Tinôco).

are suffering habitat loss (Dias & Rocha, 2006; Machado et al., 2008). It is therefore necessary to increase research on this genera in Atlantic forests to reinforce action for species conservation in the country whilst maintaining and enhancing the creation of protected areas where vulnerable herpetofauna exists (Tinoco et al., 2008a).

Cnemidophorus abaetensis is one of the few active foragers of the genus found in the Restinga habitats that are distributed in the northern coastal region of the Atlantic forest of Brazil. In the north coast of Bahia (37°21'08.57" W on northern limit, and 38°30'03.57" W on southern limit of the species distribution), it is one of the most abundant and widely distributed species. Other highly abundant species include *Tropidrus hygomi* Reinhardt & Luetken 1861 and *Cnemidophorus ocellifer* Spix 1825. *C. abaetensis*, is endemic to the north coast Bahian area and is categorised as 'under threat' by the National Red List (Machado et al., 2008). Its known distribution does not exceed 2,000 m from the high tide line. Hence its populations are at risk from tourist development (Dias et al., 2002; Dias & Rocha 2004; Dias & Rocha, 2006).

This paper presents new range findings for *C. abaetensis* across its geographic distribution in the state of Bahia and describes the major habitat types where it was found.
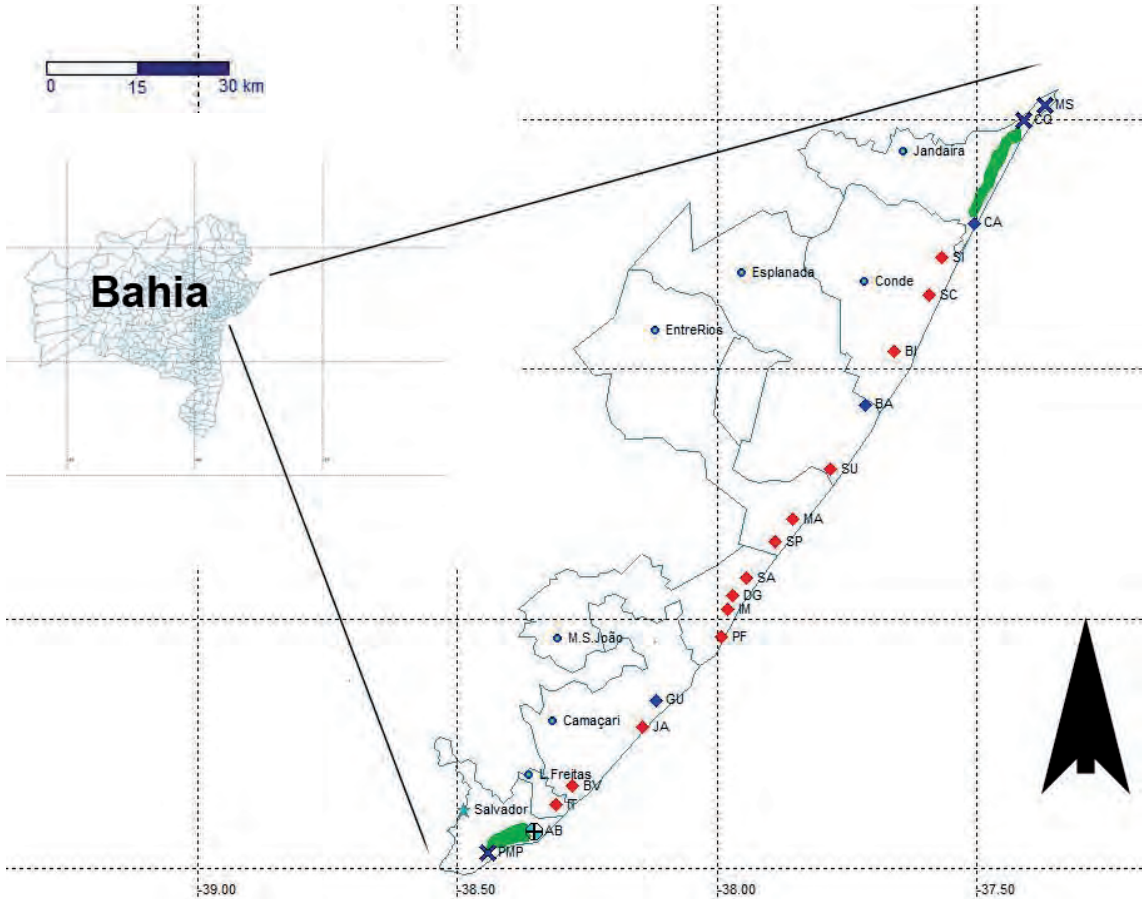
Figure 3. Geographic distribution of *Cnemidophorus abaetensis* in northern Bahia, Brazil. Red Diamonds = localities of sympatry between *C. abaetensis* and *C. ocellifer*; Black encircled cross = type locality; Green filled area = approximately extended distribution north and southbound; Blue Diamonds = literature records and confirmed localities; Red Diamonds = new localities (voucher specimens in Centro ECOA collection); Gray Lines = municipality limits; Blue X = new localities to the north and south; Capital city (Blue Star) and sites for main coastal cities are included with Blue dots.

METHODS AND MATERIALS

The region in which this study was conducted comprises approximately 220 km of coast line across eight municipalities and 25 metropolitan major districts (Fig. 3). The study's design covered all eight municipalities and 16 districts. Several field trips were carried out between 2005 and 2009 to the north coast municipalities to sample *C. abaetensis* by trapping and visual encounter survey. Lizards were sampled with ten pitfall traps (20 litres each) distributed on four transects covering major Restinga habitats, herbaceous sand dune vegetation, scrubby sand dune vegetation, and open scrubby vegetation in 16 localities.

Lizards were captured, marked and released at the site of capture. Survey and sample campaigns lasted for five days. Latitude, longitude and elevation were recorded using a Garmin™ GPS 12 Global Position Device and were later transfered to GPS Trackmaker™ software for complete distribution mapping and analysis (Fig. 3).

Voucher specimens from one locality were collected and deposited in the reference collection of the Animal Ecology and Conservation Center (ECOA), housed in the Biological Sciences Institute, of the University Catholic of Salvador, UCSAL, Salvador, Bahia, Brazil. Vouchers were
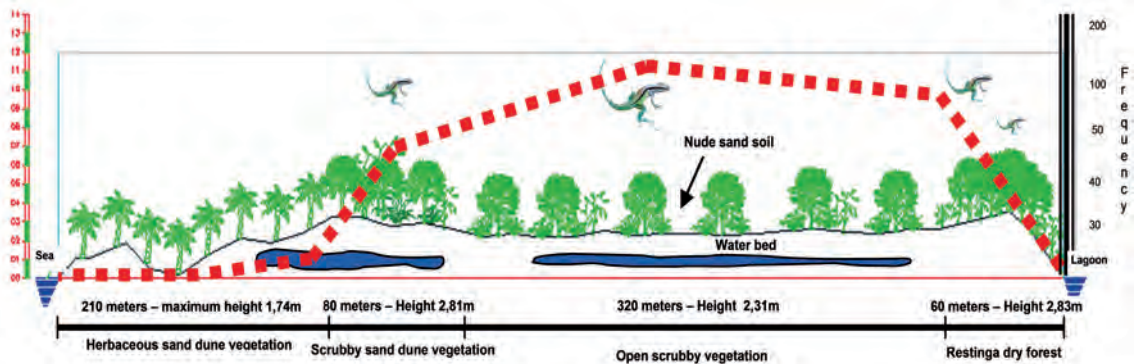
Figure 4. Broad habitat use of *Cnemidophorus abaetensis* in northern coast of Bahia based on the Praia do Forte locality's data. Diagram shows species abundance in different vegetal formation (red dots). Note the species exhibits higher frequency on open shrub vegetation. The species frequency falls to zero on the herbaceous sand dune vegetation where *C. ocellifer* is abundant. On sand dune shrub vegetation the species frequency also falls where it meets the dense vegetated dry Restinga Forest habitat. *C. abaetensis* also becomes more frequent where the water bed is shallower (Diagram by C.M. Menezes, 2007).

collected under national environmental license number: 03/2009-NUFAU-IBAMA-BA.

RESULTS

The study captured and sampled (via pitfall traps and visual search) 618 lizards from 500 traps and 640 hours of field effort. Lizards were mainly found on open dune scrub habitats (> 70%) (Fig. 4) and some were also recorded in dry restinga forest habitat.

No lizards were found in the humid zones and herbaceous beach vegetation. The samples collected provide new distributional records and habitat types. One site, where the type locality exists showed specimens had extended into new territory, south of where they had previously been found.

New site locations are shown in Fig. 3, where we point out the previously known geographic distribution of the species based on literature and further localities surveyed as part of a biogeographical study of Bahian lizards, conducted by the ECOA, UCSAL (ECOA, 2009).

In thirteen localities, *Cnemidophorus abaetensis* was found in sympatry with *C. ocellifer* (Blue Spotted Whiptail Lizard) and other Teiids, including *Tupinambis merianae* Duméril & Bibron 1839 (Tegu Lizards), *Ameiva ameiva* Linnaeus 1758 (Greater Whiptail Lizard) and *Kentropix*

calcarata Spix 1825 (Water Whiptail Lizard). Over 40 amphibian species, some of them endemic to the restinga habitats, were also found in the same habitats (Tinoco et al., 2008b). Six localities between Guarajuba and Baixios, and from Baixios to Costa Azul represent major new localities for *Cnemidophorus abaetensis*. Ipitanga, Busca Vida, Barra do Jacuípe, Praia do Forte, Imbassaí, Diogo, Santo Antônio, Sauipe, Massarandupió, Subaúma, Barra do Itariri, Sítio do Conde, Siribinha, Coqueiros and Mangue Seco are also all new localities, not previously recognised in literature or other official records (Dias & Rocha, 2004; Dias & Rocha, 2006; Machado et al., 2008). One locality, Parque Metropolitano de Pituaçu, south of the APA (Environmental Protection Area) Lagoas e Dunas do Abaete (type locality), represents a southerly extension of approximately 8.30 km relative to the previously known locality of *C. abaetensis*.

This means that all eight municipalities along the northern coast of Bahia now have records of *C. abaetensis*, filling a number of gaps on the map for this species in the region and State. All these localities are included in the political geographic distribution of Litoral Norte (North Coast), the second economic region of the State. The 16 localities studied are distant, occurring approximately 10 km from one another. With this in mind, we believe that the species shows a contiguous

distribution along the coastal line. However, we consider that because of habitat loss and other impacts on the species' natural environment it is possible that populations are becoming disjunct in some localities, especially those to south of its now known distribution.

Our results report not only new records which fill gaps between previously published localities, but also a significant extension in geographical range for *C. abaetensis*, which is verified by voucher specimens and consideration of previous literature. One specimen of *C. abaetensis* was found at the Pituaçu Metropolitan Park (12º57'55.78" S 38º24'38.51" W), on an open slope alongside a road. This locality is about 10 km south of APA Lagoas e Dunas do Abaeté, the southern-most locality cited by Dias & Rocha (2006).

DISCUSSION

Although *Cnemidophorus abaetensis* was found on the three major habitats of the Restinga ecosystems at Praia do Forte (12º32'39.66" S 37º59'22.59" W from 2005 to 2007) and Imbassaí (12º28'45.00" S 37º57'23.21" W from 2005 to 2008) with some 247 and 184 individuals sampled respectively (Fig. 4), we found that our frequency of capture information showed the highest abundance of the species was in open scrub habitats. Dias & Rocha (2004) also verified that both species used open scrub vegetation on the APA Lagoas e Dunas do Abaeté.

The open scrub habitat lies between Restinga forest and herbaceous sand dune habitat to the east, and Atlantic Rainforest to the west. This type of habitat is more frequently used by *Cnemidophorus ocellifer* (Blue Spotted Whiptail Lizard) which is scarcely found in most open bush habitats (Dias & Rocha, 2004). Despite this, we noticed that in the sand dunes beach herbaceous vegetation *C. ocellifer* seemed to have low or no niche overlap with *C. abaetensis*.

The samples in our survey of the north coast of Bahia are intended to aid the future conservation of *Cnemidophorus abaetensis* and complete its geographic mapping. Although we recognize that the ecology of the taxon requires further study, our results provide a baseline of data. Pressures on the land from tourism that may alter populations

of *C. abaetensis*, and *C. ocellifer* by changing their distributional patterns is discussed by Browne-Ribeiro et al. (2008). Our study provides quantitative data toward showing that both species are affected by altered human habitat compared with data for natural habitats. Natural habitats seem to be the most suitable for the species (Dias & Rocha, 2004, 2006; Browne Ribeiro, et al., 2008) and because of the major threat of habitat loss imposed over these landscapes, we recommend the creation of regulations, through public policies to protect these habitats. As shown in our results, most of the species distribution is restricted to the Restinga habitats on the coast line of Bahia, which also agrees with Dias & Rocha (2006). However we suggest that *Cnemidophorus abaetensis* must be considered as more broadly distributed in the coastal Bahia State, as well as being an inhabitant of specialist open shrubby vegetation habitat. Given its status we recommend that the species should be considered for inclusion on a State Red List to assist in its protection.

In conclusion, we suggest, in support of Machado et al. (2008), that further new protected areas be created for *C. abaetensis* that improve measures to safeguard habitat. We acknowledge that such effort is already carried out by IBAMA (National Environmental Agency) in partnership with the ECOA Center. These institutions are proposing the creation of major conservation units, which will hopefully include over 30,000 ha of natural Restinga vegetation in three of the species' geographic municipalities, mostly at the northern end of its distribution. However, we advocate that the same measures should be alloted for the southerly distribution of the species range.

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Growth and demography of the Fan-throated Lizard *Sitana ponticeriana* (Sauria: Agamidae) from a tropical environment in India

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ABSTRACT - This growth and demographic study of the Fan-throated Lizard *Sitana ponticeriana* was conducted from 2001-2003 in a tropical environment at Balukhand-Konark Wildlife Sanctuary, Orissa, India. A total of 216 hours (9 hrs/day) of observation were made and 2612 (mean 217.66 ± 88.95) lizards were studied. The size structure between the demographic size classes such as juveniles, subadults and adults changed between the wet (rainy and winter) and dry (summer) seasons. Lizards exhibited a maximum 58-60 mm of SVL. Regression relationships were expressed as linear regression equations and revealed that males were slightly larger than females. Hatchlings were observed in the field between early July and mid-November. For three demographic size classes growth rates varied with season i.e., faster in wet season than dry season. There was no significant sexual dimorphism in growth rate. Lizards reached sexual maturity within a year. On average, the subadult and adult sex-ratio was close to 1:1; however, the data for each group indicated that there was greater abundance of males in the population during the dry than the wet season. Our results indicate that, like other lizard species, growth and demographic characteristics of *S. ponticeriana* populations fluctuate with the proximate seasons of a tropical environment in natural habitats.

THE biological specializations of reptiles are associated with body size and morphometric parameters that are a part of life history and demography of an organism. The information on size i.e., snout-vent length, tail length and total length of most agamid lizards is described by Smith (1935), Singh & Thapliyal (1962), Sharma (1982), Goel & Reddy (1983), Tiwari & Aurofilo (1990) and Pradhan (2000). Bhupati & Kannan (1997) reported some information on size, specifically snout-vent length and tail length of several agamid species. For agamids, the size/morphology of the lizard does not depend upon the sex, rather it depends on the age of the animal and the amount of food intake (Mahendra, 1935). There is also an evolutionary association between morphology and habitat use by lizards. For Phrynosomatid lizards, that are similar to Agamids in autecology, male and female lizards of 30 species have been shown to exhibit these associations (Herrel et al., 2001).

Early theoretical work by Cole (1954) and Lewontin (1965) established that the pattern of life history determines the dynamics of biological populations and that life history variables differ with respect to their influences on population dynamics. Subsequent theoretical and empirical works have extended this idea (Caswell & Hastings, 1980; Stearns, 1992; Dobson & Oli, 2001). Furthermore, theoretical studies dealing with the relative importance of life history variables

to population growth rate have focused on the sensitivity of the finite rate of population growth to changes in various life history variables. Lemos-Espinal et al. (2003) demonstrated in seasonal tropics, that lizards experience seasonal variation in their proximate environment and seasonality can affect many aspects of a lizard's life history and demography. Population regulation underlies many ecological and evolutionary processes and thus serves as a central, unifying concept in ecology (Murdoch, 1994; Turchin, 1995, 1999; Sinclair, 1996). Dobson & Oli (2001) demonstrated that an understanding of demography is essential for discerning the factors or processes that underlie biological populations. This is because life history variables differ substantially in density-dependent responses (Sinclair, 1989, 1996; Leips et al., 2000; Coulson et al., 2001) and because populations are potentially influenced by dynamic behaviour (Cole, 1954; Saether & Bakke, 2000) and often influenced by demographic origin of density dependence (Neubert & Caswell, 2000).

There is substantial literature demonstrating that ingestion levels, below what is required to sustain maximum growth rate, appear to increase the probability of survival under laboratory conditions (Metcalfe & Monaghan, 2001). Such mechanisms could also be important factors in directing the evolution of life histories in natural populations, which has, until recently, been overlooked by evolutionary ecologists (Metcalfe & Monaghan, 2001). In some lizard populations diet breadth and composition, and abundance of prey items, in lizard stomachs are also affected by seasonality (Vitt, 1991; Christian et al., 1996; Griffiths & Christian, 1996; Pal et al., 2007). In addition, recent research demonstrated that growth rate can be increased or reduced by an individual organism depending on these seaonal environmental triggers. In the majority of lizards, the number of males is more than females in natural populations. Published work by Singh & Thapliyal (1962), Subba Rao (1974) and Koul & Duda (1977) reported variable sex ratio for several species of lizards; *Agama tuberculata*, *Lygosoma himalayanum*, *Calotes nemoricala* and *Calotes versicolor*. Pradhan's (2000) observations indicated that more males than females appear to be common in lizards present in

different geographical areas of Orissa, India.

We present the results of a two-year study of growth and demographic variation in the Fan-throated Lizard *Sitana ponticeriana*, a species of agamid lizard that lives in sandy soils in Balukhand–Konark Wildlife Sanctuary, Orissa, India. Here we investigated whether growth was slower in the dry than in the wet season, and how population structure, such as size and sex ratio, changes with season in natural habitats.

METHODS AND MATERIALS

Censuses for *Sitana ponticeriana* were conducted on the Balukhand-Konark Wildlife Sanctuary (19º48' to 19º54'N, 85º52' to 86º 14'E), which is located in the District of Puri, Orissa, India. This Sanctuary is 71.7 km² and established on a sandy tract along the coast between Puri and Konark, bordered by vegetation. The boundaries of the Sanctuary include the Bay of Bengal on the east and villages on the west, north and south. There were scattered Tamarind (*Tamarindus indica*), Karanja (*Pongamia glabra*), Polanga (*Calophyllum inophyllum*), Neem (*Azadirachta indica*), *Eucalyptus* spp. and *Acacia* spp. trees on both sides of the sandy tract along the coast. The principal ground cover consisted of thickets of *Anacardium* spp. and *Casuarinas* spp. Understorey shrubs included *Pandanus* spp., Adhatoda (*Adhatoda vasica*) and various horticultural plantings, which provided refuges for lizards. Over the two years of our study period in this Sanctuary, we observed *S. ponticeriana* to be by far the most abundant lizard species, followed by in order of decreasing abundance *Calotes versicolor*, *Eutropis bibroni*, *E. macularia* and *Lygosoma punctata*. The mean maximum air temperature was 40ºC during summer (April-July) and mean minimum winter (November-January) temperature was 10ºC.

Sitana ponticeriana is found on sandy soft-soil throughout Puri but population densities are higher in coastal than in forested areas. It is the only member of the *Agama* that is abundant in the casuarinas plantation area, near the sea, especially in the Balukhand-Konark Wildlife Sanctuary (Pal et al., 2009b). The lizard's body is brown on the dorsum with a series of dark brown, black-margined, rhomboidal patches and vertebral spots on the back

(Shanbhag et al., 2003). They were observed to shelter at night in holes or cracks in the ground, or in bushes, and emerged out in the morning when direct sun rays fell upon the respective sites after sunrise (Pal et al., 2009b). There was daily variation in the timing of emergence and after the accomplishment of daily routine activities, lizards returned to their known shelters during evening hours when direct sunlight lessened on the activity sites (Pal et al., 2009b). The lizard eats primarily arthropods but occasionally consumes plants and small gastropods (Pal et al. 2007). In natural populations, the species becomes sexually mature within a year and minimal longevity in nature is around six years (Pal et al., 2009a). The biochemical aspects of the lizard species indicates higher amount of proteins and cholesterol in the blood serum of females than in males, and other biochemical blood parameters vary markedly from each other (Pal et al., 2008).

Surveys were conducted in various habitat patches in and around the wildlife sanctuary between 07:00 to 16:00 from October 2001 to September 2003. We carefully searched all habitat types in the sanctuary to eliminate potential bias of searching for lizards only where they were likely to be very common in their natural habitat. Focal observations were photographed from a distance of 3-5 m. Lizards were caught by hand or net, placed in a plastic jar, and snout-vent length (SVL) and tail length (TL) measured with digital calipers (Pal et al., 2009b). Time of capture and microhabitat use was recorded when lizards were first sighted/captured and the location of capture marked on a map of the study site. Lizard sex and age were classified using previously determined characteristics (Pal et al., 2007, 2008, 2009a). Lizards that were captured as hatchlings could be accurately aged based on their body size. All individuals were returned to their original place of capture within two hours. Care was taken to avoid sampling the same individual twice by visiting locations once per sample visit.

Growth rate was determined by calculating the change in SVL in each month over two years of our study period. We used a two-way ANCOVA to analyze growth rate with sex, season, and year as factors and mean SVL as a covariate. For the study of population age structure in natural habitat over two years and between seasons, we divided the population into three demographic size classes based on SVL; juveniles, subadults and adults. Size class juveniles included all individuals having SVL of < 25 mm, size class subadults had SVLs between 25 and 35 mm (likely individuals that were less than one year old but not reproductively mature), and size class adults included any individuals above 35 mm, and were most likely reproductively mature (Pal et al., 2009a). Gravid female lizards were also grouped with the adult size class. We analyzed population structure by using the proportion of individuals in each size class found in the monthly samples and treated these samples as statistically independent. To analyze the sex ratio in the population structure in natural habitat, we compared the mean of the proportions of males and females in the population for each sample to a 1:1 sex ratio using a T-test. Means are expressed ± 1 SD throughout.

RESULTS

A total of 2612 (217.66 ± 88.95) specimens of *S. ponticeriana* was sampled in 216 hours (9 hrs/day) during two study years. Maximum samples of juvenile, subadult and adult lizards in 2001-2002 and 2002-2003 were, 441 (36.75 ± 36.95), 390 (32.5 ± 32.21) and 405 (33.75 ± 36.65), and 422 (35.16 ± 3621), 477 (39.75 ± 15.09) and 477 (39.75 ± 14.48) respectively. Estimates of densities were made for the three different seasons for both study years. As shown in Fig. 1, the juvenile populations were dominant during the rainy season, declined in early winter and were totally absent in late summer months. Similarly, the subadult populations were smaller in rainy season, appeared to reach maximum densities in winter, over that of juveniles and adults, and were totally absent in late summer. Adult populations were present during all three seasons in the study area and maximum densities were observed in summer. As the peak breeding season was May through July, all the gravid females were sampled during these months (unpublished data). In each study year, population peaks were observed from July to November, followed by a steady decline in late winter. Minimum densities of lizards were observed in summer (Fig. 1). The variation in population size in the sanctuary over
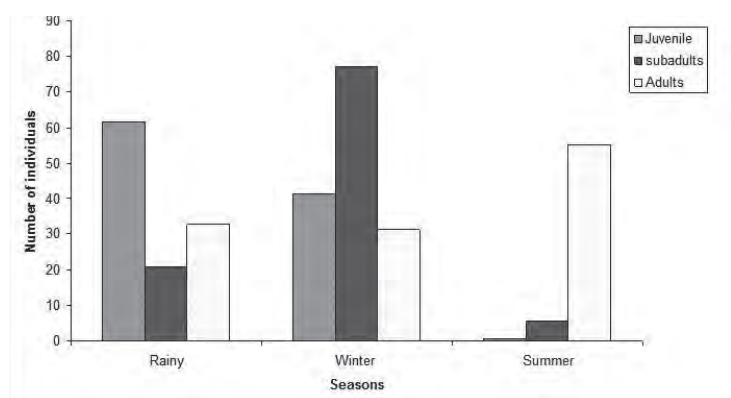
Figure 1. Mean ± 1SD distribution of three demographic size classes (juveniles, subadults and adults) of *Sitana ponticeriana* in three seasons from October 2001 to September 2003 at Balukhand–Konark Wildlife Sanctuary.

Year/Month	Sex	SVL Range (mm)	TL Range (mm)	TOL (mm) Range	Mean TOL (mm)	SD
October	J	22-27	46-60	68-93	77.5	+ 0.692
	M	28-49	70-91	107-140	123.5	+ 3.229
	F	28-45	55-63	90-108	93.5	+ 0.929
November	J	18-27	38-56	56-85	70.5	+ 1.024
	M	28-38	57-80	85-118	101.5	+ 1.016
	F	28-47	48-73	76-120	96.0	+ 2.521
December	J	17-27	26-60	43-87	65.0	+ 0.963
	M	28-53	58-91	86-144	113.0	+ 1.863
	F	28-47	40-90	68-139	103.5	+ 1.936
2002						
January	J	20-27	40-51	60-78	69.0	+ 0.976
	M	30-49	57-91	87-140	113.5	+ 1.383
	F	28-33	43-74	71-107	89.0	+ 0.806
February	J	27-28	56-57	83-85	84.0	+ 0.057
	M	28-45	60-97	88-142	115.0	+ 1.524
	F	28-37	66-74	94-111	102.5	+ 0.610
March	J	---------	---------	82	82.0	+ 00
	M	30-48	66-96	96-144	120.0	+ 2.370
	F	33.41	60-83	93-124	108.5	+ 0.912
April	J	---------	---------	---------	---------	+ 00
	M	43-51	102-108	145-159	152.0	+ 0.453
	F	34-43	80-97	114-140	127.0	+ 0.820
May	J	---------	---------	---------	---------	+ 00
	M	39.53	82.115	121-168	144.5	+ 1.065
	F	39.48	59.96	98-144	121.0	+ 0.523
June	J	---------	---------	---------	---------	+ 00
	M	38-54	84-104	122-158	140.0	+ 1.101
	F	43-47	58-94	128-141	134.5	+ 0.427
July	J	18-23	33-44	51-67	59.0	+ 0.614
	M	44-53	85-110	129-163	149.0	+ 1.002
	F	47-54	67-92	114-146	130.0	+ 1.042
August	J	15-27	32-56	47-83	65.0	+ 1.136
	M	28-49	64-109	92-158	125.0	+ 3.466
	F	28-48	52-90	80-128	104.0	+ 0.801
September	J	16-27	29-52	45-79	62.0	+ 0.723
	M	49-55	102-108	151-163	157.0	+ 1.131
	F	45-49	79-93	124-142	133.0	+ 2.683

Table 1. Body size data of *Sitana ponticeriana* collected from October 2001-September 2003 at Balukhand–Konark Wildlife Sanctuary. Continued overleaf.

Year/Month	Sex	SVL Range (mm)	TL Range (mm)	TOL (mm) Range	Mean TOL (mm)	SD
October	J	16-27	35-58	47-84	78.7	+ 0.472
	M	28-57	57-100	85-157	127.5	+ 3.631
	F	28-50	45-98	73-148	97.5	+ 0.899
November	J	21-27	38-59	61-85	73.8	+ 0.993
	M	28-42	59-88	86-130	105.4	+ 1.115
	F	28-47	59-80	87-127	98.0	+ 1.981
December	J	19-26	38-54	54-79	63.2	+ 1.103
	M	28-50	55-105	83-155	119.5	+ 1.906
	F	28-50	58-89	86-139	101.5	+ 2.021
2002						
January	J	23-27	41-58	57-85	69.0	+ 0.827
	M	28-45	48-95	76-142	113.5	+ 1.203
	F	28-35	49-72	78-109	89.0	+ 1.085
February	J	25-27	34-48	59-75	68.0	+ 0.121
	M	28-45	52-98	80-142	124.5	+ 1.394
	F	28-40	47-76	76-112	1042.0	+ 0.568
March	J	26-26	55-55	81-81	81.0	+ 00
	M	35-46	66-101	101-147	123.5	+ 2.571
	F	30-45	45-79	75-118	106.0	+ 1.210
April	J	0-0	0-0	0-0	00	+ 00
	M	40-51	85-106	127-157	145.5	+ 0.547
	F	38-43	76-83	116-128	123.5	+ 0.769
May	J	0-0	0-0	0-0	0	+ 00
	M	40-51	85-107	127-157	146.5	+ 1.214
	F	37-53	77-95	114-148	137.5	+ 0.653
June	J	0-0	0-0	0-0	0	+ 00
	M	43-56	90-119	133-175	157.0	+ 1.313
	F	50-53	90-95	140-150	144.5	+ 0.562
July	J	15-20	22-33	41-52	44.5	+ 0.784
	M	50-51	109-115	159-166	162.5	+ 1.322
	F	46-58	83-103	131-161	149.0	+ 0.978
August	J	16-27	25-60	42-81	68.0	+ 1.526
	M	28-60	54-102	82-175	132.5	+ 2.986
	F	28-55	56-89	84-140	118.5	+ 1.037
September	J	17-27	30-59	47-88	67.0	+ 0.893
	M	28-55	59-112	87-167	143.5	+ 1.287
	F	28-51	59-99	87-150	136.0	+ 2.385

the two years presented a similar pattern. As shown in Fig. 1, a large portion of individuals disappeared from the population before the first reproductive season, beginning in March.

The snout-vent length (SVL), tail length (TL) and total length (TOL) distribution frequencies in both sexes are presented in Fig. 2. As shown in Table 1, the cumulative data on size range of three demographic size classes were represented for the two study years. Male lizards ranged from 15-60 mm with a mean of 33.42 ± 10.31 mm and coefficient variation (CV) was 106.29. Similarly, the tail length ranged from 22-119 mm with a mean of 68.73 ± 22.53 mm and the CV was 508.01. The total length ranged from 41-175 mm with a mean ranged 102.07 ± 32.61 mm and CV was 1063.45. The SVL of females ranged from 15-58 mm with a

mean of 30.45 ± 9.56 mm and CV was 91.41. The TL ranged from 25-103 mm with a mean of 60.53 ± 18.45 mm and CV was 340.56. The total length ranged from 38-161mm with a mean ranged 90.98 ± 27.55 mm and CV was 759.49. The regression curve of SVL, TL and TOL of both the sexes are shown in Fig. 3. This indicates that the males were slightly larger than females.

In natural habitat, hatchlings were observed between early July and mid November in both study years. There was sufficient data from lizards caught in the study area after hatching during the two years (July, August, September, October and November) to allocate some comparison of hatchling size. The smallest hatchlings were 15 mm SVL and mean size was 17.34 ± 0.67 mm (N = 102) (Table 1). Data on body size of hatchlings
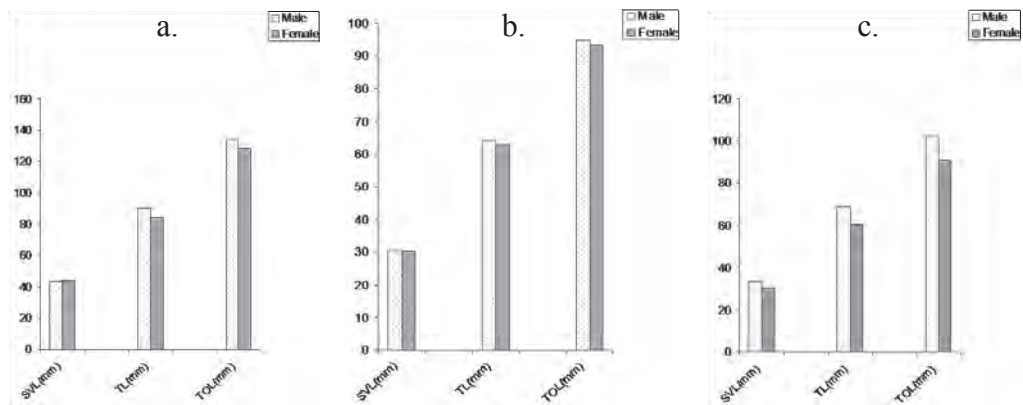
Figure 2. Histogram illustrating mean size distribution of snout-vent length (SVL), tail length (TL) and total length (TOL) of subadult males and females (a), adult males and females (b) and total males and females (c) of Sitana ponticeriana from October 2001 to September 2003 at Balukhand–Konark Wildlife Sanctuary.

was combined to test for differences in hatchling size among months. Hatchling SVL did not vary significantly among months (F = 0.562, P< 0.0001). Of the 102 hatchlings, 57 % (N = 58) were < 20 mm SVL, and had presumably hatched

within a few days prior to capture in the study area, and 43 % (44) were 20-25 mm SVL, and presumably represented the early hatchlings. In the fall following hatching by early August, September and October they had reached an average of 23.68
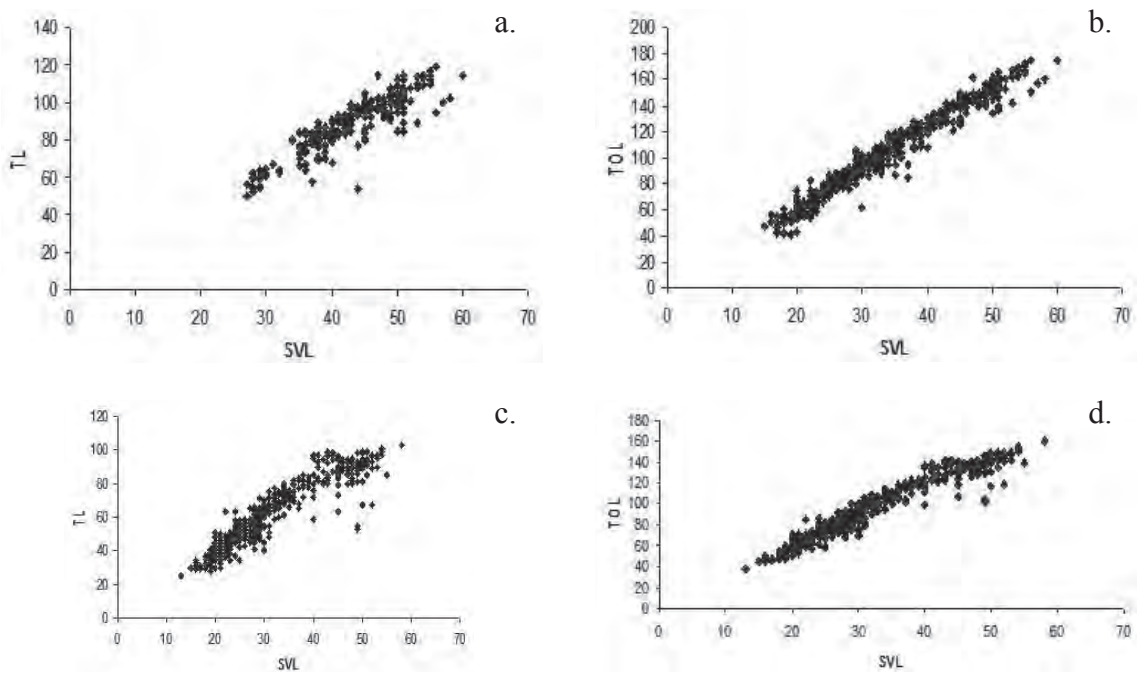
Figure 3. Regression curves of (a) tail length (TL) against snout-vent length (SVL) of total male, (b) total length (TOL) against snout-vent length (SVL) of total male (c) tail length (TL) against snout-vent length (SVL) of total female and (d) total length (TOL) against snout-vent length (SVL) of total female *Sitana ponticeriana* from October 2001 to September 2003 at Balukhand–Konark Wildlife Sanctuary.

± 0.83 mm SVL, indicating the growth rate was 0.147 mm SVL per day and an average rate of 0.106 mm/d. Within three seasons (i.e. rainy, winter and summer), juvenile, subadult and adult growth rates were calculated based on their SVL captured in the last week of each month. Two-way ANOVA was used to test for differences in average growth rates between the different seasons ($F = 7.94$, $P < 0.001$) as well as between subadult male and female ($F = 0.14$, $P > 0.5$). The only pair wise contrast was between rainy (0.232 mm/day), winter (0.197 mm/day) and summer (0.012 mm/day). During the rainy and winter seasons of both years, subadult males showed an average growth of 0.032 mm/day-0.029 mm/day, and subadult females 0.028 mm/day-0.025 mm/day respectively. Interestingly, growth rates of subadult lizards that were captured in early summer averaged 0.008 mm/d for males and 0.009 mm/d for females, indicating minimal growth rates during this sampling period. There was no significant difference between the growth rates of males and females of subadult and adults within the rainy, winter and summer sampling intervals (Kruskal-Wallis Test; all $P > 0.05$). Similarly, the growth rates of both mature adult males and females did not significantly change in wet and dry seasons over the two years (Kruskal-Wallis Tests; all $P < 0.05$).

Table 1 shows the size reached by yearling animals in the summer (March, April, May and June) of their first growing season at age 9 to 12 months. The maximum size reached by yearling females at the end of the reproductive season in their first growing season was 37 mm SVL and since the vast majority of females reproduce until they are at least 35-58 mm SVL our data suggests that yearling females have the possibility to reach sexual maturity. During summer months (April-Junne), and sometimes in the rainy season (July-October), sexually mature females had enlarged oviducts or large yellow-orange ovarian follicles. These females contained ova in early stages of vitellogenesis and the smallest female containing oviducal eggs was 37 mm SVL. The smallest sexually mature male and female were 35 and 38 mm SVL (Pal et al., 2009a). Thus, it it likely that animals mature within a year of birth.

For the analysis of age structure in natural population, the lizards were divided into demographic size groups (i.e. juveniles, subadults and adults) among animals handled in three different seasons (Fig. 1) in both study years. Snout-vent length was adjusted to rainy and winter periods using the average growth rates calculated for juveniles and subadult lizards. In both study years, monthly fluctuation in size structure was varied (Table 1). For the adult lizards, it was not possible to derive accurate data on age from their sizes recorded in natural habitats. Therefore, age structure of the adult lizards was derived from skeletochronology (Pal et al., 2009a) of aged individuals. As shown in Fig. 4, sex ratio (male: female) of *S. ponticeriana* was determined for the two study years. All the specimens sampled were grouped into three demographic size classes (juveniles, subadults, and adults). The minimum and maximum number of males was sampled during April (N = 9) and during September (N = 46) respectively. The minimum and the maximum number females sampled were 6 during April and 63 during September respectively. The minimum and maximum sex ratio (0.615:1 and 2.647:1) was obtained during April 2001 and August 2003 respectively. Sex ratio of *S. ponticeriana* was, in different months, represented by more females than males (Fig. 4). However, the cumulative sex ratio of all the adult males (N = 591) and adult females (N = 604) obtained over a period of 24 months was 0.978:1. Hence, the high sex ratio 2.647:1 obtained during August 2003 is attributed to sampling error. Among the few dissected juveniles (used for skeletochronology [Pal et al., 2009a]) the sex ratio was not significantly different from 1:1.

DISCUSSION

Populations of *Sitana ponticeriana* from the Balukhand–Konark Wildlife Sanctuary showed variation in life history traits and demography. As discussed in our previous publications, seasonal tropical environments potentially present organisms with demographic traits that vary both within months and among seasons. In our present study, populations of Fan-throated Lizards exhibited variation in growth and demographic traits between different seasons of our two year study period.

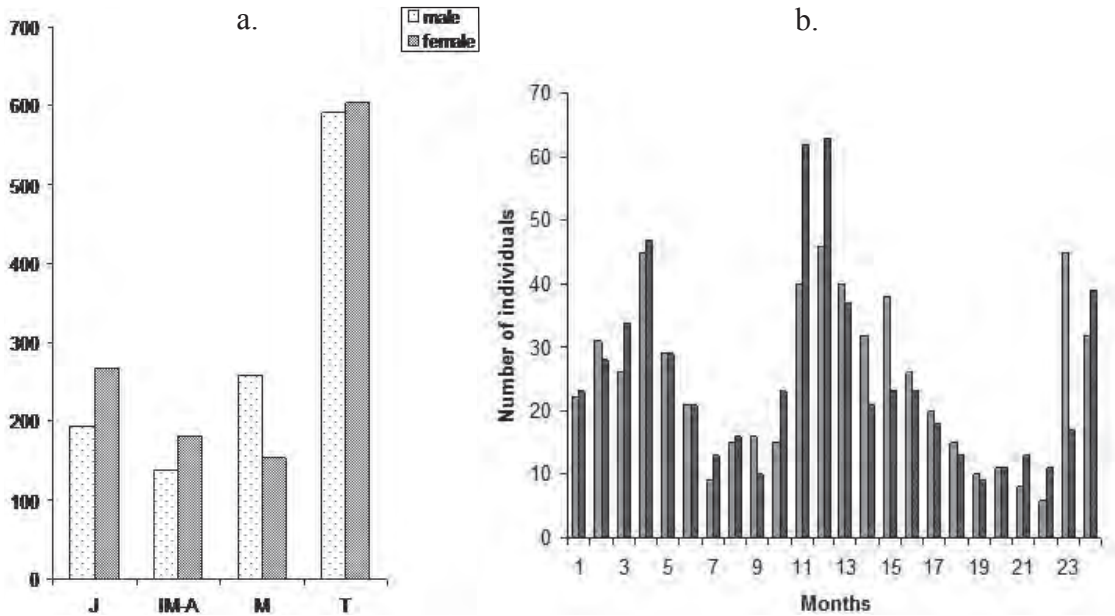An important aspect of this study is the

Figure 4. Histogram illustrating sex ratio of (a) demographic size classes i.e. juveniles (J), subadult (IM-A), mature adults (M) and total (T) and (b) in different months of *Sitana ponticeriana* from October 2001 to September 2003 at Balukhand–Konark Wildlife Sanctuary.

demonstration of high turnover of lizards during the wet season (wet and winter) and more or less stable population sizes over the complete two year period. The juvenile population dominated in abundance during the rainy season, whereas the subadults were dominant in abundance during the winter season. At the onset of summer neither juveniles nor subadult lizards appeared in their natural habitat, which reveals that the juveniles grow to be subadults during, and become, adult within one year. In comparison of the population density in three different seasons, the numbers of individuals were more in rainy and winter seasons than summer, possibly due to higher availability of food in their natural habitat (Pal et al., 2007). In India, there are several studies on size analysis of agamid lizards found in different geographical areas (Singh & Thapliyal, 1962; Tiwari & Aurofilio, 1990; Kastle et al., 1993; Bhupathy & Kannan, 1997). Regarding *S. ponticeriana*, Smith's (1935) report suggests larger physiology in Western India (Bombay) populations (SVL; 70-80 mm). On the other hand Bhupathy & Kannan (1997) reported only a maximum SVL of 46 mm. Similarly, Sharma's (1982) study of the species from Gujarat

indicated SVL ranges of 21-51 mm. Pradhan (2000) reported maximum SVL of males which ranged from 30 to 53 mm and females that ranged from 37 to 58 mm in different geographical areas of Orissa, India. On the basis of our sample size, the SVL of mature male and female *S. ponticeriana* (including gravid females) was 60 and 58 mm respectively. This size range of *S. ponticeriana* is comparable to those reported by Sharma (1982), Bhupathy & Kannan (1997), and Pradhan (2000).

This study also examined the interactive effects of demography and weather on fitness components, and their effect on the growth rate of *Sitana ponticeriana*. Despite the large biological differences of the study species, the results revealed the same patterns as those reported for mammals and birds (Gaillard et al., 1989; Saether & Bakke, 2000), suggesting that these patterns may be general for most terrestrial vertebrates. The main finding is that growth rate of *S. ponticeriana* in its natural habitat is seasonally variable. Lizards grew faster during rainy and winter seasons than during the summer season in both study years. Interestingly, the arthropods in tropical habitats are often more abundant during the wet season (Vitt & Blackburn,

1991; Griffiths & Christian, 1996; Pal et al., 2007) and *S. ponticeriana* feeds primarily on insects (Pal et al. 2007). This factor may have been attributable to the variation.

Seasonal growth rates in lizards are not a new phenomenon and there are a few examples of other tropical lizard species that show seasonal variation in growth rates. Andrews & Wright (1994) reported that adding water to experimental plots increased the growth rates of *Anolis humilis* during the dry season; but that growth rate did not differ between the dry and wet seasons for control lizards. Similarly, *Chlamydosaurus kingii* from another seasonal tropical environment of Australia exhibits growth that is limited to the wet season (Griffiths & Christian, 1996). Vogel (1984) reported in a population of *Anolis lineatopus* that reduction in growth rates of juveniles during the dry season was attributed to lower arthropod abundances during the dry season. In addition, Rocha (1995) found a correlation between rainfall and growth in *Liolaemus lutzae* populations from the seasonal tropics of Brazil. In our study, male and female lizards grew at the same rate although males and females did differ in growth rate annually and seasonally. These results suggest that males and females of Fan-throated Lizards react to changes in their proximate environment in similar ways. In a population of *Tropidurusi tambere* from a Cerrado area of southeastern Brazil, Van Sluys (1998) demonstrated that male growth rates were affected by environmental conditions such as temperature and food availability, but that male growth rates were not. In the tropical sanctuary in this study, we noticed the growth pattern of both male and female *S. ponticeriana* to be comparable with other lizard species over the two years of our study period.

Age structure of the *S. ponticeriana* population also varied seasonally. During the recruitment period, from July to November, there was a predominance of juveniles that were not recorded from December onwards. These results reflect a similar pattern of seasonal reproduction in other lizard species (Wiederhecker et al., 2002). Early age of maturity was estimated at five months for *Tropidurus torquatus* (Squamata, Tropiduridae) (Pinto, 1999). The importance of juvenile

recruitment for a population is basically due to the low permanence rates and the population's annual reproductive success (as shown in *Anolis limifrons* [Andrews, 1988]). The predominance of juveniles, at least in part of the year, is typical of species with short life cycles that result in a high annual turnover of individuals in a population (Barbault, 1976; Howland, 1992). Martori et al. (1998) reported, for *Liolaemus wiegmannii*, that size structure varied with season, which reflected recruitment and growth of the species. Similar seasonal fluctuations in population size structure were also observed in *L. lutzae* (Rocha, 1992) and *T. itambere* (Van Sluys, 2000). The main finding in the above studie was that variation in lizard survival was strongly affected by summer temperature and scarcity of food in their natural habitats. Many publications demonstrate that climatic variation often affects subsets of a population differently, and in such cases, its effect on population dynamics depends on the current demographic composition of the population (Leirs et al., 1997; Coulson et al., 2001). The results of our study suggest that survival of *S. ponticeriana* is more susceptible to harsh summer conditions than other fitness components.

For most lizards, the number of males is more than females in a natural population. Publications by Singh & Thapliyal (1962), Subba Rao (1974) and Koul & Duda (1977) reported variable sex ratio for several species of lizards viz. *Agama tuberculata*, *Lygosoma himalayanum*, *Calotes nemoricala* and *Calotes versicolor*. Pradhan's (2000) observations in different geographical areas of Orissa indicate that more males than females appears to be a common feature in lizards. Previous data regarding sex ratio of Fan-throated Lizards are rather sparse. This study reports the sex ratio of *S. ponticeriana* to have a slightly higher number of males to females and the mean density of those individuals to be lower than previously documented, suggesting that differences between the two sexes can result from higher competition among males in denser populations, which generates a female biased sex ratio. Another factor that may contribute to a proportional higher number of females in the population of *S. ponticeriana* was the greater size difference between established males and males at the onset of sexual maturity.

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CORONELLA AUSTRIACA Laurenti (Smooth Snake): REPRODUCTION. The Smooth Snake is the rarest of the six reptiles native to the UK and is confined to the lowland heaths of Dorset, Hampshire and Surrey (Beebee & Griffiths, 2000). Although it has been the focus of several research and monitoring programmes (e.g. Spellerberg & Phelps, 1977; Goddard, 1984; Braithwaite et al., 1989; Gent & Spellerberg, 1993; Reading, 2004a, 2004b) many aspects of its behaviour in the wild remain poorly documented as a result of its restricted distribution and cryptic nature. Mating behaviour, and, specifically, copulation is a case in point. Spellerberg & Phelps (1977) inferred a mating period extending from May to early June based on observations of receptive females and a small number of observed copulations. They also suggested that mating may occur later in the year, explaining the observation that some females were found to be gravid in the spring. One of the few published accounts of Smooth Snake copulation in the wild in the UK is given in Braithwaite et al. (1989) who describe a mating seen in August 1987. In this note I report a Smooth Snake copulation observed in late summer in the New Forest, southern England.

The snakes were found on 6 September, 2009 at 14:20 BST during surveys conducted as part of a surveillance programme. The survey area consisted of ericaceous heath on a gentle south-west facing slope overlooking a valley mire drainage system. The two snakes were found under an artificial refuge of corrugated cellulose-bitumen measuring 45 x 50 cm. The substrate under the refuge consisted of dead, flattened heather (*Calluna* sp.) under which the snakes had buried themselves such that only their heads and the front 3-4 cm of their bodies were visible. The visible portions of the snakes were aligned in lateral contact with each other with the head of the larger individual immediately behind the head of the smaller. Multiple occupancy of artificial refuges by Smooth Snakes is not uncommon in this area and it was not until the snakes were retrieved for recording biometric data that it became apparent that the two were a mating pair. The left hemipene of the male was inserted into the cloaca of the female. Both individuals remained passive during handling, allowing routine photography of head and anterior body markings to be made for identification purposes. During this period the two voluntarily separated, allowing a full suite of measurements to be made. The male was markedly larger than the female. Total length, snout-vent length (SVL) and body mass of the male and female were 57.2 cm, 45 cm, 42 g and 47.4 cm, 39.5 cm and 32 g, respectively. Separation revealed some milky effluvium around the cloaca of the female. After data collection the snakes were released back under the refuge.

Environmental temperature data were recorded using a digital thermometer. Air temperature was 18.3ºC (the weather conditions were overcast [cloud cover: 8/8 oktas] and had been so since the afternoon of the previous day). Air temperature under the refuge was 19.7ºC prior to the refuge being lifted. Oesophageal body temperatures obtained from the snakes were 20.4ºC for the male and 21.6ºC for the female. These temperatures were markedly lower than the preferred body temperatures selected by this species in laboratory tests e.g., Gent & Spellerberg (1996) or the plateau temperatures recorded from specimens in the field e.g., de Bont et al. (1986) both of which are typically in the range of approximately 29-33ºC. The body temperatures were, however, markedly higher than the 15.3ºC and 15.5ºC recorded for a male and female mating in May, recorded by de Bont (1986). Thus, as has been noted by Shine et al. (2000) the ability to attain and maintain the preferred body temperature may be relatively unimportant for some aspects of snake behaviour.

The highly contrasting markings of the female indicated that she had recently sloughed (several other females were recorded in slough, or newly sloughed with freshly cast skins nearby on the same day). There was no neck-bite by the male on the female and no scarring to indicate that such a hold had occurred. 'Lizard-like' seizing of the female, behind the head, by the male, has been reported (e.g. Braithwaite et al., 1989; Phelps, 2004) but does not always occur. Engelmann et al. (1990) reported two matings in the Swiss Jura in which neck-biting was not observed.

The ecological significance of the current observations remains unclear. The small size of the female suggests that she was breeding for the first time. The smallest gravid Smooth Snake that I have encountered previously had a total length of 44.3 cm and a SVL of 37.2 cm, while the smallest of seven females found breeding for the first time by Reading (2004a) had a SVL of 41.3 cm. The female currently reported had been captured before in April of the previous year, when it had a total length of 31.5 cm and a SVL of 27 cm and presumably would not have been sexually mature at that time. The male was first recorded in April 2006 with a total length of 48 cm and a SVL of 36.5 cm and would already have been sexually mature for several years.

Late summer mating in Smooth Snakes from England has been observed in captivity by Street (1979). He documented a late August mating of recently captured snakes, consisting of a male trailing a female and behaving aggressively towards other males, culminating in two copulations of several hours each over a period of 24 hours. To my knowledge definitive outcomes of these late summer copulations have not been recorded. The ability to produce young from autumn mating could impart a significant ecological advantage to a species that is at the extremes of its range in the UK. The lack of knowledge of the outcomes of these copulations is a significant gap in our understanding of Smooth Snake ecology. Spellerberg & Phelps (1977) concluded that matings late in the year resulted in the appearance of gravid females early the following year, prior to the spring mating period. That late summer copulation might produce viable offspring through the process of delayed fertilisation is suggested by the observation of Strugariu (2007) who recorded sperm storage in a wild-caught female, which was taken into captivity in May and produced six offspring in the September of the following year, throughout which time it was kept in isolation. It has also been suggested that in poor summers females may carry their litters over the winter and give birth the following year, which could also account for the observation of gravid females in the early spring (Braithwaite et al., 1984).

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TOMODON DORSATUS (Pampas Snake): REPRODUCTION. The colubrid snake *Tomodon dorsatus* (Duméril, Bibron & Duméril, 1854) occurs in Latin America in Brazil, Paraguay, Argentina and Uruguay. It is normally found in areas of humid tropical vegetation, including "ciliar" forests (Bizerra, 1998). *T. dorsatus* feeds only on molluscs, is diurnally active (Marques, 1998), and is viviparous with a seasonal reproductive cycle (Bizerra et al., 2005). There is little known about reproduction in *T. dorsatus*, especially biometry of neonates.

This note presents information on birth, litter (size and mass) and sex ratio in newborn *T. dorsatus*. Three gravid specimens of *T. dorsatus* (here named female 1, 2 and 3) were collected in São Paulo state (cities of Ibiuna, São Paulo and Cotia) and brought to Instituto Butantan where they were kept in captivity. The female's body size, relative clutch mass (RCM: clutch mass/body mass of mother after parturition) and detail about the neonates is shown in Table 1. Fifty-eight animals were produced. Male newborns (n = 34) averaged 163.15 mm snout-vent length - SVL (range = 150-180 mm), 47.06 mm tail length - TL (range = 40-55 mm) and 2.62 g mass (average = 1.90-4.0 g). Female neonates (n = 24) averaged 165.46 mm SVL (range = 150-180 mm), 46.46 mm TL (range = 30-55 mm) and 2.69 g mass (range = 1.7-4.0 g).

The sexes of neonates did not differ significantly in mean snout-vent length (t = 1.10; P = 0.27), tail length (t = 0.41; P = 0.67), mass (t= 0.39; P = 0.69), and sexual dimorphism.

In adults, females are larger and heavier than males and males have greater higher relative tail length (Bizerra et al., 2005). This suggests ontogenetic variation in neonate growth. Neonates did not show correlation between TL and SVL and between total length and mass. Only one stillborn was observed. *T. dorsatus* seems to invest heavily in reproduction, since the RCM value (Table 1) is higher than values reported for other viviparous colubrids e.g., *Helicops leopardinus* (RCM 0.39) and other species (Seigel & Fitch, 1984).

Table 1.	Female 1	Female 2	Female 3
Female SVL (mm)	560	590	570
Female TL (mm)	170	155	170
Female wt (g) post birth	62	95	60.5
Litter size	13	24	21
	(4 ♀/9 ♂)	(12 ♀/12 ♂)	(8 ♀/13 ♂)
Litter mass (g)	39	72	42.64
RCM	0.69	0.76	0.70
Birth	Aug. 2001	Oct. 1999	Aug. 2009

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Herpetofauna of Vietnam

Nguyen Van Sang, Ho Thu Cuc
and Nguyen Quang Truong

2009, Edition Chimaira,
Frankfurt am Main, 768 pp.
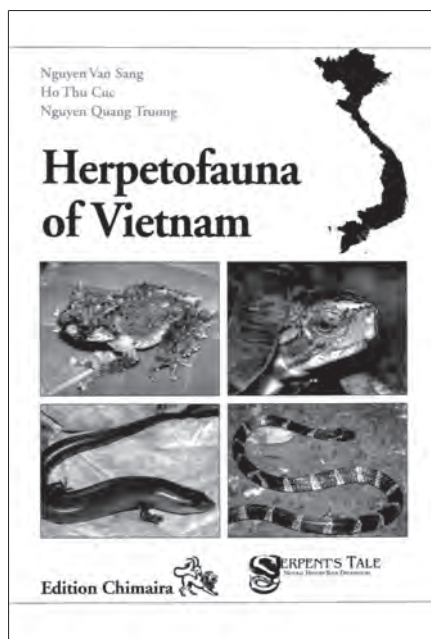
When I first set eyes on 'Herpetofauna of Vietnam' I was immediately taken by its sheer size, for a small book it is a veritable tome. The first quick flick through the pages revealed why, a comprehensive checklist of all the 296 reptile and 162 amphibian species currently recognised in Vietnam, followed by an extensive set of high quality colour plates some 200 pages long. A closer look at the species accounts revealed the first downfall as very little in the way of ecological data or identification features for most species. I have to stop at this point and remind myself that this book is exactly what the blurb on the back cover says it is – a checklist for the herpetofauna of Vietnam.

By far the most interesting part of this book, at least as far as the text is concerned, is the chapter entitled 'Herpetological Exploration, Research and Conservation in Vietnam'. Written by Kraig Adler of Cornell University it describes the colourful herpetological history of the country. Starting with the medicinal text of the Buddhist monk Tue Tinh (Nam Duoc Than Hieu circa C17-18) which listed those species that were considered to have medicinal properties (a grand total of 16).

Adler goes on to explain in great detail the exploits of the various European colonialists, in particular the French. All of the great 19th Century texts covering Vietnamese herpetology are detailed in this chapter as well as a detailed history of where the author's collections are held; unsurprisingly most of them are held in France. Some of the characters responsible for the stories covered will be familiar to most professional and serious amateur herpetologists – names such as Günther, Smith, Schmidt and Tirant.

Included in the introductory chapters are three maps, two of which will be invaluable when reading the species distributions in the checklist (for all except those with a detailed knowledge of Vietnam) in particular the physical and political maps. The third map (first in the book) of the wider region, enables the reader to orientate themselves, but is erroneously labelled as a 'Physical map of Southeast Asia' as it includes areas such as the Russian Federation, the Indian sub-continent, much of the Middle East, Japan and Indonesia. I suspect the reason for this is due to the ranges often covered by various species present in Vietnam. So in order to be correct the legend should read something along the lines of 'Physical map of Asia and Indonesia'. Or is that me just being picky!

As you would expect the checklist makes up the majority of this book, accounting for over 400 of the 768 pages, and is arranged in the standard systematic way. Each genus starts with comments about its taxonomic status. Species accounts are arranged as follows - taxonomic revisions, holotype where available, vernacular names (both English and Vietnamese), distribution by region in Vietnam, and by additional country (sometimes by region), references, comments on taxonomy.

The taxonomic revisions are very well researched and have obviously been heavily influenced by recent revisions such as Frost et al. (2006) and Malhotra & Thorpe (2000). The distribution by Vietnamese region is extensive

and particularly useful when used in conjunction with the aforementioned physical and political maps. The distribution of species in countries other than Vietnam is particularly useful when detailed regional distribution is given. It is unfortunate that this is not consistent, though the book may have been a great deal larger if this were the case. A quick analysis shows that 80% of amphibians, 60% of lizards, 90% of snakes, and 90% of chelonians are found in at least one country other than Vietnam (neither species of crocodilian found in Vietnam, *C. porosus* and *C. siamensis*, is endemic). The countries covered regularly by this book range from Iran in the West, to Japan in the East and down to Malaysia and Indonesia in the South. This simple fact makes this book useful for anyone interested in the herpetofauna of wider South East Asia.

Looking through the distribution information turned up some interesting pieces of information, for instance 12 out of 13 species of *Cyrtodactylus* (Gekkonidae) found in Vietnam are either known only from the type locality or from a small area within Vietnam. In fact the Gekkonidae show an amazingly high level of endemicity in the country (accounting for more than half of the 50 or so endemic lizard species in the country).

The widest ranging of all the species in the book is the Blind Snake *Ramphotyphlops braminus* that can be found from Africa all the way to Guatemala, Mexico and USA via the Pacific islands. A quite extensive distribution, that took me by surprise. I am familiar with *R. braminus* from studying Latin and South American herpetology for some years, yet I had no idea that its range is so vast.

Given that the amount of information on the species is limited in terms of descriptions and morphometrics, the generally extensive reference list and the additional comments on taxonomy for each species could prove invaluable to researchers interested in furthering our knowledge of the herpetofauna of this region.

Following the checklist is an extensive selection of colour plates, some 200 pages long, containing superb photographs of most of the species found in Vietnam. In my opinion this is the 'crown jewel' of 'Herpetofauna of Vietnam' with, in most cases, photographs of specimens from multiple locations. The inclusion of such a set of colour plates makes

'Herpetofauna of Vietnam' shows how much the 'Frankfurt Contribution to Natural History' series has moved on compared to the earlier books.

One of the early volumes, 'Snakes of Sumatra' (David & Vogel, 1996), was one of the first detailed herpetological books I purchased in 1999. 'Snakes of Sumatra', although fantastic as a checklist with natural history notes, again lacked identification features but also had an additional setback - the lack of a comprehensive set of colour plates, which would have been extremely useful when learning what the species looked like just before one sets out on an expedition to a new area. The high quality of photography in the current publication is possibly due to the advent of affordable digital cameras meaning that it is easier to photograph herpetofauna in the field, compared to the early '90s.

'Herpetofauna of Vietnam' is a very commendable effort to summarise the current scientific knowledge of this subject, making this book is a superb starting point for any herpetologist interested in Vietnam or the wider South-East Asian region. It is also an essential addition to the bookshelf of any professional herpetologist involved in research in this region. If anything 'Herpetofauna of Vietnam' highlights the paucity of the scientific community's knowledge and the need for further research into the ecology of its immense herpetofauna. Enough said I'm off to a well known travel agent to buy a plane ticket!

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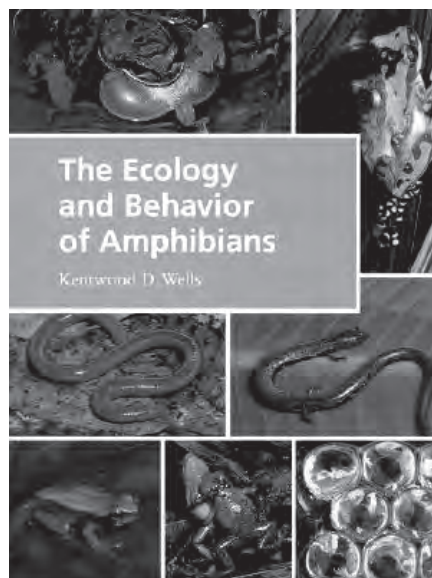
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The Ecology and Behavior of Amphibians

Kentwood D. Wells.

2007, Chicago University Press,
1400 pp.

The 'Ecology and Behavior of Amphibians' has enormous breadth as a title and at 1400 pages has an equally wide impact on ones' bookshelf. Kentwood Wells was arguably one of the only herpetologists equipped with a wide enough grasp of Amphibia literature to amass a testament worthy of the title. The volume was patiently awaited by many herpetologists keen to enjoy an ecological compendium that would build upon the classic text of Duellman & Trueb (1986). Taking a mere thirty years to compile, it is therefore difficult for a young academic herpetologist of my standing to fully appreciate the effort that has been required. I was in ecological diapers when the conception of this book began and therefore my opinion of the book should only really be expressed as a token gesture of appreciation.

The book should be regarded among the herpetological masterpieces of our time. While numerous publications have flirted with specialist topics within the subject of amphibian ecology, the content of this book undoubtedly stands apart from all other attempts and easily stands out as the current definitive guide to amphibian biology. Most of what many of us currently know about the world of frogs, toads, salamanders, newts and caecilians is documented in this book. The depth of literature reviewed is equally overwhelming.

The 'Ecology and Behavior of Amphibians' has been squeezed into 16 orderly chapters that have appropriate nested subsections. It begins with a detailed overview of the paleoecology and taxonomic origin of Amphibia. It commences by documenting the current evidence of morphological change that amphibians have experienced since their departure from the primordial swamps of Gondwana. This chapter also carefully dissects many phylogenetic relationships between extant families, allowing the reader to become immersed in a swathe of taxonomic source material. It also includes and adapts the recent Amphibian taxonomic shake up by Frost et al. (2005). Concise descriptions of each family follow and provide the reader with a full consideration of evolutionary contributions to amphibian diversity. The information presented is reinforced with high quality photographs that are used to illustrate a number of amphibian morphologies.

In chapters 2-6, the reader is presented with a comprehensive review of amphibian physiology. Wells covers a diversity of topics, from basic metabolism to behavioural navigation. What I noted from these chapters is that amphibians have a fascinating array of adaptation that is influenced not just by where they live but by the very extremes of those environments.

Moving along, Chapters 7-12 covers behavioural ecology. If a reader has never discovered the behavioural adaptation and bizarre evolutionary survival exhibited by the Amphibia, then they should consult these chapters as an immediate starting point of reference.

Chapter 7 treats mostly anuran vocal communication and when reviewed against previous literature, almost includes the entire published research that exists on the subject. Despite this, visual and chemical communication is unfortunately not treated in such detail but there is less known on the topic. The detail presented for communication is very diverse and surprisingly makes for easy reading on the topic. Chapter 7 does

prepare the reader for following chapters, where the topic starts to get to its fruition.

In Chapters 8-12 the reader is totally spoiled with a rich insight into the diverse array of sexual behaviour exhibited by several groups of Amphibia. Most conceivable sexual strategies are presented including polygamy and mate competition. A good summary of amphibian mating also clearly exhibits the interest that scientists have paid to amphibians in the deciphering of sexual selection theory. Wells also treats the reader to the basics of genetic sexual selection and provides ideas for further research.

Chapters 13-15 ramp up current knowledge on metamorphosis, predation and community dynamics of Amphibia. The taxonomic coverage in these sections is massive, with countless examples summarised, both classic and new in origin.

Chapter 16 appropriately concludes the book by delving into Global Amphibian Decline. This chapter heeds good warning to readers of the perilous state of amphibian populations in all areas of the planet and categorises some of the biological, behavioural and ecological susceptibilities of various species to current decline causes. Environmental causal factors are also connected with population decline thus presenting the issue of synergistic declines from a number of angles. Throughout this section I was left quizzically engaged in solving aspects of decline factors purely from Wells' engaging tone. The message from this chapter is on the negative, but truthful and realistic.

The citable work collated in this single volume accurately utilises over eight thousand references that include nearly all the key works performed on amphibians. Wells' style of writing also makes for easy reading for enthusiasts and I found the kitchen clock accelerated fast during this review. Each chapter also ends with a definitive summary, allowing the reader time to reiterate the core elements of what has been documented.

The 'Ecology and Behavior of Amphibians' should in my opinion be an essential blueprint for young and old herpetological eyes alike. It will likely stand as a popular reference book to a wide audience for many years to come. Anyone who is serious about amphibian ecology, and who doesn't already possess a copy of this book is strongly advised to procure it. Its reasonable cost on the UK market highlights Chicago University Press' commitment to providing an affordable price to students, amateurs and professionals alike. Like all literary masterpieces, my only complaint was that this book didn't achieve press sooner!

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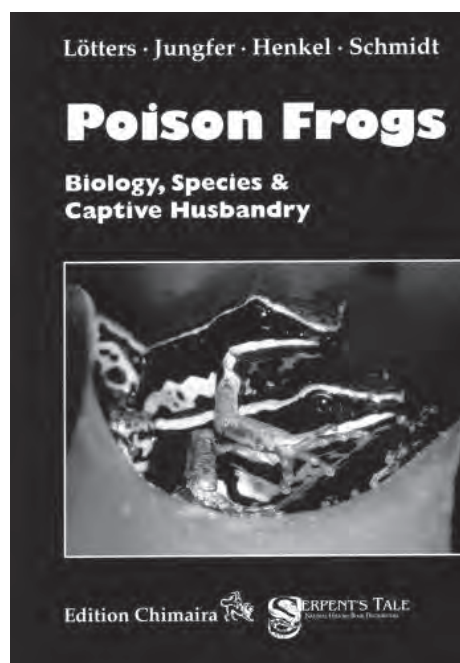
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***Poison Frogs: Biology, Species
and Captive Husbandry***

Stefan Lötters, Karl-Heinz Jungfer,
Friedrich Wilhelm Henkel
and Wolfgang Schmidt

(with a chapter on Diseases of Poison
Frogs by Frank Mutschmann)

2007, Edition Chimaira,
Frankfurt am Main, 668 pp.

In recent years we have come to expect the finest quality herpetological literature from Chimaira and this fat, information packed volume richly peppered with good-quality colour illustrations should please both herpetoculturalists and herpeto-bibliophiles alike! I think I can be said to fall into both of these groups (though one should seek professional help if one is of the latter!).

Part 1 of the book begins with an introduction to amphibian biology and taxonomy and describes the place of the superfamily Dendrobatoidea, (poison frogs) within the larger picture. Though books on other specialized groups may not require this, it is

sensible that it is included here because of the great variety of colour forms and degree of taxonomic revisions regularly found in dendrobatids. It is also early in Part 1 that the fact that the book has been translated from German becomes obvious. Though I can easily forgive the amusingly untranslated heading on page 300, section 1.2 is titled "Bauplan". I had to look the word up and it means "Structural Drawing" apparently! Fortunately, it is obvious from the text that the "structure" or anatomy of a poison frog is being described, and reasonably accessibly too. Non-specialists may be put off by the occasional use of a technical term that goes unexplained but those of us who'll buy this book probably won't be. In fact the writing style throughout is easy-going and accessible and is complimented by the aforementioned illustrations and colour photographs. A great thing shown here that one hardly ever sees in books on poison frogs are photos and drawings of eggs and larvae and a short text section on "Tapoles" which, like all sections in Part 1, ends with a useful list of key literature on the subject.

Part 1 continues with a more detailed delving into dendrobatid systematics that will fascinate many (or you could just skim it!), and descriptions of all currently recognised dendrobatid families and genera. If, like me, you started keeping poison frogs when anything brown was "*Colostethus*" and anything with more than one primary colour was "*Dendrobates*" you'll be simultaneously enlightened, educated, and slightly confused, but at least you'll understand why nobody knows what you're talking about these days! There also follow interesting sections on speciation in the group, skin toxins, ethology (with a good selection of in-habitat photos), reproduction, human uses and a section called "Into the present". This latter discusses such issues as trade and the amphibian decline phenomenon.

Part 2 is devoted to poison frog husbandry. It builds well on the biological contexts described in Part 1 and addresses the issues faced in successful and responsible captive care of dendrobatids. A wide range of topics are addressed, from acquiring captive animals to life expectancy, and through everything in between including siting and designing a suitable terrarium and its

maintenance technologies, food for poison frogs, planting, decorating and captive reproduction. All are well-illustrated and again the reader is treated to valuable photographs of eggs and larvae, both being tended by their parents in the terrarium and being artificially reared. The experienced keeper will be inspired and the novice well-informed. As I write this, I'm beginning to wonder if anyone still has any offspring from the *Dendrobates truncatus* I used to breed?

Part 3 is the section on diseases of the dendrobatids, mostly with reference to those occurring in captivity but sensibly also covering chytridiomycosis (the fungal pathogen responsible for at least some amphibian declines - it can be found in captive frogs). Importantly, in context of the dendrobatid group, this section makes reference to problems of malformation and poor development usually attributable to bad diet, either during the tadpole stage or later (I personally found that these did not occur in animals properly raised during tadpole development).

The final part of the book, Part 4, takes up about half of its total pages! It is devoted to accounts of the species and groups of dendrobatids. The format is consistent throughout the accounts of each genus, beginning with a distribution map for each genus, descriptions of the status, distribution, habitat, biology, husbandry and breeding for each species. Over 70 species are covered but the authors limit themselves to the aposematic,

colourful, diurnal and generally toxic species so, if you're looking for details on *Mannophryne* spp., look elsewhere! Suffice to say, however, that most "keepers" will find this part of most interest. Species with different colour forms have often several photographs to cover the range of variation found. For *Dendrobates tinctorius* there are 18 high quality colour plates. Part 4 follows naturally from the sections on biology and captive husbandry and can be used as reference or read from start to finish. Indeed, this holds true for the whole book. Though there are various errata that cover a two-page sheet supplied with the book, they are easily forgiven. This fascinating book with its wealth of information and illustrations will prove a favourite of those who want to "collect" and dip into it, use it for reference, or read it avidly to increase their knowledge of the poison frogs and herpetology in general. It's such a shame, therefore, that it is not provided with an index!

Such a weighty and quality tome could be put in a bank vault and bequeathed to the grandchildren, or indeed be used to weigh down the back of a BMW that is stuck in the snow, but this would be a shame. I recommend that it is read and, having done that for the purposes of writing this review, I think I'm going to read it again.

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