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Front cover illustration. Plectrohyla chrysopleura © Josiah Townsend. See article on page 22.

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Notes on reproduction of Jackson's chameleon *Chamaeleo jacksonii* (Squamata, Chamaeleonidae), from Hawaii

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ABSTRACT - Histological examination of gonads from invasive *Chamaeleo jacksonii* collected in Oahu, Hawaii revealed both male and female populations were reproductively active in December and February. Litter sizes of 12.2 ± 4.4 SD (range 7-21) are within limits reported for *C. jacksonii* in previous studies. Linear regression analysis revealed a significant positive relationship between *C. jacksonii* female body size and clutch size. The smallest reproductively mature females measured 94 mm SVL. Adult males were significantly larger than females. The smallest reproductively mature *C. jacksonii* male from Hawaii measured 70 mm SVL as opposed to 90 mm in Kenya (Lin & Nelson, 1981). This indicates Hawaiian *C. jacksonii* males join the breeding population at an earlier age compared to those in native populations and this may suggest that *C. jacksonii* has a higher reproductive potential in Hawaii compared with Kenya.

JACKSON'S chameleon *Chamaeleo jacksonii* Boulenger is native to Kenya and Tanzania, Africa (Tilbury, 2010). It was established in Oahu, Hawaii in the 1970s from released pet-trade animals (McKeown, 1996) and is also established in California (McKeown, 1997). The subspecies established in Hawaii is reported as C. jacksonii xantholophus (McKeown, 1991) but we have also been informed that all three subspecies of C. jacksonii were deliberately released in Hawaii (G. Howard, pers. comm.). Reproduction has been studied in a wild population of C. jacksonii from Kenya which exhibited a seasonal reproductive cycle with minimum reproductive activity from January to March; average litter size was 21.7 (Lin & Nelson, 1981). The purpose of this note is to report information on reproduction in the alien population of C. jacksonii from Hawaii. Information on reproductive characteristics of invasive species is important in assessing their rate of spread, possible ecological impact and for assessing the feasibility of potential management programs to ensure the survival of native species. Furthermore, it is little known to what extent reproductive parameters of invasive species are modified in their invaded environments or

how long might be required to achieve such modification.

METHODS

A sample of 88 *C. jacksonii* consisting of 30 adult males (mean snout-vent length [SVL] = 98.1 mm \pm 16.8 SD, range 70-140 mm), 19 adult females (mean SVL = 107.1 mm \pm 11.5 SD, range 90-130 mm) and 39 juveniles (mean SVL = 48.9 mm \pm 11.1 SD, range 25-67 mm) deposited in the Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii, USA and The University of Michigan, Museum of Zoology (UMMZ), Ann Arbor, Michigan, USA was examined (Appendix). Chameleons were collected from Honolulu, Oahu, Hawaii during February 2000 (BPBM) and December 2002 (UMMZ).

The left gonad was removed from each specimen and embedded in paraffin. Histological sections were cut at 5μ m and stained by haematoxylin followed by eosin counterstain (Presnell & Schreibman, 1997). Enlarged follicles > 4 mm length and oviductal eggs or embryos were counted. An unpaired t-test was used to compare *C. jacksonii* male and female mean body sizes (SVL); the relationship between clutch/litter size and female SVL was examined by linear regression

using Instat (vers. 3.0b, Graphpad Software, San Diego, CA).

RESULTS

Adult males of *C. jacksonii* were significantly larger than females (unpaired t-test, df = 47, t = 2.0, P = 0. 047). Two stages were observed in the testicular cycle (Table 1): (1) spermiogenesis, in which the lumina of the seminiferous tubules were lined by clusters of sperm or metamorphosing spermatids; and (2) recrudescence, in which there was a proliferation of primary spermatocytes in preparation for the next period of sperm production.

Month	Ν	Spermiogenesis	Recrudescence			
December	15	14	1			
February	15	15	0			

Table 1. Stages in monthly testicular cycle fromDecember and February in 30 C. jacksonii from Oahu,Hawaii.

Regression (inactivity in which the seminiferous tubules are reduced in size and spermatogonia and Sertoli cells predominate) was typically seen in subadult males. The smallest male that exhibited spermiogenesis (UMMZ 236284) measured 70 mm SVL and was collected on 3 December 2002. Testes of males smaller than 70 mm SVL were either in regression or early recrudescence (with a small number of primary spermatocytes present).

Three stages were observed in the ovarian cycle (Table 2): (1) quiescent, with no yolk deposition; (2) enlarged ovarian follicles (> 5 mm length); (3) oviductal eggs or embryos. The smallest reproductively mature females (UMMZ 236287, 236289) both measured 94 mm SVL and contained 7 and 9 oviductal eggs respectively. They were collected 3 December 2002. Mean clutch/embryo size (N = 14) was 12.2 ± 4.4 SD, range 7-21. The relationship between female body size (SVL) and clutch/embryo size for $14 \ C. \ jacksonii$ was significant and is expressed by the linear regression equation Y = -16.08 + 0.260X, r = 0.65, p = 0.011.

DISCUSSION

Chamaeleo jacksonii exhibited seasonal reproduction in Kenya with 'post-reproductive quiescence' extending from January to March (Lin & Nelson, 1981). We are unable to comment on seasonality in *C. jacksonii* from Hawaii as our samples were from only December and February. However, we did find both sexes to be reproductively active in February (Tables 1, 2), the period of quiescence in the species' native range.

Usually one, but occasionally two litters of C. jacksonii are produced each year (Tilbury, 2010). Gestation is about six to nine months (Dorval, 2006). The number of neonates produced by C. *jacksonii* is variable in different publications: 6-57 (Lin & Nelson, 1981) or 7-28 (Spawls et al., 2002) in Kenya; 8-52 (Lilley, 1984) or 10-50 (Dorval, 2006) in captivity; and 5-50 in Hawaii (McKeown, 1996). Our range of 7-21 neonates from Oahu, Hawaii falls within the wide range of previously reported clutch sizes. However, our maximum litter size of 21 is markedly smaller than the 50 reported by McKeown (1996) and may be the result of our small sample size of 19 females from only two months, February and December. It is unstated what the sample size was for the earlier determination of clutch size range from Hawaii (McKeown, 1996). Despite this result it is clear that the reproductive potential of C. jacksonii in Hawaii is quite high, consistent with the rapid expansion and high densities seen in that archipelago (FK, unpubl. data).

Lin & Nelson (1981) reported a minimum SVL of 90 mm for mature males from Kenya. Our minimum size for male maturity in *C. jacksonii* from Oahu, Hawaii is considerably smaller at 70 mm SVL. This suggests either that Hawaiian *C. jacksonii* males join the breeding population at an earlier age as compared to those in native populations or that Hawaiian specimens grow at a slower rate than seen in native populations. The former might indicate that male *C. jacksonii* have a higher reproductive potential in Hawaii than in their

Month	Ν	Quiescent	Enlarged follicles >5 mm	Oviductal Eggs or Embryos
December	5	1	3	1
February	14	4	2	8

Table 2. Stages in monthly ovarian cycle from December and February in 19 C. jacksonii from Oahu, Hawaii.

native Kenya; the latter explanation would lead to no obvious difference in reproductive potential between the two. Without comparative analysis of growth rates it is currently impossible to distinguish between these two possibilities. However, the fact that the Hawaiian specimens were obtained from much lower elevations (100-500 m) than the samples from their native range (1667-1881 m elevation) (Lin & Nelson, 1981) suggests that the former explanation is more likely.

ACKNOWLEDGEMENTS

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APPENDIX

Chamaeleo jacksonii from Oahu, Hawaii examined for the present study.

BPBM 14000, 14003-14007, 14010, 14011, 14013-14022, 14024-14028.

UMMZ 236284, 236285, 236287-236289, 236292-236295, 236299, 236301, 236306, 236307, 236309, 236311-236313, 236322, 236327, 236336, 236342, 236357, 236369, 236373-236395, 236397-236403, 236405-236411, 236412, 236413, 236415, 236416, 236419, 236537.

Use of artificial wildlife ponds by reptiles in eastern Texas

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ABSTRACT - Reptiles and amphibians can make up a significant part of the biomass in some ecosystems in southeastern North America. Habitat alterations occur on most of the land in the United States and can have both negative and positive effects on the herpetofauna. However, some modifications are intended primarily as wildlife habitat improvement, such as the creation of wildlife ponds. We surveyed 8 artificial wildlife improvement ponds in two National Forests in eastern Texas for the presence of reptiles from 2 May 2001 to 27 December 2006 using aquatic mesh funnel traps. We captured 119 individuals of 11 species in the eight ponds. Snakes accounted for over 78% of the total captures while turtles only accounted for 22%. Reptile captures differed across ponds and across forest and were most common between March and October.

A rich diversity of amphibians and reptiles inhabit the forested lands of the southeastern United States (Peterson, 1998; Harris, 1980). More than half of the herpetofauna native to the United States occurs in the southeast (Russell et al., 2004) and can account for a large portion of the overall biomass in some forest ecosystems (Burton & Likens, 1975; Congdon et al., 1986; Gibbons et al., 2006; Iverson, 1982).

Southern forests cover over 86 million ha and of that, 12 percent is publicly owned (Smith et al., 2003). Much of this public land is managed for timber production, wildlife conservation and recreation. Various forest practices such as clearcutting, thinning and prescribed fire are often used to manage public lands. Concerns about the impacts of these forest practices on wildlife populations have led to a multitude of research. Silvicultural practices such as clearcutting and thinning can positively affect some species of amphibians and reptiles while negatively affecting others (Goldstein et al., 2005; Phelps & Lancia, 1995; Ross et al., 2000). In Pennsylvania, Ross et al. (2000) found that salamander abundance and richness increased with an increase in stand basal area while there was an increase in snake abundance and richness with decreased basal area in forested habitats. They also noted that anuran abundance and richness was not affected by basal

area; however, the presence of water did affect amphibian abundance and richness. Semlitsch et al. (2009) found that timber harvest treatments can have different effects on amphibians depending on life stage.

Prescribed burning is another tool used in the management and restoration of forest in the southeastern United States, and can have positive or negative effects on herpetofauna (Floyd et al., 2002; Moseley et al., 2003; Mushinsky, 1985, Mushinsky, 1986; Wilgers & Horne, 2006). Other management practices such as wildlife clearings (openings in the forest canopy that are maintained to retain a herbaceous ground cover), streamside management zones (land adjacent to streams, rivers or lakes that are retained during management practices to protect water quality, wildlife habitat, fish, and other resources), and formation of road rut ponds (holes left in dirt or gravel roads from vehicle traffic that fill with water) can positively affect herpetofauna (Adam & Lacki, 1993; Pais et al., 1988; Rudolph & Dickson, 1990).

In 1930, the United States Congress passed the Knutson-Vandenberg (K-V) Act, which states that some proceeds from the sale of national forest timber will be used for the planting, sowing of tree seeds, and removal of undesirable trees left by the purchaser to improve the future stand of timber within (Knutson-Vandenberg Act, 1930). In 1976,



Figure 1. Map of Texas, USA showing the Davy Crockett National Forest and Stephen F. Austin Experimental Forest.

the Act was amended to allow K-V funds, generated from a given sale timber area, to be used to improve the productivity of the renewable resources and for wildlife habitat management within that sale area. Since the passing of the Act, millions of hectares of timber have been harvested on the national forests producing millions of dollars for the improvement of these lands. In the early 1990s, the National Forests and Grasslands of Texas began to use some of these K-V funds to create artificial ponds to improve wildlife habitat. More than 150 ponds have been created across the four national forests in east Texas (Angelina, Davy Crockett, Sabine, and Sam Houston National Forests). These ponds were created by simply excavating holes in the earth or by damming streams. Some ponds have been stocked with fish to create public fishing opportunities while fish were not added to others. The use of these wildlife ponds by reptiles is currently unknown. Snakes and turtles are common in north America, and many of these species prefer aquatic environments (Ernst et al., 1994; Gibbons & Dorcas, 2004; Werler & Dixon, 2000). Thus, it is reasonable to assume that some snakes and turtles would use these wildlife ponds.

The objective of this study was to determine reptile use of these artificially created wildlife ponds in eastern Texas.

METHODS AND MATERIALS

We sampled eight wildlife ponds from 2 May 2001 to 27 December 2006 in eastern Texas. Four ponds (numbered 1-4) are located in the Stephen F. Austin Experimental Forest (SFAEF). The SFAEF, located in Nacogdoches County, Texas, is part of the Angelina National Forest and contains habitats ranging from bottomland hardwoods to upland pine (Pinus spp.) (Fig. 1). The four ponds were constructed in April 2000 in secondary growth pine forest. Four additional ponds (numbered 5-8) were located in the Davy Crockett National Forest (DCNF; Fig. 1). The DCNF is located in Houston County, Texas, and consists of various habitat types. The ponds located in the DCNF that were selected for this study were created in 1994 and are also located in areas of second-growth pine stands. All ponds contained water year around and varied in size from 63 m^2 to 1945 m^2 .

We placed two 25 x 25 x 46 cm, collapsible mesh funnel traps with 6 cm openings in each pond. The traps were made of flexible mesh material, stretched over a wire frame. We located the traps in the littoral zone of each pond with at least 5 cm of each trap above the water to allow captured animals to breathe. The water level in some of the ponds fluctuated greatly. In these ponds, we placed foam in the traps to act as a float in order to keep the trap from becoming submerged during flood conditions. We opened and monitored the funnel traps one day per week. Reptiles in the traps were removed, identified to species, counted and then released. Traps were not left in situ.

Habitat characteristics were measured at each pond within a 100 m radius. This was accomplished by using 4 x 100 m transects which extended in the four cardinal directions (north, south, east, and west) from the pond. Data were collected every 50 m for a total of 3 plots per transect and twelve plots per pond. Every 50 m we sampled trees using a prism with a basal area factor of 1.0 m²/ha⁻¹, and we measured percent canopy closure, percent dicot cover, and percent monocot cover using an ocular tube (James & Shugart, 1970). At each pond, we measured overstorey and midstorey height (using a clinometer) and horizontal foliage density (MacArthur & MacArthur, 1961); we also determined stand age

by collecting increment cores from two of the dominant trees in the stand. Midstorey density was visually estimated and assigned a categorical score of 1-5, where 1 was the least dense and 5 was most dense.

We used ArcMap[™] (Environmental Systems Research Institute, 2006) to determine the distance (km) from each pond to the nearest permanent water source (pond, creek, lake, etc.). We collected GPS locations for each pond, using a Garmin® GPSMAP® 60CSx, and projected the data onto a GIS layer displaying an aerial photograph of the respective stands. We then located the nearest preexisting permanent water source and calculated the straight line distance from the pond to the water source.

We calculated Shannon's diversity index for cumulative reptile captures for each pond and compared the cumulative reptile community among ponds with the Bray-Curtis distance measure (BCI) (McCune and Grace 2002).

RESULTS

We sampled the eight wildlife ponds for reptiles for a total of 16,560 trap days (the cumulative number of days all traps were open). We captured 119 individuals of 11 species in the eight ponds. Of the 119 individuals, 93 were snakes (7 species) and 26 were turtles (4 species). In the SFAEF ponds we captured 107 individuals (11 species) while we captured only 12 individuals (4 species) in the DCNF (Table 1). We captured most reptiles between March and October but one individual was captured in January (Table 2).

Shannon's diversity index for reptiles ranged from 1.509 to 1.743 in the SFAEF and 0 to 1.011 in the DCNF (Table 1). Ponds 7 and 8 in the DCNF had only one individual capture and thus a diversity index could not be calculated. Ponds 5 and 6 had 3 species and thus low indices of 0.637 and 1.011, respectively. The cumulative reptile communities were more similar within the SFAEF (avg. BCI = 0.4693) than within the DCNF (avg. BCI = 0.7103) (Table 3). Pond 3 was the most dissimilar within the SFAEF (BCI = 0.6228) and pond 8 (BCI = 0.9048) was the most dissimilar among the DCNF ponds.

Nerodia erythrogaster was the most common reptile captured in traps, occurring in seven of eight

ponds (n = 44); in contrast, we only captured one *Regina rigida* and one *Deirochelys reticularia*. The traps in pond 4 captured the most individuals (n = 42) and pond 4 had the highest species richness (n = 8) while the traps in ponds 7 and 8 only captured one individual (Table 1).

We captured the most individuals in 2003 (n = 35) followed by 2004 (n = 25) (Table 4). The fewest individuals were captured in 2002 (n = 7), which was the first full calendar year of trapping.

Habitat characteristics varied across pond and forest (Table 5). Average basal area ranged from 0.9 m²/ha to 22.6 m²/ha across the eight ponds. The average basal area was typically lower around the ponds in the SFAEF when compared to the ponds in the DCNF. The average foliage density measurement (0-1 m) ranged from 2.5 m to 20.1 m with most of the ponds in the DCNF having a higher measurement (less foliage) compared to the ponds in the SFAEF (Table 5). The average percent canopy closure ranged from 15.8% to 90.1%. The habitat surrounding the ponds in the DCNF typically had a more closed canopy compared to the habitat surrounding the ponds in the SFAEF (Table 5). The average distance to a permanent water source for the ponds in the SFAEF was 0.67 kilometers while the average distance for the DCNF was 1.23 kilometers. Also, it is important to note that the permanent water source nearest the ponds in the SFAEF was a creek; conversely the nearest water source for the DCNF ponds were all ponds with the exception of pond 8 which was closest to Ratcliff Lake

DISCUSSION

We captured more than 100 individual reptiles across eight artificial wildlife improvement ponds. Snakes accounted for most of the individuals captured and most of the species. Turtles were much less commonly trapped and only accounted for 26 individuals and four species. This difference could be due, in part, to the type of traps we used. All of the turtle species that occur in eastern Texas can grow to a size that is too large to fit in the openings in the traps we used (Ernst et al., 1994). Thus our sampling might have been biased towards sampling smaller immature turtles while excluding adults.

	SFAEF ponds					DCNF ponds				
Species Squamata	1	2	3	4		5	6	7	8	Total
Nerodia erythrogaster	9	11	5	14		2	2	1	0	44
Nerodia fasciata	2	4	0	6		0	1	0	1	14
Nerodia rhombifer	1	5	6	6		0	0	0	0	18
Thamnophis proximus	3	1	0	4		0	0	0	0	8
Farancia abacura	3	2	0	1		0	0	0	0	6
Regina rigida	0	0	1	0		0	0	0	0	1
Agkistrodon piscivorus	0	0	0	1		1	0	0	0	2
Testudines										
Trachemys scripta	2	2	0	9		0	0	0	0	13
Kinosternon subrubrum	0	0	5	1		1	3	0	0	10
Sternotherus odoratus	0	0	2	0		0	0	0	0	2
Deirochelys reticularia	0	0	1	0		0	0	0	0	1
Total	20	25	20	42		4	6	1	1	119
Shannon's diversity index	1.539	1.509	1.584	1.743	0	.637	1.011	0.00	0.00	

 Table 1. Number of individuals and species captured in each wildlife pond in the Stephen F. Austin Experimental Forest (SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A., from 2 May 2001 to 27 December 2006.

	Month											
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Squamata												
Nerodia erythrogaster	0	0	2	6	10	8	5	5	5	3	0	0
Nerodia fasciata	1	0	1	3	3	2	1	2	1	0	0	0
Nerodia rhombifer	0	0	0	1	7	2	2	2	3	1	0	0
Thamnophis proximus	0	0	0	2	4	0	0	0	1	1	0	0
Farancia abacura	0	0	0	0	2	1	2	0	1	0	0	0
Regina rigida	0	0	0	0	0	1	0	0	0	0	0	0
Agkistrodon piscivorus	0	0	0	0	2	0	0	0	0	0	0	0
Testudines												
Trachemys scripta	0	0	0	1	7	5	0	0	0	0	0	0
Kinosternon subrubrum	0	0	1	1	2	2	2	0	0	2	0	0
Sternotherus odoratus	0	0	0	0	1	0	1	0	0	0	0	0
Deirochelys reticularia	0	0	0	0	1	0	0	0	0	0	0	0
Total	1	0	4	14	39	21	13	9	11	7	0	0

 Table 2. Number of individuals and species captured in traps by month from 2 May 2001 to 27 December 2006 in the Stephen F. Austin Experimental Forest (SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A. All ponds combined.

Pond	1	2	3	4	5	6	7	8
1	0.0000	0.2444	0.7000	0.4194	0.8261	0.7692	0.9048	0.9048
2	0.2444	0.0000	0.5556	0.2836	0.8571	0.8065	0.9231	0.9231
3	0.7000	0.5556	0.0000	0.6129	0.7391	0.6154	0.9048	1.0000
4	0.4194	0.2836	0.6129	0.0000	0.8667	0.8333	0.9535	0.9535
5	0.8261	0.8571	0.7391	0.8667	0.0000	0.3333	0.5000	1.0000
6	0.7692	0.8065	0.6154	0.8333	0.3333	0.0000	0.7143	0.7143
7	0.9048	0.9231	0.9048	0.9535	0.5000	0.7143	0.0000	1.0000
8	0.9048	0.9231	1.0000	0.9535	1.0000	0.7143	1.0000	0.0000
SFAEF mean	0.4546	0.3612	0.6228	0.4386				
DCNF mean					0.6111	0.5873	0.7381	0.9048
Overall mean	0.6812	0.6562	0.7325	0.7033	0.7318	0.6838	0.8429	0.9280
N standard deviations	-0.68	-0.95	-0.13	-0.45	-0.14	-0.66	1.05	1.96

Table 3. Sorensen (Bray-Curtis) distance measures comparing the cumulative reptile community among wildlife pondsin the Stephen F. Austin Experimental Forest (ponds 1-4) and Davy Crockett National Forest (ponds 5-8), Texas,U.S.A., 2 May 2001 to 27 December 2006.

Species	2001	2002	2003	2004	2005	2006	Total
Serpentes							
Nerodia erythrogaster	6	3	17	3	8	7	44
Nerodia fasciata	1	0	7	1	3	2	14
Nerodia rhombifer	8	0	3	3	0	4	18
Thamnophis proximus	0	3	1	1	2	1	8
Farancia abacura	0	0	5	1	0	0	6
Regina rigida	0	0	0	1	0	0	1
Agkistrodon piscivorus	0	0	0	1	0	1	2
Testudines							
Trachemys scripta	0	0	2	9	0	2	13
Kinosternon subrubrum	0	0	0	5	4	1	10
Sternotherus odoratus	1	1	0	0	0	0	2
Deirochelys reticularia	0	0	0	0	0	1	1
Total	16	7	35	25	17	19	119

Table 4. Number of individuals and species captured each year in the Stephen F. Austin Experimental Forest(SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A., from 2 May 2001 to 27 December 2006.All ponds combined.

		SFAEF ponds				DCNF ponds			
Vegetation Characteristics	1	2	3	4	5	6	7	8	
Basal area (m ² /ha)	0.9	17.6	10.1	15.4	22.6	19.3	15.9	15.1	
Canopy closure (%)	15.8	61.8	57.7	82.3	90.1	67.9	75.3	76.3	
Dicot/fern ground cover (%)	7.1	14.3	21.0	4.2	0.8	20.0	23.9	31.8	
Monocot ground cover (%)	5.0	17.8	30.5	0.1	9.9	9.3	9.5	21.8	
Foliage density 0-1 m (m)	2.5	7.3	2.6	6.2	20.1	6.5	6.8	4.0	
Foliage density 1-2 m (m)	2.8	13.0	7.6	16.0	50.0	10.4	12.6	15.6	
Midstorey density (1-5)	5.0	2.0	2.0	3.0	3.0	2.0	4.0	2.0	
Overstorey height (m)	27.4	27.4	21.3	29.0	27.4	25.9	27.4	25.9	
Midstorey height (m)	6.1	9.1	9.1	10.7	7.6	9.1	12.2	7.6	
Stand age (year)	84.0	86.0	35.0	63.5	98.0	73.5	80.0	78.5	
Distance to permanent water (km)	0.37	0.80	0.50	0.99	1.14	0.67	1.50	1.61	

Table 5. Habitat characteristics measured at each wildlife pond in the Stephen F. Austin Experimental Forest (SFAEF)and Davy Crockett National Forest (DCNF), Texas, U.S.A. Values for basal area, canopy closure, dicot cover, andmonocot cover represent means. Values for foliage density represent the mean distance (m) to 50% obscurity of adensity board. Midstorey density values range from 1 to 5, with 1 being the least dense and 5 the most dense.

The traps in the ponds in the SFAEF captured more individuals than the traps in the ponds in the DCNF, with the SFAEF accounting for 90.6% of the total captures. Reptile diversity was also higher in the SFAEF ponds than in the DCNF ponds. Several factors could have played a role in the differences in the species and numbers of individuals captured. The ponds in the SFAEF were created 1 year prior to sampling, while the DCNF ponds were created 7 years prior to sampling. The distance to the nearest permanent water source from each pond could also play a key role in the colonisation rates of these wildlife ponds by reptiles. The ponds in the SFAEF were closer to a pre-existing permanent water source than those located in the DCNF. Also, since the permanent water sources were different (creek versus ponds/lake) this could have had an effect on the species and numbers of reptiles dispersing to the ponds. The differences between the SFAEF ponds and DCNF ponds likely explain why the reptile communities within the SFAEF ponds were more similar to one another than those within the DCNF. All eight ponds surveyed were created in similar age stands; however, there were some differences in the management of these stands as is evident in the basal area, canopy closure, and foliage density measurements (Table 5). These three variables are highly correlated and could explain some of the variability found across ponds. Our trends followed Ross et al. (2000) who found an increase in snake abundance and richness with a decrease in basal area. However, we had too few replicates to make any definitive inferences regarding the effect these habitat variables may have on the distribution of the reptiles in our study area.

We captured the most individuals in 2003 followed by 3 years in which we captured fewer individuals (Table 4). Since the traps in the ponds in the SFAEF accounted for most of the individuals captured, and these ponds were relatively new, it is possible that the number of individuals moving into these ponds peaked in 2003. However, we do not have enough data to determine if we observed ecological succession or merely yearly variation.

All of the species that were captured in funnel traps were aquatic to semi-aquatic reptiles; these species are known to prey heavily on other organisms that inhabit aquatic habitats (Gibbons & Dorcas, 2004; Werler & Dixon, 2000). For example, the genus *Nerodia* is a common group of watersnakes in eastern Texas. The three species of *Nerodia* that we captured accounted for more than 63% of our captures and primarily prey on fish and amphibians. The four turtle species that we captured are also classified as aquatic species and feed on a variety of aquatic algae, invertebrates and vertebrates (Ernst et al., 1994).

In eastern Texas, the mean annual air temperature falls between 15.5°C and 21°C and the growing season (time between last and first frost) in eastern Texas exceeds 200 days in most years; the last frost can occur from February to April but most often occurs in March, while the first frost can occur from October to December but typically occurs in November (Chang et al., 1996). As expected, most reptiles were captured from March to October, which coincides with the warm months in eastern Texas.

Our study suggests that creating artificial wildlife ponds is an effective wildlife management practice for improving habitat for aquatic and semi-aquatic reptiles in eastern Texas. A larger sample size is needed in order to truly understand the effect pond age and forest structure have on reptile use of wildlife ponds. Our study also did not control for recaptures since we did not mark any of the captured animals: as a result, our capture numbers could be inflated. Future studies should use multiple-sized funnel traps, mark captured individuals and take pond size into account when determining number of traps per pond. There are many aspects that we still do not know about these wildlife ponds (colonisation rates, successional stage, predation rates, etc) that would help us understand differential use of ponds by reptiles.

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Assessment of an established population of atypical grass snakes *Natrix natrix* in the Aire Valley, UK

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ABSTRACT - During the past 20 years, an atypical population of grass snakes has been observed within and around the Esholt Sewage Treatment facility, West Yorkshire, UK. Based solely on phenotypic appearance, the snakes were suspected of originating from southern or eastern Europe. This study sought to ascertain the origin of the snakes through genetic means. An estimate of the population size was calculated using a capture/mark/recapture (CMR) programme. This study also investigated the possibility of discriminating between races using morphometric measurements. Phylogenetic analysis indicated that the Esholt population had originated from eastern Romania and was genetically distinct from native snakes. The CMR programme calculated a population estimate of approximately 46 snakes (95% CI = 28-106), although the actual value was expected to be closer to the latter. Morphometric analysis indicated that snakes could be discriminated by SVL to head width ratios as well as markings. There are no physical barriers enclosing the Esholt Sewage Treatment facility and striped grass snakes have been reported from the surrounding areas. Future monitoring is recommended in order to ascertain population trends and range expansion.

S INCE 1990 atypical specimens of the grass snake *Natrix natrix helvetica* (L) have been observed within and around the Esholt Sewage Treatment facility, West Yorkshire, UK (53°51'07.43, 1°43'13.12) (Sunderland, 2003). The Esholt population differs from typical British grass snakes by the presence of two dorsolateral stripes running the length of the body and a relatively indistinct collar (Fig. 1). Grass snakes with this patterning are found throughout southern and eastern Europe, ranging from the east Adriatic coast through to the Crimea (Arnold & Ovenden, 2002).

It is unclear how the striped grass snakes arrived at Esholt; however, the discovery of a striped neonate (pers. obs.) indicates that the population is breeding. The current study sought to ascertain the origin of the snakes through genetic means. Samples of four mitochondrial DNA (mtDNA) genes, collected using buccal swabs (following Beebee, 2008) were extracted, amplified and sequenced. Sequences were then inserted into the existing natricine phylogeny (Guicking et al., 2006), the results of which enabled inferences to be made regarding the origin of the snakes. An estimate of the population size (N_c) was calculated using a capture/mark/recapture (CMR) programme. In this case, rather than applying a mark, snakes were re-identified using the unique natural markings on the anterior ventral scales. Population estimates were generated using a Peterson-Schnabel maximum likelihood census model. In addition to the census size, the effective population size N_e (i.e. the genetic population size) was also determined.

It is expected that future monitoring will be carried out by volunteers, who may not have access to a genetics laboratory. Hence a comparative morphometric study was carried out to investigate the possibility of discriminating between races using multivariate statistics (following Thorpe [1984]). A range of measurements, including lengths, widths, weights, scale counts and markings were taken from the Esholt population. These measurements were compared with grass snakes from southern Europe (Rome) and Britain (Dorset and Norfolk). A principal component analysis (PCA) using snout to vent length (SVL), head width, head depth and head length was carried out. All data were log transformed to account for the influence of



Figure 1. An adult female striped grass snake (700 mm SVL) found within the Esholt Sewage Treatment facility in 2010. Photograph by Darryn Nash.

allometry and analyzed using a combination of analysis of variance (ANOVA) and non-parametric equivalents.

RESULTS

Phylogenetic trees, based on the mtDNA genes Cytochrome b and NADH dehydrogenase subunit 4, indicated that the Esholt population was genetically distinct from native snakes (Fig. 2). The genetic sequences, obtained from the Esholt population, closely resembled those Guicking and colleagues (2006) described from the Tulcea region of Eastern Romania; in the case of Cytochrome b, the two sequences were an exact match. This particular genotype is likely to occur throughout Romania; although snakes occupying the east of the country are genetically distinct from those in the west.

The CMR programme calculated an N_c of 46

snakes (95% CI = 28-106), although this figure is considered to be conservative. Low recapture rates are typical for highly transient animals (Madsen, 1984). Based on a census estimate of 46, a N_e of 25 was calculated, assuming a constant sex ratio and excluding animals of less than 300 mm (assumed sexually immature). The principal reason for this disparity in population estimates was a skew in the sex ratio with a greater number of females recorded.

The PCA identified two components that were significant (i.e. had eigenvalues of greater than 1); however, because of the high degree of overlap observed in Component 2 only Component 1 was considered suitable for the purpose of discrimination. Component 1 was based on the SVL to head width relationship. The value for the Esholt population ranged from 35 to 63,



Figure 2. A phylogentic tree based on the mitochondrion DNA gene Cytochrome b. Sequences taken from the Esholt snakes were inserted into a *Natrix* phylogeny originally produced by Guicking et al. (2006). The sequence generated from the Esholt snakes was identical to that of the Tulcea region of Eastern Romania.

considerably higher than the observed values for the native snakes (16 to 39). A combination of this morphometric relationship and markings (presence of dorsolateral striping and the relative intensity of the collar) enable discrimination of native and alien snakes with a high degree of confidence.

Despite the fact that both the southern European and Esholt populations were significantly larger (SVL) than native snakes (F = 7.716, d.f. = 2, p = 0.01) (Fig. 3), there were no significant differences in gape size (head length x width x depth) (F = 1.11, d.f. = 2, p = 0.334). As gape size is a principal determinant of prey choice in snakes, it can be assumed that similar sized prey items would be selected. On two occasions, Esholt snakes regurgitated common frogs *Rana temporaria* during handling.

DISCUSSION

Although the Esholt population is genetically distinct from native snakes, both belong to the subspecies *helvetica*. It is unlikely that any reproductive barriers exist that would prevent either the transmission of genetic material or the production of viable offspring (R. Thorpe, pers. comm.). However, interbreeding would result in the loss of each of the unique genotypes. This could lead to the dilution of locally adapted genes, thereby lowering the population fitness (outbreeding depression [see Tallmon et al., 2004]).



Figure 3. Head widths plotted against snout to vent lengths (SVL) of native and non-native grass snakes. Native specimens exhibited a larger head width relative to body length, when compared with individuals from the Esholt population.

It is important to note that no native grass snakes were located during the surveys and local records were ambiguous. Should the Esholt population encounter native snakes, the effects of interbreeding are likely to be localised and short lasting, with the Romanian genotype being overwhelmed by the native form.

The study population was found to occur at a density of approximately 3 ha⁻¹, comparable to that of native snakes (Beebee & Griffiths, 2000). The Esholt Sewage Treatment facility comprises approximately 140 ha of suitable habitat, which includes unmanaged grassland, hard standing, woodland, scrub and a series of drainage ditches. The River Aire and Leeds-Liverpool Canal both horizontally bisect the site and link up with parcels of habitat in the wider landscape. There are no physical barriers enclosing the Esholt Sewage Treatment facility and striped snakes have been reported in the surrounding areas.

Future monitoring is expected to concentrate on two key areas: monitoring population trends (there

is already speculation that sightings have declined) and range expansion.

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Pigmentation loss and regeneration in a captive wild-type axolotl, *Ambystoma mexicanum*

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O^{VER} a period of approximately 10 weeks from December 2009 until March 2010 a captive axolotl (*Ambystoma mexicanum*) was observed to change from a wild-type phenotype to a leucistic phenotype. It is common for leucistic axolotls to darken as they mature (Scott, 1995) but a change from wild-type to leucistic is a phenomenon that, to the author's knowledge, has not been documented before.

The animal was purchased by the author from a local pet shop in Bristol, UK, in May 2005 as a juvenile. It was approximately 100 mm TL and had fully developed legs. The gender of the animal was unknown. It was purchased together with a leucistic female of the same size. Since then the pair have been housed together in a 90 cm freshwater tank at room temperature. Both animals are healthy, active, and feed well on a diet of bloodworms with occasional supplementation of waxworms and appropriately sized (gut-loaded) crickets.

Over the winter of 2009 the axolotl began to lose pigmentation across its whole body becoming increasingly pale. Pigmentation loss began uniformly and the animal passed through stages of appearing brown and grey (Fig. 1) until it finally became fully white, with semi-translucent skin and pink gills (Fig 2.). The dorsal surface retained small amounts of pigment giving a pale grey appearance. The pigment of the eyes remained unaffected, as found in leucistic morphs. After the pigmentation loss the animal suffered the complete loss of its left foreleg, past the elbow, and a small section of the tail tip due to an attack by the second specimen (both portions were ingested). The axolotls were then separated with the injured animal being moved to a smaller tank to recover. In the recovery tank, both injured body parts started to regenerate and the areas of new tissue were pigmented. It remains

to be seen if the pigmentation will be lost as the tissues mature. Stress caused to this animal due to being the subordinate individual in the aquarium, and the aggressive nature of the female did not seem to be a likely factor in the pigmentation loss. The two specimens have co-habited without any signs of problems for nearly five years, although they have previously had some aggressive interactions. Stress is also associated with loss of appetite and behavioural change, none of which have been observed. Environmental change also seems an unlikely factor contributing to stress as the aquarium set-up and maintenance have been constant since the axolotls were introduced to it. and the second animal has not shown any change. The change appears to be genetic, and is perhaps linked to the maturation of the animal

Coloration in axolotls is controlled by four genes with all mutations being recessive. These genes produce four mutant phenotypes; albino, leucistic, axanthic and melanistic plus the ancestral wild-type (Frost et al., 2006). Axolotl coloration is produced through three types of pigment containing cells; melanophores, xanthophores and iridophores. In leucistic animals melanophores do not develop correctly but xanthophores and iridophores are still fully formed (Scott, 1995.).

As this animal has retained pigmentation in the eye and exhibits a typical leucistic phenotype it is possible that there is a mutation at the melanophore related loci. Pigment loss may be a result of this individual being heterozygous for the wild-type and possibly having leucistic genes with a loss of function of the dominant allele. It may be possible that the allele is reactivated in the regenerating tissue, or is an unstable mutant of the melanophores, however, this notion is conjecture.

An alternate possibility is that pigment loss may



Figure 1. (Left) and Figure 2. (Right). Pigmentation loss in Ambystoma mexicanum during winter months of 2009.

be a result of melanophore death. Melanophore death has previously been described in the white leghorn breed of chicken (Jimbow et al., 1974). However, to consider this notion, raises the question of where new melanophores originate in the regenerating blastema. As an amphibian leg regenerates, cells of the stump de-differentiate to form a blastema, which Kragl et al. (2009) showed has restricted potential and normally serves to re-populate the parent cell type. If melanophores have died, then a different cell type must be the source of the new melanophores. It is also possible that the cells do survive but cease to produce melanin In this case the de-differentiation and redifferentiation processes must re-programme the melanophores to produce pigment.

The ancestry of this animal is not known and so recent hybridisation with the closely related tiger salamander *Ambystoma tigrinum*, is also a possibility.

Pigment loss has been observed with several anecdotal references appearing in the online amphibian forum www.caudata.org. However, none show the extent of change observed in this individual, nor the short time period over which pigment was lost.

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Notes on reptiles inhabiting a secondary, post development habitat, south Paphos, west Cyprus

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IN April 1989 I visited southeast Cyprus and reported on the herpetofauna observed, noticing that some reptile species were more abundant in degraded habitats adjacent to new housing developments (Bowles, 1989). This current report comments on reptiles observed on a visit to Paphos, west Cyprus from 7-14 April 2010.

The first week was cool with both wind and rain, but the second week had more sunshine, with temperatures reaching up to 24°C.

The accommodation I used was in the third last of a string of hotels ranging south along the coastline from the town Paphos. Between the accommodation and the next hotel to its south was an area of degraded Mediterranean scrubland that spread west to the coast and east to the main road and immediately in front of the hotels (Fig. 1).

Despite the constant movement of various vehicles and motorcycles, large numbers of holiday makers, and locals with their dogs, seven species of reptile were found within 300 m of the hotel. Of these, only four were found in East Cyprus during the 1989 visit (Bowles, 1989).

SPECIES LIST

Gekkonidae

Cyrtopodion kotschyi (Fig. 2)

This small gecko, previously reported from Bowles (1989), with its clawed toes, and characteristic dorsal markings, was seen at night, under lamp-light on a low wall dividing the hotel garden from the seashore. Away from the hotel, it was also found during the day under pieces of wood lying on the ground of the yard of a deserted mill approximately 700 m west of the hotel. Here I encountered one normally marked adult and two black juveniles. We also found an adult basking in the knoll of a severely pruned olive tree in the same vicinity.

Agamidae

Laudakia stellio cypriaca (Fig. 3)

As in eastern Cyprus, this species was very abundant on most piles of big stones, even within the densely populated hotel gardens. The choice habitat for *L. s. cypriaca* was on scrubland, nearer the beach, on the foundations of long-destroyed buildings. Here, dominant males bobbed their heads rapidly as they postured on the highest point of their territory. If one responded to their head bobbing by doing it oneself (an activity best done unobserved by the more conventional holiday makers!), the lizard would at first rapidly respond, then, when fearing it would no longer stand its ground, would speedily run with its tail held in an upturned curve, in a semi-circle round the site, to alight on stones about 7 m distant.

Lacertidae

Acanthodactylus schreiberi

As observed in eastern Cyprus, this spiny footed lizard was seen to be progressively more abundant towards the sandy coastline. Unlike eastern Cyprus, where there were many large, virtually unmarked adults, all the animals seen here were sub-adults, with striped bodies, and, in many cases, red tails. Again, as in the east, their existence is threatened by motor-bikes, mountain bikes, and other types of vehicle.

Phoenicolacerta troodica (Fig. 4)

This handsome lacertid, superficially resembling a race of relatively unmarked *Podarcis muralis* with olive-green backed males, was very common on the stone borders of flower-beds and found well within the hotel garden amidst throngs of supine sun-worshippers. Unlike the very timid spiny-footed lizards, they were quite unconcerned by the proximity of human beings, and could be approached very closely and photographed at leisure. They were only observed near human



Figure 1. Degraded secondary habitat hosting reptiles.



Figure 2. Cyrtopodion kotschyi.



Figure 3. Laudakia stellio cypriaca.



Figure 5. Ophisops elegans.



Figure 4. Phoenicolacerta troodica.

habitation; none being seen in the scrubland or cultivated countryside.

Ophisops elegans (Fig. 5)

This elegant little lizard with its lidless eyes, was ubiquitous in all areas of the scrubland where there was adequate ground cover. Strangely, unlike those seen in eastern Cyprus, the males lacked the turquoise pigmentation along their flanks. Whether this was due to the relatively cold weather inhibiting mating, or whether they were a morphologically different race, is unsure. This lizard was seen sharing basking sites with banded skinks (*Trachylepis vittata*).

Scincidae

Trachylepis vittata

Unlike eastern Cyprus, where the skink species observed was the snake-eyed skink *Ablepharus budaki*, the animal seen here was the much bulkier, interestingly marked banded skink *Trachylepis vittata*. This species was observed in scrubland, on well vegetated rubble on the southern side of a cleared area adjacent to a main road. It could be watched in the very late afternoons, but was extremely timid and had to be approached with considerable care. The only other habitat that we saw this lizard was on the side of a tree-lined road boarding rough pasture, where it basked on pieces of dead trees, which had been used to enclose the ground.

Colubridae

Dolichophis jugularis

In Cyprus this large whip snake grows to 2.5 m and becomes black, with the exception of the underside of the brownish jaw. Two clear sightings of this snake were seen. A 1.5 m specimen was seen crossing a path just outside the hotel. The second specimen, of a similar size, was disturbed on the hotel refuse pile. It was coiled up, basking and near enough to be observed accurately, even though it quickly retreated at considerable speed.

DISCUSSION

Unlike the flatter countryside of southeast Cyprus, Paphos lies at the western foothills of the Troodos Mountains, which might explain the presence of *Phoenicolacerta troodos*. Although we made intensive searches in those areas of the surrounding countryside accessible to pedestrians no other species of reptile was seen, nor any amphibians. We also made two visits to an archaeological site near Paphos Harbour, where the splendid classical remains lie distributed across a very large area of prime habitat. Several years ago a colleague of ours saw a basking levantine viper (*Macrovipera lebetina*), but despite reasonably good weather conditions on both visits, we saw no other reptile species than those lizards present on the littoral scrubland adjacent to the hotel.

Like so much of the Mediterranean coast of Cyprus, and its immediate hinterland, Paphos exhibits some sprawling building developments. Some of these developments stretch out of Paphos and are actually pushing up into the Troodos foothills, causing considerable reduction and degradation of the environment. The littoral scrublands, like our Dorset heaths, are seen as prime building land. Their final loss could possibly result in the dissappearance of several reptile species. Therefore it behoves the Cyprus government to legislate for their protection and the wide variety of fauna and flora that the habitat supports.

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Discovery of an extant population of the critically endangered treefrog *Plectrohyla chrysopleura* (Anura, Hylidae) in Refugio de Vida Silvestre Texiguat, Honduras

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ABSTRACT - We report the discovery of *Plectrohyla chrysopleura* at a locality in Refugio de Vida Silvestre Texiguat, Departamento de Atlántida, Honduras. This critically endangered treefrog was previously known only from a single site, 55 km to the east-northeast in Parque Nacional Pico Bonito, where it had not been documented since 1996.

RESUMEN - Se reporta el descubrimiento de *Plectrohyla chrysopleura* de la localidad del Refugio de Vida Silvestre Texiguat, Departamento de Atlántida, Honduras. Esta rana en peligro crítico estaba reportada anteriormente para un único sitio, 55 km en dirección noreste en el Parque Nacional Pico Bonito, donde no ha sido encontrada desde 1996.

DLECTROHYLA chrysopleura McCranie, Wilson, and Cruz, 1994 is a large, critically endangered spikethumb frog only known from the vicinity of its type locality in Parque Nacional Pico Bonito (Cruz et al., 2004). This locality, Ouebrada de Oro, is among the most remarkable sites of amphibian endemism and, unfortunately, one of the best documented cases of catastrophic amphibian decline in Central America (McCranie & Wilson, 2002; McCranie & Castañeda, 2005, 2007; Townsend & Wilson, 2010). Quebrada de Oro is a premontane rainforest locality that has been under study since 1980 (McCranie & Castañeda, 2005). It is the type locality for six species of amphibians (Craugastor aurilegulus, C. chrysozetetes, C.

fecundus, *Duellmanohyla salvavida*, *Plectrohyla chrysopleura* and *Rhinella chrysophora*). In addition, two other species (*Craugastor cruzi* and *C. saltuarius*) were described on the basis of material collected on the slope of Cerro Búfalo above Quebrada de Oro. Almost all of these species are considered to be in decline, with some even considered to be extinct or close to extinction. McCranie & Castañeda (2007) discussed this disastrous situation.

Like other species from Quebrada de Oro that have declined or disappeared, *P. chrysopleura* is apparently extirpated from that locality, and given that Quebrada de Oro is the only locality where this species has been found, despite consistent focused work in the area (McCranie & Castañeda, 2005, 2007), it raised the concern that the species may be near extinction, if not already extinct. The last time *P. chrysopleura* was documented as extant was in May 1996, when two metamorphs and two tadpoles were collected along Quebrada de Oro (McCranie & Wilson 2002; McCranie & Castañeda 2005). At that time, one of two tadpoles collected had deformed mouthparts (McCranie & Wilson, 2002). A return visit to Quebrada de Oro in May 2010 by one of us (CCM) found the area around the locality to be heavily disturbed and impacted by cattle ranching and illegal logging.

Based on these data and additional considerations, Cruz et al. (2004), IUCN (2008), and Townsend & Wilson (2010) all judged P. chrysopleura to be Critically Endangered based on IUCN criteria (IUCN, 2001). For P. chrysopleura, the criteria were A2ace and B1ab(iii,v)+2ab(iii,v), meaning that a reduction in population size of \geq 80% was observed, estimated, inferred, or suspected over the last 10 years based on direct observation, a decline in area of occupancy, extent of occurrence and quality of habitat and the suspected impact and susceptibility to decline from chytridiomycosis.

In June 2010, we undertook the first herpetological survey work in a large area of premontane wet forest (Holdridge, 1967) on the northeastern side of Refugio de Vida Silvestre Texiguat known as 'La Liberación.' As with Parque Nacional Pico Bonito, Refugio de Vida Silvestre (RVS) Texiguat has been documented as having a high degree of herpetofaunal endemism that is at risk of being lost, in this case due to persistent deforestation in the leeward portions of the reserve (Townsend & Wilson 2010; Townsend et al., 2010). Parque Nacional Pico Bonito and RVS Texiguat share a number of endemic species, being found at opposite ends of the Cordillera Nombre de Dios (Wilson & McCranie, 2004). During this survey, we collected a series of Plectrohyla chrysopleura that provide us with 1) the first evidence of this species' survival in 14 years, 2) the second known locality for this species, approximately 55 km west-southwest of the type locality, and 3) an indication that this, and perhaps other Quebrada de Oro endemics, might inhabit areas of suitable premontane wet forest habitat in other parts of the

Cordillera Nombre de Dios.

We collected vouchers of two adult males (USNM 573995 [Fig. 1B], SVL = 58.6 mm; USNM 573996, SVL = 62.5 mm; sex determined by presence of vocal slits), one adult female (USNM 573993 [Fig. 1A], SVL = 65.8 mm) and four recently metamorphed froglets (USNM 573994 [Fig. 1D], USNM 573997). All three adult specimens agree with the descriptions of P. chrysopleura provided by McCranie et al. (1994) and McCranie & Wilson (2002), in having 1) an enlarged prepollex with a flat and blunt distal end, 2) uniform pale brown to bronze dorsal coloration (Fig. 1A) or pale brown ground coloration with dark mottling (Fig. 1B) in life with bright yellow flash marks around the portions of the legs and body hidden when the legs are along the body, 3) large size (SVL 58.6-65.8 mm in three adults) and 4) spatulate maxillary teeth.

One adult female (Fig. 1A; USNM 573993) was collected on 14 June 2010 while sitting on a branch at night 2 m above a small tributary of the Río Jilamito (1,030 m elevation). A second, noticeably larger individual (presumably another female) that was not collected was seen less than 5 m upstream as it sat approximately 4 m high in vegetation overhanging a pool (Fig. 1C). Two adult males (USNM 573995 [Fig. 1B], USNM 573996) were collected on June 19 2010, on the ridge above a lagoon at the top of Cerro El Chino (1,420 m elevation). Both frogs were on branches of the same small tree above a small, but apparently permanent, pool; (USNM 573995 was approximately 1.5 m above ground level, and USNM 573996 was approximately 1 m directly above it. Recently metamorphed froglets of Plectrohyla, all herein assigned to P. chrysopleura, given we found no other species of *Plectrohyla* in the area), were collected on low (0.5-1 m above ground-level) vegetation near two small tributaries of the Río Jilamito (1,020-1,030 m elevation).

Of the six endemic species of premontane forest amphibians described from the Quebrada de Oro area, we now know that two of them (*Duellmanohyla salvavida* and *Plectrohyla chrysopleura*) occur at La Liberación. Given the robust nature of the populations of these two treefrogs and the intactness of the premontane



Figure 1. A) Adult female *Plectrohyla chrysopleura* (USNM 573993) from La Liberación, 1,030 m elevation, Refugio de Vida Silvestre Texiguat, Honduras. B) Adult male *P. chrysopleura* (USNM 573995) from Cerro El Chino, 1,420 m elevation, Refugio de Vida Silvestre Texiguat, Honduras. C) Large adult *P. chrysopleura* (not collected) from La Liberación; even at this distance, yellow flash marks are visible around the throat and hind legs. D) Recently metamorphosed *P. chrysopleura* (USNM 573994) from La Liberación.

rainforest in this area, we are hopeful that perhaps other endemic anurans that have undergone decline at Quebrada de Oro will be discovered residing at La Liberación.

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Ecological data on road killed *Amphisbaena alba* Linnaeus, 1758 (Squamata, Amphisbaenidae) in southeast Brazil

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ABSTRACT - Vehicles running over vertebrates has been an increasing challenge to the local conservation of some herpetofauna. The Amphisbaenidae are fossorial reptiles which are poorly known ecologically. Biological and natural history data were obtained from three specimens of *Amphisbaenia alba* that were found dead along 8320 km survey of highways. The rarity of road kill and the importance of the species conservation are discussed.

THE mortality of wild fauna caused by road traffic has been a problem in the developed and developing country motorway systems around the world (Saeki & Macdonald, 2004). It has long been considered a challenge for local conservation of many species due to negative trends in species populations that are aggravated by humancentric expansion and global economic growth (Seiler 2003; Forman et al., 2003).

According to Hels & Buchwald (2001) the impact of highways on fauna can be seen in two ways; directly, when animals are run over and killed, and indirectly, through the fragmentation and isolation of populations. The killing of anurans *Pelobates fuscus* Wagler, 1830, *Rana temporaria* Linnaeus, 1758 and *Rana arvalis* Nilsson, 1842 by vehicles in Denmark resulted in mortalities of up to 21-25% (Hels & Buchwald, 2001). Ehmann & Cogger, (1985) also report approximately 5.5 million reptiles and amphibians are killed every year on Australian highways.

Amphisbaena alba Linnaeus, 1758 is a Squamate lizard of the Amphisbaenidae and is distributed from Panama through Venezuela and the Guianas, Colombia, Peru and Bolivia, east of the Andes, to Brazil, north of Paraguay, Trinidad and the Guianas (Gans, 1962). The species is among the largest of the amphisbaenians. It has the widest distribution among them and it has been suggested

that it may comprise a complex of species (Gans, 1962).

A. alba diet was recorded by Colli & Zamboni (1999) and data about their biology and reproduction was studied in captivity by Andrade et al. (2006). The species has been noted from few studies of road kill events in Brazil (Prada, 2004; Rodrigues et al., 2002). Despite numerous studies on the systematics and anatomy of amphisbaenians (Vanzolini, 1955, 2002; Gans 1962, 2005; Barros-Filho & Valverde, 1996; Jared et al., 1999; Kearney, 2002) data on the ecology and natural history of many species are still scarce. The current study obtained information on the habits, occurrence and morphometrics of three *A. alba* using road kill specimens from an area of Brazilian savanna (Cerrado).

MATERIAL & METHODS

The three samples were collected during a study on vertebrate road kill by highways. Highway MG-428 which hems the National Park of Serra da Canastra in Sacramento, state of Minas Gerais (19°49' S 47°16 W) and SP-334 beside Furnas do Bom Jesus State Park, in Pedregulho, state of São Paulo (20°10' S 47°28 W), southeast Brazil were studied. The highways were travelled weekly by car at an average speed of 60 km/h (January-December 2007; n = 52 days, 8320 Km) aiming to record vertebrates that were run over within a



Figure 1. Location of the highways in the study, MG-428 and SP-334, MG-Minas Gerais State and SP-São Paulo State.

section of 160 km between the cities of Franca-SP and Araxá-MG (97 km on the MG-428 and 63 km on the SP-334) in the southeast of Brazil (Fig. 1).

The specimens of A. alba were collected, placed in plastic bags and brought to the Laboratory of General Biology of the Institute of Sciences and Health in the University Center of Araxá (UNIARAXÁ - MG, Brazil). In the laboratory, the weight of the carcass (WC) was obtained by using a digital weighing scale (+/-10 g) and measurements of snout-vent length (SVL), and tail length (TL), were taken with the aid of a measuring tape (mm). The pre-cloacal pores of each specimen were counted and their standard deviation determined. Animals were then dissected and sexed by inspection of the gonads. The digestive tube was opened longitudinally and the content was taken out and washed through with tap water over a sieve (mesh 0.5 mm).

A triage was made with the aid of a stereomicroscope (4 x amplification, ZeissTM)to separate the different items ingested into groups of invertebrates to Class and Order. Each item was recorded according to the number of the present parts and identified as morpho-species, whenever possible. This method allowed the simultaneous consideration of the fragmentation of the mandibles of invertebrates, their size, and what occurred most frequently in the gut. The calculation of the proportions of the parts of the different items of

invertebrates that were found was calculated from the formula:

$$P_i = F_i / N \ge 100$$

 P_i = proportion of the item, F_i = frequency of the item and N = total of items.

RESULTS

We found three specimens of *A. alba* that were run over. Two individuals (A and B) were collected on the same day, at the end of the rainy season in March (14/03/2007) at km 67 of the MG-428 ($19^{\circ}49'10"$ S and $47^{\circ}16'11"$ W) and 450 of the SP-334 ($20^{\circ}09'56"$ S and $47^{\circ}28'19"$ W) at altitudes of 938 and 983 m respectively. A and B were both found next to fragments of savanna vegetation and gallery forest. The third (C) on 30/11/2007 was found on km 63 of the MG-428 ($19^{\circ}49'11"$ S and $47^{\circ}14'52"$ W) at an altitude of 910 m (Fig. 2).

The three specimens had complete tails, proving the non-occurrence of caudal autotomy, even after the likely impact of a vehicle running over them. The specimen from São Paulo did not present any external signs of injuries.

The measures obtained were: 85 g (WC), 505 mm (SVL), 40 mm (TL), 170 g (WC), 580 mm (SVL) and 40 mm (TL) for the specimens from MG and 390 g (WC), 655 mm (SVL) and 55 mm (TL) for that of São Paulo. Precloacal pores numbered



Figure 2. Images showing the geographic location of the three specimens collection; Above, MG-428 Highway, A and C specimens; Below SP-334 Highway, B specimen (Source: Google Earth[™], 2010).

6-8 pores and cloacal 'plugs' were extracted from the specimen found on the highway in São Paulo. In the dissection it was possible to sex two individuals, one male, from Minas Gerais (C) and one female specimen from São Paulo (B).

The sample analysis of the digestive tube content from the São Paulo specimen exhibited: insects (59.5%), ants (Hymenoptera-32%), bugs (Coleoptera-19.5%) and crickets (Orthoptera-8%), unidentified invertebrates (28%), plant material (11.5%), Clitellata (1%) and worms (Haplotaxida;

1%). The remaining two specimens had empty digestive tubes.

DISCUSSION

It is intriguing that the specimens presented tails, even after the likely death shock caused by a vehicles. However, according to Gans (1962) refusal of caudal autonomy is a characteristic which differentiates *A. alba* from the other amphisbaenians.

The date that the two first specimens were

collected coincided with the reproductive period of the species in the Brazilian Cerrado and can also be related to periods of intense rain in their habitat, a seasonal period that promotes the soaking of soil and may encourage A. alba to exit from fossorial tunnels (Abe & Johansen, 1987) with consequent overland movement that could lead them to encounter a road. The female was sexually mature, with well developed eggs, possibly due to being found during the seasonal period of mating. Colli & Zamboni (1999) found two female specimens reproductively active in April. Their reproductive period is likely therefore to be at the end of the rainy season and the beginning of the dry season. The same authors also documented that 45.8% of the stomachs of 214 specimens that were analysed were empty.

The items in the diet that were recorded for specimens herein are much like those registered by Colli & Zamboni (1999) and the proportions found are also similar to the specimens' dietary composition in this study (ants 32%, bugs 19.5%, crickets and grasshoppers 8%, unidentified invertebrates 28%, plant material 11.5% [Colli & Zamboni, 1999]). The major differences between the finds are between crickets/grasshoppers, vegetal material and bugs. Such a dietary composition can result from the environment of roadside habitat and the generalist dietary habits of the species (Colli & Zamboni, 1999). In another encounter of a single specimen in Bahia, northwest Brazil, only nematode worms were recorded in the stomach (Barros-Filho & Valverde, 1996). However, as our sample data and the northwest study were obtained from one specimen, interpretation of the analysis should be viewed carefully and not considered a definitive dietary analysis for the species.

The amphisbaenians are fossorial reptiles that occur in various tropical regions of the globe. *Amphisbaena alba* is the largest species of the family with a wide distribution throughout south America (Pough et al., 1998). In studies from Brazil the species constituted only 0.5-1% of the total number of specimens encountered during reptile surveys (Prada, 2004). This highlights the low encounter rate expected for the species and how difficult it is to sample these fossorial reptiles, despite their wide geographical distribution. Two of the individuals found (B and C) are larger than the known average for the species (572 mm [Colli & Zamboni 1999]) and this factor may suggest that larger specimens have more probability of being killed in the wet season, although this is only a conjecture. Due to the difficulty in locating this species, it is expected that the occurrence of roadkill is likely a rare event. What also makes these encounters rare is that there are many scavenging animals that prey on corpses near roadsides and thus the likelihood of finding specimens could be considered very low.

We consider that the presence of *A. alba* close to highway shoulders could be associated with the occurrence of nests of cutter ants (*Atta* sp.) as this species is known to shelter inside ant nests (Riley et al., 1986). This theory is fortified by Vasconcelos et al. (2006) work that showed the presence of cutter ants using man made roads as corridors to colonise new areas in the central area of Brazil. Specimens of *Atta* sp. ants were also found in the digestive tube of one of the specimens.

Amphisbaena alba is poorly known by zoological science and information herein assists in documenting knowledge for the species. We therefore encourage other herpetologists to consider using more roadkill herpetofauna specimens to investigate the ecology and biology of species that are accidently killed in this manner.

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NATURAL HISTORY NOTES

MICRURUSNIGROCINCTUS(CentralAmerican Coral Snake): CANNIBALISM. Many snake species are known to include other snakes in their diet, and New World coral snakes (Leptomicrurus spp., Micruroides sp., and Micrurus spp.) are well known for their ophiophagous tendencies. Approximately 75% of all coral snake species are known to feed on other snakes and about 36% are exclusively ophiophagous (Roze, 1996). Along with other snakes, the diet of coral snakes consists of other elongate ectothermic vertebrates including lizards, amphisbaenids, caecilians and fishes, as well the occasional invertebrate (Roze, 1996: Campbell & Lamar, 2004). Coral snakes also prev on congeners, even conspecifics, yet cannibalism is poorly documented within this group.

Micrurus nigrocinctus (Fig. 1) is widely distributed in several central American habitats, extending from southeastern Oaxaca, Mexico southward to northern Colombia (Savage, 2002). Like most coral snakes, M. nigrocinctus feeds largely on other snakes (Adelphicos, Anomalepis, Coniophanes, Dendrophidion, Drymobius, Enulius, Geophis, Helminthophis, Imantodes, Leptodeira, Mastigodryas, Ninia, Porthidium, Rhadinaea, Tantilla, Typhlops, Tropidodipsas, and Urotheca) but also eats lizards and their eggs (Ameiva, Cnemidophorus, small Ctenosaura, Gymnophthalmus, small Eumeces. Iguana, Mabuya and Sphenomorphus), caecilians, and eels (Synbranchus marmoratus) (Schmidt, 1932; Swanson, 1945; Landy et al., 1966; Greene & Seib, 1983; Roze, 1996; Campbell, 1998; Savage, 2002; Campbell & Lamar, 2004; Solórzano, 2004). Smith & Grant (1958) reported that a M. nigrocinctus collected from Panama contained another coral snake nearly equal in size but failed to mention if the snake consumed was a conspecific or another species of *Micrurus*. Here we document the first confirmed record of intraspecific cannibalism by *M. nigrocinctus* in the wild.

From 13-19 July 2008 herpetofaunal surveys were conducted in and around Reserva Natural Cerro Kilambé (Kilambé), a cloud forest reserve in north-central Nicaragua. On 19 July 2008 at 15:30 hrs an adult male *M. nigrocinctus* (Florida Museum of Natural History (UF) 155981, 56.4 cm



Figure 1. Micrurus nigrocinctus.

SVL, 10.4 cm TL) was collected dead on a small dirt road near the community of La Escuelita at 1075 m elevation on the northern versant of Kilambé (13°37.178'N, 85°43.399'W). The surrounding habitat was a mosaic of secondary broadleaf forest fragments and denuded areas of livestock and agricultural land. Near where UF 155981 was found a local resident told us that he killed the snake earlier that day with a machete as it crossed the road, and we found a juvenile M. nigrocinctus (UF 156353, 36.8 cm SVL, 4.4 cm TL) protruding from the machete wound (Fig. 2). The prey's anterior region was partially digested and the posterior end had been separated from the rest of the body (7.3 cm above the tip of the tail), yet the specimen was still easily diagnosable.

Although a few species of *Micrurus* are reportedly cannibalistic in captivity, intraspecific cannibalism has only been documented in seven species from the wild (Roze, 1996; Cambell & Lamar, 2004). Our record thus augments knowledge of the diet of *M. nigrocinctus* and increases the number of *Micrurus* species known to exhibit this uncommon behaviour. Unfortunately, the significance and prevalence of intraspecific cannibalism in coral snakes has received very little study, although several researchers have proposed explanations (Curtis, 1952; Greene, 1984; Roze, 1996). Future research on this unusual phenomenon would be a worthwhile contribution to our knowledge of the ecology and natural history of coral snakes.

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Natural History Notes

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Figure 2. Dead *Micrurus nigrocinctus* with conspecific meal.

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BOTHROPS MOOJENI (Brazilian lancehead): MATING. Information about ovarian and testicular cycles is available for several neotropical species of snakes (Marques et al., 2009). However, descriptions of courtship, mating or combative behaviours are scarce and most information currently available comes from extratropical species (Sasa & Curtis, 2006). Herein we describe an observation of wild mating by *Bothrops moojeni* in nature.

B. moojeni is a large terrestrial pitviper that inhabits riparian areas in central and southeastern Brazil, including marshes, the border and interior of gallery forests and mostly areas of Cerrado (Brazilian savannah) (Nogueira et al., 2003; Campbell & Lamar, 2004; Sawaya et al., 2008).

Published literature about reproductive biology of B. moojeni reports a lengthy and seasonal reproductive cycle with a vitellogenic period that starts in May (mid-fall) and ovulation around July (early winter). The litter size varies from three to 32 embryos and births are concentrated during the rainy season (summer) from late December to March (Leloup, 1984; Faria & Brites, 2003; Nogueira et al., 2003; Sawaya et al., 2008). Leloup (1975) observed mating in captivity from March to May (late summer to mid-fall) and births from December to January (summer), suggesting a gestation period of about 200 days. Méier & Sandoz-Ogata (1996) observed a captive peak in reproductive activity during January. Almeida-Santos & Salomão (2002) observed UMT (uterine muscular twisting) in females under primary vitellogenesis in February and March and secondary vitellogenesis in June, suggesting sperm storage for B. moojeni. Although seasonal timing of mating is an important event to help characterise the reproductive cycle, we did not find any published observations of mating in B. moojeni in nature.

On 4 March 2009 (late summer), during a herpetofaunal survey in a forest fragment in the municipality of Patrocínio Paulista (20°38'S, 47°15'W), southeastern Brazil, two adult *B. moojeni* (male 912 mm SVL, 145 mm tail length, mass 410 g; female 977 mm SVL, 139 mm tail length, mass 550 g) were found mating at 09:20 on a cloudy day. The snakes were found mating on leaf-litter, close

to a fallen tree and temperature inside the forest was 28°C. The female was stretched and partially hidden under the fallen tree while the male was exposed on leaf-litter. No other individuals were found nearby the mating couple. Mating continued for 190 minutes before disturbance by capture. When researchers approached snakes for capture, the female reacted vibrating its tail against the ground, struck and tried to escape dragging the male behind her. The male and female ceased mating after the disturbance caused by physical restraining. Both individuals were marked (ventral scale clipping #01, male and #02, female) and released in the capture locality.

Observation of reproductive events in nature is rarely seen in neotropical snakes due to the secretive nature of many species and also because of generally low encounter rates for many species (Sasa & Curtis, 2006). The information herein contributes to the general ecological profile of the species and observations of mating behaviour in neotropical *Bothrops*. A long-term study using radio-telemetry would allow more observations of reproductive events and contribute to building a stronger database of reproductive biology for neotropical species of snakes.

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The National Forest of Saracá-Taquera in the north of Pará state, northern Brazil (FLONA), is a protected area that has a rich array of drains and small to large rivers with elevated plateaus (up to 180 metres). Its unique hydric resources include temporary ponds formed during the wet season. On the plateaus, juvenile specimens of the two known species of Paleosuchus (P. trigonatus and P. palpebrosus) exist. On May 19 2010 during a survey of the crocodilians of the area, one female specimen of *P. trigonatus* (64.5 cm TL, 960 g) was captured in a temporary pond in an elevated area named Bacaba plateau. The individual was found at 80 m elevation and 800 m from the nearest river. indicating that it moved through forest to reach the upper plateau. The stomach contents of the individual were obtained by flushing (see Taylor et al., 1978) and revealed gastrolites and remains of two specimens of Brotheas paraensis (Arachnidea, Scorpionia, Chactidae) (Fig. 1). To the best of our knowledge this is the first record of consumption of this scorpion species by a caiman. Scorpions of the genus Brotheas are terrestrial (Höfer et al., 1996) and B. paraensis is usually found among leaf-litter in dense forests in the area (S.A.A. Morato, pers. obs.). A single record of predation of a scorpion is known for the smooth-fronted caiman. Brotheas has been recorded in its diet but this species of scorpion is mainly found nearby water. What is interesting is that the record of two individuals of B. paraensis as a dietary item may suggest that smooth-fronted caiman prey terrestrially in forest leaf-litter, not soley in riparian areas (cf. Magnusson et al., 1987). Movement across land to preferred feeding resources has also been recorded for Caiman crocodilus, previously considered a riparian specialist (Grant et al., 2008).

Smooth-fronted caiman juveniles are found during the wet season on the upper portions of the plateaus and this may suggest that they move larger distances in their territories when younger. Only individuals of 50-70 cm (N = 5) were found in these uper areas. According to Magnusson & Lima (1991), adult females of *P. trigonatus* were not strongly territorial when concentrated in small streams with overlaping territories. Juveniles of *P. trigonatus* were also found 100 m from the nearest creek and at a nest 2 km from the Tiputini river, Ecuador Amazon Basin (Rivas et al., 2001). Such movements suggest that smooth-fronted caiman have large territories that encompass terrestrial and riparian habitats although further work on their abundance and distribution is needed to confirm this.



Figure 1. Remains of two specimens (evident from two telsons) of *Brotheas paraensis* (Scorpionida, Chactidae) found in the stomach contents of *Paleosuchus trigonatus* from FLONA de Saracá-Taquera, Pará State, Brazil. Photograph by Sérgio A.A. Morato.

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ENYALIUS BIBRONII (NCN): ECTOPARASITISM. Leiosaurid lizards of the genus Envalius comprise nine recognised species (Bérnils, 2009), restricted to forested areas in Atlantic rainforest remnants of eastern Brazil (Jackson, 1978; Ávila-Pires, 1995), patches of savanna, and gallery forests of the Cerrado in central Brazil, and in scattered patches of the semiarid Caatingas (Rodrigues et al., 2006; Freire et al., 2009). Envalius sp. is mostly diurnal and insectivorous. They use tree trunks, shrubs, fallen logs or leaves as perches, but are also commonly found on the ground or leaf litter (Jackson, 1978; Sazima & Haddad, 1992; Vitt et al., 1996;

Zamprogno et al., 2001; Teixeira et al., 2005). *Enyalius bibronii* Boulenger, 1885 (Figure 1A) is typical of relictual forests of the arid interior of northeastern Brazil (Jackson, 1978) where, according to Rodrigues (2003), after their original habitat deteriorates, this species remains in a few areas that are compatible with their ecological and physiological habits. In this short note we report *E. bibronii* as an unusual egg-laying substrate for a lepidopteran.

During a study of the structure of lizard assemblages, sixteen E. bibronii were collected by pitfall traps in a forest enclave (06°10'80"S, 36°43'38"W, 751 m ASL) inside the Caatinga biome, in the municipality of Tenente Laurentino Cruz, State of Rio Grande do Norte, Brazil. The local climate is classified as semi-arid, hot and dry, with rainfall of 705 mm/year, mean temperature of 26.6°C and relative humidity of 65% (Beltrão et al., 2005). On 19 November 2009 at ca. 09:00, during a herpetological survey, MG and LBR collected an adult female E. bibronii (97.7 mm SVL) presenting a group of four lepidopteran eggs (~ 1.2 mm in diameter) adhered to its dorsum (Figure 1. B-C). Although the caterpillars had already hatched, the oviposition was identified as of a moth belonging to the family Noctuidae. The eggs were of a sub-spherical shape, slightly flattened and flat based. The corium (outermost extraembryonic membrane, that serves to protect inner layers) was translucent and of a friable texture without pubescence.

The majority of noctuid moths are nocturnal, but there are also crepuscular species (Gallo et al., 1988). In this instance we suggest that the E. bibronii was perched on shrubs, vines, tree trunks and branches (Ribeiro pers. obs., Figure 1A) and was possibly mistakenly selected as an oviposition substrate by a female noctuid. The cryptic colour pattern of E. bibronii that makes it inconspicuous in its environment may also have confused the moth in its site selection to lay eggs. The selection of an oviposition site is particularly crucial in Lepidoptera as the fitness of the progeny depends mainly on that instinct (Renwick & Chew, 1994). The choosing of an unusual host like E. bibronii by the noctuid is unusual and risky because Envalius lizards are known to feed on lepidopteran larvae

(Zamprogno et al., 2001; Sousa & Cruz, 2008). The voucher specimen of *E. bibronii* (CHBEZ 3209) was deposited in the herpetological collection of the Universidade Federal do Rio Grande do Norte, Natal, Brazil.



Figure 1. *Enyalius bibronii* as a host of lepidopteran eggs: (A) Specimen resting, at night, on a branch (Top); (B) Group of four eggs on the lizard's dorsum (arrow) (Middle); (C) Detail of the top of the eggs eaten by the caterpillars when they began to emerge (Bottom).

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Natural History of West Indian Reptiles and Amphibians

Robert W. Henderson and Robert Powell 2009, University Press of Florida, 495 pp.



If you like the idea of putting your feet up on a dull British evening, skimming through some colourful pictures of exotic herps and reading easily digestible snippets of Caribbean natural history – then you would be advised to pass by this book.

This solid feeling, quality book, is a serious work, condensing a huge amount of knowledge accumulated not just by the authors themselves but also a vast range of contributors that spans decades of research and observations. Other than the colour cover pictures and one black and white full-page photo to accompany the title page there is a distinct lack of visual impact to this book. In fact it is limited to one black and white figure per family. Those that are featured are good and depict interesting features or behaviours.

The book begins with a species list and this alone is enough to fill the reader with wonder.

The West Indies is home to a herpetofauna of over 700 species. The introduction tells us that this amounts to 3% and 6.3% of the world's reptiles and amphibians respectively – in just 0.15% of the world's landmass. The variety is enough to make a British herper mad with envy, ranging from the genus *Allobates* with a single representative to *Eleutherodactylus* and *Anolis* with an amazing 161 and 157 species respectively.

A couple of much needed maps are included, one showing the West Indies and their proximity to north, south and central America, with the other showing on a larger scale, the chain of islands that make up the Lesser Antilles. Both maps are vital if one is to try and make any sense of the distribution of animals in the area.

A very interesting introduction follows which builds on the maps by clearly defining exactly what is classed as the West Indies (a surprising 600 islands) and then discussing exactly what was included and omitted from the information provided in the species accounts that follow. An overview of West Indian herpetology is provided followed by a discussion of the 'Threats to the Herpetofauna'. These include the now ubiquitous habitat loss that is of concern globally, the evermore worrying introduced species problem and the more localised problems of hurricanes and even volcanic eruptions. The 'Current Overview' section reinforces the variety of habitats utilised by reptiles and amphibians across the region before briefly covering the need and scope for future research.

The species accounts naturally take up the majority of the book and they really are comprehensive. The level of detail included is just staggering at times and goes far beyond the obvious distribution, habitat and conservation status that might be expected. Additional information provided for some species includes; parasites, longevity, foraging and diet, salinity tolerance and water hole fidelity. In the 'Introduction' the authors apologise for presumed omissions but with a citations list running to 80 pages that includes information from approximately 2,600 publications the authors cannot be accused of being anything less than thorough.

It is apparent that for some species there is a wealth of information available while for many others almost nothing is known. Even within well studied genera such as Anolis there can be a huge disparity between species. The authors have estimated that only 12% of the herpetofauna of the West Indies had been studied by 1999. This lack of knowledge regarding many species (resulting in Conservation Status of either 'unknown' or 'not assessed') is cause for concern and hints at the direction that future research needs to take I have no doubt that the authors, with their vast experience of this part of the world, have some very clear ideas of which areas or species should be prioritised and I found it surprising that the 'Future Emphases' section was not firmer in tone with more direct exposure of particular problems (although forgivingly the authors perform a wonderful job of enticing the reader to the islands!). The book in its entirety is perhaps the best indication of where future directions should lie and I suspect that is how the authors intend it to be read.

Nomenclature and systematics are kept to a minimum throughout the book and recently adopted or proposed changes are mentioned in the 'Remarks' section of each species account. For example the cane toad account remains faithful to *Bufo* but mentions the fact that this species has been placed in both *Rhinella* and *Chaunus* in recent years. This seems a wise approach given the furious rate at which nomenclature is changing at present.

It is difficult to get a feel for any one island from this book and an overview of some of the larger, more species rich, or perhaps most threatened, may have been of value. While this is not a book that I could say every herpetologist needs in their library it is certainly a resource that would be essential if research work or even serious herpetofauna observation is to be undertaken in the West Indies. It is also an incredibly ambitious and admirable work and the authors should be highly commended for it.

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Handbook of Venoms and Toxins of Reptiles

Stephen P. Mackessy 2009, CRC Press, Boca Raton, Florida.



The Handbook of Venoms and Toxins of Reptiles comfortably fills an existing hole in the literature for toxinologists, biochemists, physicians and herpetologists interested in natural toxins. Representing the most comprehensive review of reptile venoms for a number of years, this book provides a thorough and attractive exploration of the field of toxinology, with numerous colour (an eight page insert) and black and white figures supporting detailed text which primarily describes the molecular, structural and functional aspects of the toxic components that make some reptile venoms so potent.

As with a number of biological research areas, a rise in DNA and proteomic technologies over the past decade has led to substantial advances in the field of toxinology, with scientists utilising these techniques to provide comprehensive overviews of the toxic components present in the venoms of animals – a number of which are have been of particular interest for use as tools for understanding human biological pathways or rational drug design. As a result of the recent exponential rise in scientific studies on natural toxins, the Handbook of Venoms and Toxins of Reptiles is a welcome addition to a relatively sparse collection of toxinology textbooks. In fact this book represents the most thorough update of reptile venoms for a number of years. Consisting of four sections and 24 chapters written by some of the most eminent toxinologists from across the world, this book represents a thorough review of the enzymes and toxins present in reptile venoms, and also describes how venoms have evolved, how venomous species are related and how envenomation can be prevented and treated in different regions of the world.

The first section of the book, entitled 'Reptile toxinology. systematics, and venom gland structure', is headed by the editor's introduction to reptile venoms - defining the venoms and their components and also describing the variation in venom that exists between species. Subsequently, an interesting overview of the recent advances in venomous snake taxonomy describes how species classification can affect the field of toxinology. Perhaps more importantly, this chapter also details how reptile venoms have evolved - correcting a surprising omission from the introductory chapter. The final chapter in this section provides a detailed description of the anatomical and functional workings of different venom delivery systems.

The following two sections detail the enzymatic and toxic components that are present in the venoms of reptiles. These sections make up the centre piece of the book and consist of 17 chapters penned by different experts from across the world, describing the biological activity, evolution, structure and function of individual protein families present in different venoms. The coverage of toxins described by these chapters is impressive, with chapters detailing a number of barely studied toxin families alongside well characterised pathological components. Some authors also discuss how to experimentally isolate the protein of choice in the lab and carry out studies to identify their function – a nice touch that may encourage new researchers into the field. The only slightly disappointing aspect of these sections is that there is little information regarding how different venom components may work together – descriptions of individual toxin families are detailed but there is little reference to how mixtures of these components may combine to kill or immobilise prey in a real world situation.

The final section 'Envenomation: occurrence, prevention, treatment', consists of four absorbing chapters that detail the consequences of reptile envenomation in Australia, Africa and north and central America. Each of these chapters is written by clinical and toxinological experts from these geographical regions, describing the animals that present a risk to humans, the epidemiology of envenomation in the area and an overview of treatment that follows cases of envenoming. These chapters nicely summarise the book and provide a fascinating description of the human consequences that arise due to the action of the toxic components described elsewhere.

There are a few minor problems with the book – the inevitable result of different authors writing separate chapters leads to some reproduction of introductory text, whilst more considerable redundancy exists on occasions between adjacent toxin chapters – I found these particularly frustrating. There are also some issues with factual consistency, with different authors citing, deriding or ignoring recent important advances in the field, leaving the reader confused as to what is readily accepted by the toxinological community – particularly if they are new to the subject.

In summary, I enjoyed reading this book, but would suggest it is primarily aimed at toxinologists and biologists interested in venomous animals – the biochemical complexity of chapters describing the toxins and enzymes present in reptile venoms may present a challenge to the more general readership. However, introductory chapters detailing the systematics of venomous snakes and anatomy of venom delivery systems will make interesting reading for everyone, whilst the final four chapters on the prevention and treatment of envenomation provide a fascinating insight into the medical implications that arise from reptile venoms. Overall, this book is a valuable addition to the shelf of anyone interested in venom biology - the compilation of thorough reviews of toxic venom components will make it the first stop in search of a quick reference. Although the more general readership may have to 'read its way in', and other introductory texts (such as JP Chippaux's *Snake Venoms and Envenomations*) may be initially more suitable (and slightly cheaper), the comprehensive scientific detail present in this book ensures the *Handbook of Venoms and Toxins of Reptiles* will stand the test of time as a worthwhile investment.

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The Rise of Amphibians: 365 Million Years of Evolution

Robert Carroll 2009, The Johns Hopkins University Press, 392 pp.



With its bold and stylised depictions of early amphibians on its cover, '*The Rise of Amphibians*' will stir the imagination or innate interests of any lover of the animal kingdom. Additionally, a read through the preface provides an enlightening insight to the fascinating information the book holds.

The book is compiled in 14 orderly chapters with appropriately nested subsections. It begins with the chapter 'History of the Earth and Life'. A brief introduction is given with a detailed figure (1.2) that illustrates the evolutionary history of terrestrial vertebrates. A plethora of information within the first chapter highlights the universe and Earth's beginning, with interesting examples of dating ancient meteorites for accurate time scales. The whole time scale is simplified within the very informative figure (fig.1.3) on page four, which is worth a look at if you are rusty on that subject area. Plate tectonics is briefly mentioned, however, the bulk of the chapter is taken up by the eukaryotes and the rise of multicellular animals.

Chapter 2 brings together pertinent information on the origins of multicellular and vertebral life, with didactic illustrations and dioramas (figures 2.2 and 2.7) of species found in the infamous Chengjiang and Burgess Shale faunas. The homeobox, hox genes, neural crest and placodes are heavily integrated throughout the chapter and are highlighted for their importance in the evolution of complex body forms and their conceivable effects on primitive chordates emerging onto land. This makes for a very insightful read that is supported with informative diagrams (figures 2.5, 2.8). More than half of the chapter is taken up by the radiation of bony fish of the upper Devonian and their plausible connectivity to the primitive tetrapods, naming Euthenopteron as a candidate.

Chapter 3 'The Origins of Amphibians' follows on from chapter two within the upper Devonian, however, the author proceeds throughout to discuss and evaluate the conceivable morphological changes achieved to produce the primitive amphibian state. Covered is a multitude of characteristics from evidence of the oldest known tetrapods *Acanthostega* and *Ichthyostega* with addition of other co-analysed tetrapod genera *Tikaalik, Panderichthys* and *Eusthenopteron*.

Some of the more fascinating characteristics

include transition of skull roof (dorsoventrally flattened), loss of medial dorsal and anal fins, greater articulation of the neck, ossification of the vertebrae, and changes in locomotion, including many more. Some interesting propositions for the movement onto land are put forward within the chapter. Genetic basis of change is covered, with fascinating insights into additional fish and tetrapods from the late Devonian and their geographic diversity to conclude.

The fourth chapter 'The Radiation of Carboniferous Amphibians' propels the reader forward to the carboniferous. This is by far the largest and most important of the chapters due to the background information that this chapter offers for good foundation knowledge for the following chapters. The sheer amount of information will take more than one sitting to complete.

The reader is taken through a compelling journey, with specimens from the Horton Bluff locality of the Lower Carboniferous (Whatcheeriidae) to the Nýřany locality of the Upper Carboniferous (Nectridea). Robert Carroll excels himself by compiling such descriptive patterns of interrelationship information of the early amphibians throughout the Carboniferous. The chapter includes tantalizing information of the skull. limb structure and vertebral differentiation to name but a few: these can be linked to portrav the lifestyle of the specimens and/or evolutionary adaptations. The information is coupled with very informative and detailed annotated skeletal diagrams. If the reader has no background in tetrapod anatomy, primarily of the skull, they will be forced to constantly flick to the back of the book to the abbreviations page, however, this will become easier as the reader progresses through the book.

Chapter five 'Adaptation, Radiation, and Relationships' is a brief but informative chapter, highlighting the difficulties in producing conclusive interrelationships. The author puts forward that it is due to the incomplete knowledge of the fossil record such as the 30 million year gap (Romer's Gap) during the beginning of the Carboniferous. Robert Carroll exposes the inconsistency and limitations of using Phylogenetic Analysis Using Parsimony (PAUP) due to the above. The chapter proceeds to define the uncertainties of tetrapod relationships, beginning with the Upper Devonian tetrapods (*Acanthostega* and *Ichthyostega*) through to Amniotes. The chapter is brilliantly concluded with the author's thoughts of new discoveries enabling a true and conclusive knowledge of tetrapod relationships.

Chapter 6 covers the amphibians of the late carboniferous and early to late Permian. The chapter is full of excellently annotated and informative diagrams showing the major diversity of the skulls of the early amphibians, including the Gharial like skulls of Platyoposaurus (Archegosauroids) and the spiked skulls of Zatrachys (Zatracheidae). One of the most interesting parts of this chapter involves the branchiosaurid species, which showed plausible neotentic physiology and possible links to the ancestry of modern day salamanders. The end of the chapter covers a few later Permian and Triassic Temnospondyls, with mention to the decline and near total extinction of terrestrial amphibians by the end of the Paleozoic.

The flamboyantly portrayed plates and plate notes are found amidst pages 192 and 193; these are linked with text throughout the book to give the reader a good idea of early and modern amphibian morphology.

Robert Carroll explains at the end of chapter 6 the need for chapter 7 'The Origin of the Amniotes'. This is the most effortless chapter to read so far, and even though amniotes are mentioned, primarily in the Joggins locality (chapter 4, p117-121) and chapter 3 (p160), this chapter fills in the gaps. The chapter emphasises the advantages of amniotes over the other early tetrapods/amphibians. These include the evolved pterygoideus muscle, allowing for greater prey diversity, their ability to live in fully terrestrial habitats and their unique reproductive behaviour and many more. Additionally, the author briefly explains their early radiation and divergence into birds, reptiles (Diapsids) and mammals (Synapsida/Therapsids).

Chapter 8 is one of the more important chapters; it explains the timings of the abrupt extinctions of many species, including a substantial amount of the terrestrial amphibian lineages and plausible catastrophes to have caused them. One of the more significant ones is the increase of temperature due to rise in CO_2 , causing the loss of the coal swamps, a major habitat for the early amphibians. The chapter moves onto explaining the rise of Stereospondyls, an amphibian lineage with some impressively large specimens, some growing to lengths estimated at 7 metres (Brachyopidae). There is a very informative figure (8.16) that shows their dominance through to the Lower Cretaceous.

Chapter 9 'The Enigma of Modern Amphibian Origins' is the first time modern amphibians (Lissamphibians) are mentioned. The chapter highlights that the three present amphibian body forms (Anurans, Urodela and Caecilians) were not recorded until the Lower Jurassic in the fossil record. The author proceeds to examine and compare the anatomy and lifestyles of the present day amphibians, with some plausible connections to primitive tetrapods. This informative chapter prepares the reader to link information together for the up and coming chapters 10, 11 and 12 where the author tries to shed some light on the possible ancestor/s of the modern amphibians.

Chapter 10 'The Ancestry of Frogs' is a short but concise chapter. The author begins with the explanation of the oldest known frog Prosalirus bitis and its common and differing features that link it to modern Anurans. The chapter continues to put forward early ancestors such as Triassic Salientians. Triadobatrachus massinoti and Czatkobatrachus polonicus, both from the Lower Triassic, by crossexamining the anatomy and lifestyles. Furthermore, with the use of synapomorphies (character traits shared by two of more taxa) the author, in a logical manor, tries to link as far back as the earliest Temnospondyls for putative antecedents of anurans, these include characteristics of metamorphosing, the skeleton and larvae stages. This is a very nice chapter, but leaves the reader wanting more.

Chapter 11 'The Ancestry of Salamanders' begins with the author stating the difficulties of tracing the ancestry of salamanders, due to the sheer diversity of life styles and body forms present. I thought this chapter was rather more complicated to grasp than chapter 10. However, Robert Carroll brings together exquisite information reinforced by informative diagrams for the possible ancestor/s of the modern salamanders. I found the section on the

'Modern Salamander Families', very interesting; Robert Carroll briefly but informatively sums up the modern families extremely well. The chapter is slightly confusing towards the end the flow seems to be hindered by the mention of modern day families then propelling the reader back in time, then forward in time once again.

Chapter 12 '*Eocaecilia* and the Origin of Caecilians' encapsulates a great deal of information on the skeletal anatomy and lifestyles of the 6 modern caecilian families. All the information is coupled with extremely detailed diagrams; however, the information is intense and may leave any beginner to the subject puzzled.

The reader is taken back to the fossil record of caecilians, and the limited horizons ranging from the Lower Jurassic. The definitive early caecilian is named as Eocaecilia micropodia. The reader is taken through the anatomical similarities and differences of Eocaecilia and modern caecilians. The author proceeds to pinpoint a plausible ancestor with reference to the skeletal characters of Eocaecilia as a model and how they differ from ancestral anurans and urodeles. Many Paleozoic tetrapods are mentioned however, Lepospondyls, especially the microsaur Rhychonkos is selected as an ancestor due to common derived characters with Eocaecilia and caecilians. Furthermore, the author states that skeletal anatomy of Lissamphibians shows closer affinities between anurans and urodeles than either has to caecilians.

Chapter 'The Success of Modern 13 Amphibians' provides the reader with more information on the evolutionary history of the modern Amphibians. Specifically on Urodeles, that holds extensive information on the modern families' fossil records. The reader will be enlightened with fascinating information on amphibians' present and historical distributions, with distinctive figures such as 13.1A that shows anuran families and how they have increased/decreased in distribution. The latter part of the chapter covers the 'New' amphibians, incorporating sexual reproduction, changes in salamander and caecilian feeding and respiration, genome size and the most intriguing area of tadpoles with bony tails.

The final chapter ' The Future of Amphibians' is a great ending to this fine book, it expertly sums

up the earlier chapters, with explanations of how amphibians have survived for so long and their advantages over many other vertebrates. The most significant part of this book is encapsulated within this chapter; this is the informative facts of problems faced by amphibians and their modern day declines. Plausible causes emphasized are exotic predators, pollution and chytridiomycosis (*Batrachochytrium dendrobatidis*) plus many more. All are explained in a factual way, with for and against arguments. However, Robert Carroll puts forward that not all amphibians are declining and that some may outlast humans due to the catastrophes they have already faced in their long ancestry.

Robert Carroll has excelled himself by putting together such magnificent piece of work, with information that is balanced efficiently. However, 'The Rise of Amphibians' is not without a few minor omissions. On page 19, figure 2.2 showing the Burgess Shale fauna, number 12 is missing within the list, but present on the diorama and there is a spelling error on page 102 where *Balanerpeton* is spelt *Balenerpeton*. Even so, this book is a massive feat and this review cannot come close to showing how much of a magnificent book it is. With an average RRP price of £34, it would be a worthy buy for anyone doing a degree entailing vertebrate evolution and by no means should this book be left off a university library shelf.

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