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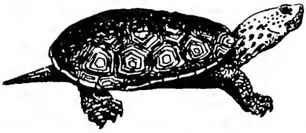

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CONTENTS

News & Notes

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BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

VOLUME 14 NUMBER 1

A FIELD KEY TO THE WHIPTAIL LIZARDS (GENUS *CNEMIDOPHORUS*)

PART I: THE WHIPTAILS OF THE UNITED STATES

Thomas Vance

ABSTRACT

A key is presented for the United States representatives of cnemidophorine lizards. Several maps are also included which summarize current range data of the whiptails and racerunners.

One of the most confusing and difficult groups of reptiles to the systematist is the whiptails and racerunners of the genus *Cnemidorphorus*. Diverse representatives are difficult to identify due to sex and age variations in color and patterns, possible hybridization, asymmetry of scalation, questionable ranges, and parthenogenetic modes of reproduction.

Many published reports have dealt with this genus and the variations within it. Burt (1931) provided a complete systematic treatment of the genus as it was known at the time. Duellman and Zweifel (1962) wrote a synopsis of the *C. sexlineatus* group while Duellman and Wellman (1960) reported on the mid-American *C. deppii* group. Stebbins (1966) provided a short key to the western forms of whiptails, and Lowe, et al. (1966) prepared a similar key to the unspotted taxa of the southwest. The field guides of Cochran and Goin (1970) and Conant (1975) do not include keys to these species. In addition, a varied and abundant recent literature has appeared which requires the construction of a current key.

Whiptails and racerunners included in the following key are: *C. hyperythrus beldingi* (Stejneger); *C. velox* Springer; *C. uniparens* Wright and Lowe; *C. sexlineatus sexlineatus* (Linnaeus); *C. s. viridis* Lowe; *C. inornatus arizonae* Van Denburgh; *C. i. heptagrammus* Axtell; *C. laredoansis* McKinney, Kay and Anderson; *C. gularis gularis* Baird and Girard; *C. exsanguis* Lowe; *C. flagellicaudus* Lowe and Wright; *C. sonorae* Lowe and Wright; *C. scalaris septemvittatus* Cope; *C. burti stictogrammus* Burger; *C. b. xanthonotus* Duellman and Lowe; *C. neomexicanus* Lowe and Zweifel; *C. tigris gracilis* Baird and Girard; *C. t. septentrionalis* Burger; *C. t. marmoratus* Baird and Girard; *C. t. aethiops* Cope; *C. t. reticuloriens* Hendricks; *C. t. multiscutatus* Cope; *C. t. mundus* Camp; *C. t. tigris* Baird and Girard; *C. t. stejnegeri* Van Denburgh; *C. tesselatus* (Say); and *C. dixoni* Scudday.

Although the maps presented here are tentative, they should provide a reasonably accurate estimate of the range of each taxon. *C. t. stejnegeri* has not been included due to the questionable and problematical aspects of this taxon as compared to *C. t. multiscutatus*. The bibliography includes the most recently published revisions and the most current assignments of names. Many of the references give individual taxonomic descriptions and can be used in conjunction with the key and maps.

Due to great complexity within the genus, the following key will only identify specimens which are adult, alive or freshly killed, and for which collection sites are known:

TENTATIVE KEY TO THE WHIPTAILS OF THE UNITED STATES

1. Presence of only one frontoparietal plate...*C. hyperythrus beldingi*

   Presence of 2 frontoparietal plates..................................2

2. Pattern of narrow light stripes and/or spots (rarely bars) on a dark background; postantebrachials enlarged or slightly enlarged; mesoptychials abruptly larger than scales of gular fold..............3

   Pattern of stripes, spots, and/or bars on a light background; postantebrachials small; mesoptychials only slightly enlarged or granular.... 17

3. Stripes vague or broken; spots or bars present...................9

   Stripes distinct; absence of bars or spots.........................4

4. Scales bordering anteriorly of gular fold enlarged and angular....5

   Scales bordering anterior of gular fold neither enlarged or angular..8

5. Interlabial scales less than 6............................*C. velox*

   Interlabial scales more than 6.....................................6

6. Postantebrachial scales granular; 62-110 granules around midbody....7

   Postantebrachial scales enlarged and angular; 59-78 granules around midbody..*C. uniparens*

7. The dorsal surface of only 6 light stripes without a middorsal stripe absence of greenish suffusion...........*C. sexlineatus sexlineatus*

   The dorsal surface of 7 or 8 light stripes with a brownish middorsal stripe; presence of a greenish suffusion.....*C. sexlineatus viridis*

8. Dorsal ground color of bluish-gray; ventrals light blue... ....*C. inornatus arizonae*

   Dorsal ground color of grayish-black; ventrals dark blue... ....*C. inornatus heptagrammus*

9. Stripes persistent...10

   Stripes vague or absent or replaced by spots.....................15

10. Presence of distinctive single and narrow vertebral stripe; paravertebral stripe distinctive; dorsolateral and lateral stripes with faded or indistinct spots on the lateral region of body....*C. laredoensis*

    Not as described above..11

11. Chin of males (if present) white; ventrum light colored; 6 or 7 stripes...12

Chin of males pink or red; ventrum dark colored; 7 or 8 stripes ... .*C. gularis gularis*

12\. Dorsal granules 62-86; unisexually female..........................13

Dorsal granules 65-115; males and females present...............15

13\. Ventrals white and tinged with blue; 32 scales between paravertebral light stripes...*C. exsanguis*

Ventrals white and immaculate; 31 or 33 scales between paravertebral light stripes...14

14\. Scales between vertebral light lines are 3-6; stripes on neck region are chartreuse..................................*C. flagellicaudus*

Scales between vertebral light lines are 5-8; stripes on neck region are light yellow.......................................*C. sonorae*

15\. Absence of bars on older individuals; absence of rusty colored rump...16

Presence of bars on older individuals; presence of rusty colored rump..............................*C. scalaris septemvittatus*

16\. Granules between paravertebrals 5-11; dorsal granules 98-115... ....*C. burti stictogrammus*

Granules between paravertebrals 4-6; dorsal granules around 85... ....*C. burti xanthonotus*

17\. Scales anterior to gular fold slightly enlarged and grading gradually into small granules of the fold...................................18

Scales anterior to gular fold abruptly and conspicuously enlarged..27

18\. 83-100 granules around midbody; tail dark gray to light gray; stripes vague or absent..19

71-85 granules around midbody; tail bluish-green; stripes distinct... ....*C. neomexicanus*

19\. Presence of 4-6 light stripes...................................20

Presence of 8 stripes; or body unicolored........................22

20\. Thighs with rounded light spots.................................21

Thighs with reticulations...26

21\. Stripes tan colored; ventral areas are dark......*C. tigris gracilis*

Stripes yellow colored; ventral areas may be spotted... ....*C. tigris septentrionalis*

22\. Marbled pattern with slight indication of dorsal stripes; or unicolored body................................*C. tigris marmoratus*

Stripes persistent and as many as 8; a definite pattern present on body...23

23\. Chin entirely black............................*C. tigris aethiops*

Chin mottled, spotted or lacking the black coloration............24

24\. Ventrum predominately white but with black flecks... ....*C. tigris reticuloriens*

Ventrum with dark spotting and blotching.........................25

25. Posterior stripes vague; chin white with large black spots covering more than 5 scales..........................*C. tigris multiscutatus*

Lateral stripes vague; chin white with small black spots covering 5 or less scales..................................*C. tigris mundus*

26. Dorsum with rows of black spots..................*C. tigris tigris*

Dorsum with blotched pattern..................*C. tigris stejnegeri*

27. Dorsum with evidence of 4-8 lines.....................*C. tesselatus*

Dorsum with evidence of 10-14 lines.......................*C. dixoni*

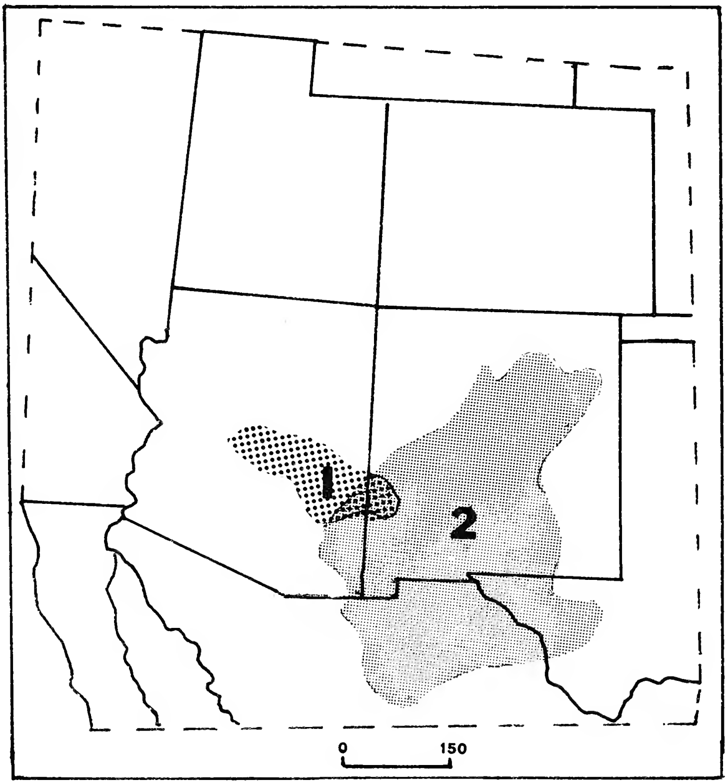

Fig. 1. Distribution of *Cnemidophorus flagellicaudus* (1), and *C. exsanguis (2).*

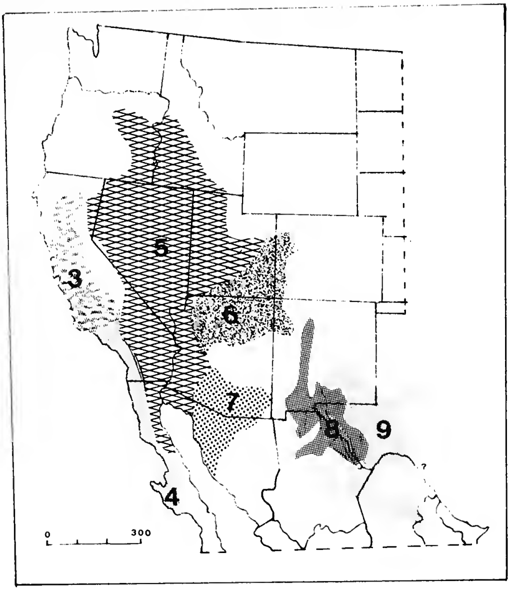

Fig. 2. Distribution of *Cnemidophorus tigris mundus* (3), *C. t. multiscutatus* (4), *C.t. tigris* (5), *C. t. septentrionalis* (6), *C. t. gracilis* (7), *C. t. marmoratus* (8), and *C. t. reticuloriens* (9).

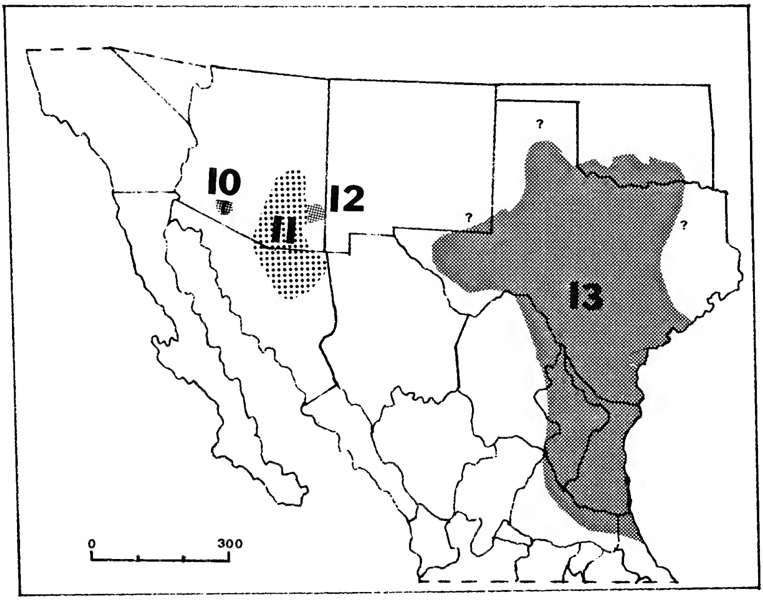

Fig. 3. Distribution of *Cnemidophorus burti xanthonotus* (10), *C. b. stictogrammus* (11), *C. inornatus arizonae* (12), and *C. gularis gularis* (13).

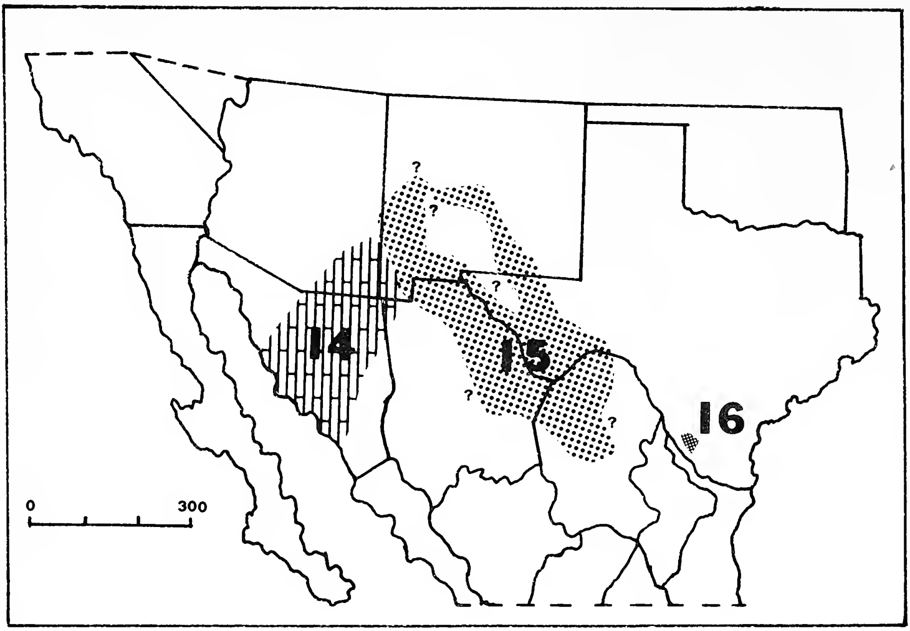

Fig. 4. Distribution of *Cnemidophorus tigris aethiops* (14), *C. inornatus heptagrammus* (15), and *C. laredoensis* (16).

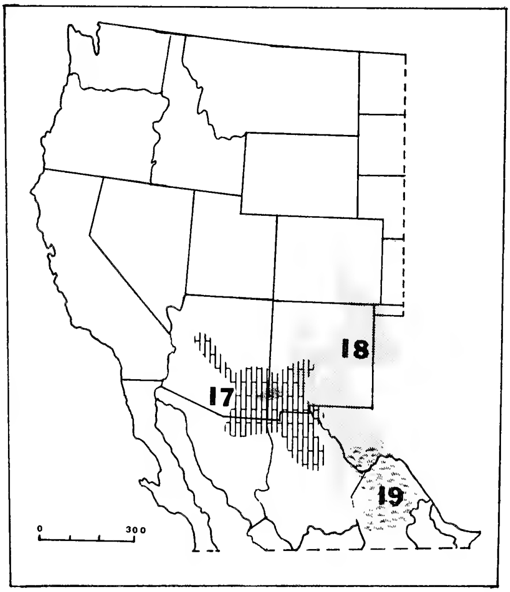

Fig. 5. Distribution of *Cnemidophorus uniparens* (17), *C. tesselatus* (18), and *C. scalaris septemvittatus* (19).

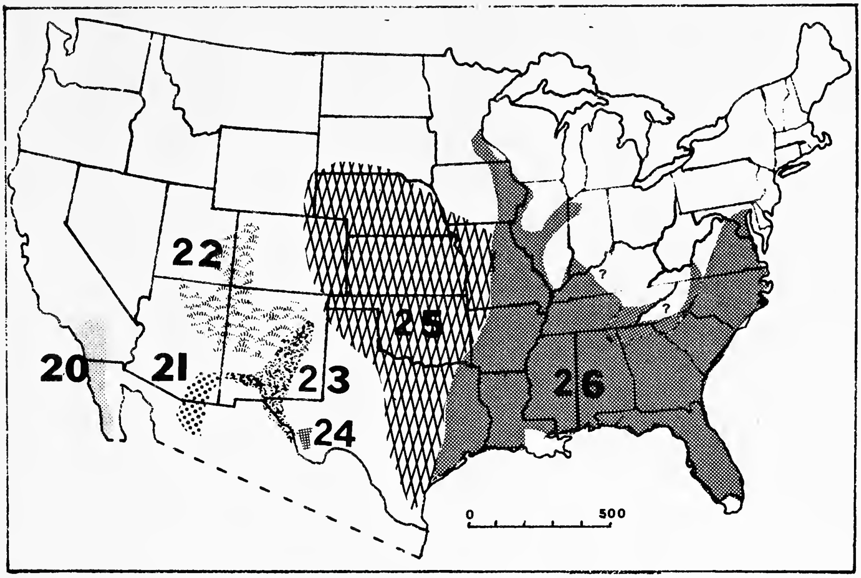

Fig. 6. Distribution of *Cnemidophorus hyperythrus beldingi* (20), *C. sonorae* (21), *C. velox* (22), *C. neomexicanus* (23), *C. dixoni* (24), *C. sexlineatus viridis* (25), and *C. s. sexlineatus* (26).

ACKNOWLEDGEMENTS

The author is grateful for the comments and criticisms of Dr. James Dixon, Dr. Fred Hendricks, and Ray Telfaire of Texas A&M University who reviewed an earlier draft of this manuscript. Wayne Siefert of the Dallas Museum of Natural History provided the author with facilities and helpful cooperation. Dr. Donald Ingold of East Texas State University graciously proofread the final version of this report.

Bibliography

Axtell, Ralph.
1961. *Cnemidophorus inornatus*, the valid name for the little striped whiptail lizard, with the description of an annectant subspecies. *Copeia 1961* 2:148-158.

Ballinger, Royce and Charles McKinney.
1968. Occurence of a patternless morph of *Cnemidophorus*. *Herpetologica 24*(3):264-265.

Burger, Leslie.
1950. New, revived, and reallocated names for North American whiptailed lizards, genus *Cnemidophorus*. *Chic. Acad. Sci., Nat. Hist. Misc. 65*:1-9.

Burt, Charles.
1931. A study of the teiid lizards of the genus *Cnemidophorus* with special reference to their phylogenetic relationships. *U.S. Nat. Mus. Bull.* 154:1-286.

Cochran, Doris and Coleman Goin.
1970. The new field book of reptiles and amphibians. *G. P. Putnams Sons, Inc., New York,* xxii + 359 pp.

Conant, Roger.
1975. A field guide to the reptiles and amphibians of eastern and central North America. *Houghton Mifflin Co., Boston,* xviii + 429 pp.

Duellman, William and Charles Lowe.
1953. A new lizard of the genus *Cnemidophorus* from Arizona. *Chic. Acad. Sci., Nat. Hist. Misc.* 120:1-8.

__________ and John Wellman.
1960. A systematic study of the lizards of the *deppii* group (genus; *Cnemidophorus). Misc. Pub. Mus. Zool. 11*:1-80.

__________ and Richard Zweifel.
1962. A synopsis of the lizards of the *sexlineatus* group (genus; *Cnemidophorus). Bull. Am. Mus. Nat. Hist. 123*(3):159-210.

Hendricks, Fred.
1975. Biogeography, natural history and systematics of *Cnemidophorus tigris* (sauria; teiidae) east of the continental divide. Ph. D. dissertation, Texas A&M University, 227 pp.

Lowe, Charles.
1955. A new species of whiptailed lizard (genus *Cnemidophorus*) from the Colorado Plateau of Arizona, New Mexico, Colorado, and Utah. *Breviora 47*:1-7.

__________.
1956. A new species and a new subspecies of whiptailed lizards (genus *Cnemidophorus*) from the inland southwest. *Bull. Chic. Acad. Sci. 10*:137-150.

__________ and John Wright.
1964. Species of the *Cnemidophorus exsanguis* subgroup of whiptail lizards. *J. Ariz. Acad. Sci. 3*:78-80.

__________, __________ and Kenneth Norris.
1966. Analysis of the herpetofauna of Baja California, Mexico. IV. The Baja California striped whiptail, *Cnemidophorus labialis,* with a key to the striped-unspotted whiptails of the southwest. *J. Ariz. Acad. Sci. 4*:121-127.

__________ and Richard Zweifel.
1952. A new species of whiptail lizard (genus *Cnemidophorus*) from New Mexico. *Bull. Chic. Acad. Sci. 9*(13):229-247.

McKinney, Charles, Fenton Kay and Robert Anderson.
1973. A new all-female species of the genus *Cnemidophorus. Herpetologica 29*(4):361-366.

Schmidt, Karl.
1953. A checklist of North American amphibians and reptiles. *Univ. Chic. Press, Chicago,* viii + 280 pp.

Scudday, James.
1973. A new species of lizard of the *Cnemidophorus tesselatus* group from Texas. *J. Herp. 7*(4):363-373.

Smith, Hobart.
1946. Handbook of lizards. *Comstock Pub. Co., Inc., Ithaca,* xxii + 557 pp.

——— and Leslie Burger.
1949. The identity of *Ameiva tesselata* Say. *Bull. Chic. Acad. Sci. 8*:277-284.

Stebbins, Richard.
1966. A field guide to western reptiles and amphibians. *Houghton Mifflin Co., Boston,* xvi + 279 pp.

Walker, J. Martin and Harry Taylor.
1968. Geographical variation in the teiid lazard *Cnemidophorus hyperythrus*. I. The *caeruleus*-like subspecies. *Am. Mid. Nat. 80*(1):1-27.

Wright, John.
1966. Variation in two sympatric whiptail lizards (*Cnemidophorus inornatus* and *C. velox*) in New Mexico. *Southwest. Nat. 11* (1):54-71.

———.
1971. *Cnemidophorus neomexicanus*. *Cat. Amer. Amphib. Rept.* :109. 1-109.3.

——— and Charles Lowe.
1965. The re-discovery of *Cnemidophorus arizonae* Van Denburgh. *J. Ariz. Acad. Sci. 3*:164-168.

Zweifel, Richard.
1956. The identity of *Cnemidophorus gadovii*. *Copeia 1956* 4:126-127.

———.
1958. Results of the Puritan-American Museum of Natural History Expedition to western Mexico. 2. Notes on reptiles and amphibian from the Pacific coastal islands of Baja California. *Am. Mus. Novitates* 1895:1-17.

———.
1962. Analysis and hybridization between two subspecies of the subspecies of the desert whiptail lizard, *Cnemidophorus tigris*. *Copeia 1962* 4:749-766.

———.
1965. Variation in and distribution of the unisexual lizard, *Cnemidophorus tesselatus*. *Am. Mus. Novitates* 2235:1-49.

—*Department of Biology, East Texas State University, Commerce, Texas 75428.*
Present address: *Department of Biology, Navardo College, Corsicana, Texas 75110.*

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THE ADAPTIVE SIGNIFICANCE OF EGG MORPHOLOGY IN TWO TURTLES (*CHRYSEMYS PICTA* AND *TERRAPENE CAROLINA*)

John K. Tucker, Richard S. Funk and Gary L. Paukstis

ABSTRACT

Parameters of eggs, hatchlings, and female parents were analyzed and compared to each other. The larger (n > 9) clutches of *Chrysemys picta* eggs were found to be significantly more variable in length than width. This appears to be true of smaller *C. picta* and *Terrapene carolina* clutches as well. Decreased variability in egg width appears to be due to selection for the widest egg that can be laid and selection against producing eggs that are too large to pass through the pelvic canal. Egg width in *C. picta* was found to be positively correlated with plastral length of the female parent. Egg width and egg weight in *T. carolina* were found to be positively correlated with female plastral length. Egg length, however, was not correlated with either female plastral length or any of the hatchling parameters measured. Egg width and egg weight are positively correlated with hatchling parameters showing that the heaviest and widest eggs at laying produce the heaviest and largest hatchlings. Correlations between measurements of eggs taken after 42 days of incubation and hatchling parameters are either not significant or are of reduced significance compared to measurements taken of the same eggs immediately at laying. This is apparently due to water absorption at varying rates.

INTRODUCTION

Much has been published on clutch size, reproductive potential and its variation, incubation periods, and other aspects of the reproductive biology of turtles (see summaries in Carr, 1952, and Ernst and Barbour, 1972). No studies, however, have considered the significance of the morphology of the egg in relation to the female parent and the hatchling. The present paper presents an analysis of the morphological variation of eggs and its possible adaptive significance in two turtles, *Terrapene carolina* and *Chrysemys picta*.

MATERIALS AND METHODS

The *C. picta* were collected at Lake Sara, Effingham Co., Illinois during May 1976 by dip net, hoop traps, and muddling. *C. picta* from Effingham Co., Illinois are classified as intergrades between *C. p. marginata* and *C. p. bellii* by Smith (1961). Eggs were removed from the oviducts shortly after the turtles were captured. Egg length and maximum egg width were measured with vernier calipers to the nearest 0.1 mm immediately after removal from the oviducts. Measurements of oviducal eggs that lacked well calcified shells are not included in this study. Plastron length was measured with a mm rule and rounded to the nearest 1.0 mm. Due to unfavorable conditions during incubation only two clutches hatched and some of the hatchlings were grossly abnormal. Consequently no data could be collected on hatchlings. Weights of the eggs could not be taken for the *C. picta.*

The *T. carolina* were collected in Gulf and Franklin Counties, Florida and are identifiable as *T. c. major* (Milstead, 1969). All were collected while crossing roads and were maintained alive for up to one week. Three turtles laid eggs in relatively dry sandy soil after they were returned to Illinois. All of the other eggs were dissected from oviducts. Eggs were measured with dial calipers immediately after being dissected out of the oviducts or after they were discovered in the case of those actually laid. Laid eggs were measured within 24 hr of laying as turtles were checked daily. Egg measurements were rounded to the nearest 0.1 mm. Eggs were weighed shortly after being found or removed from oviducts. Seventeen of the eggs were measured and weighed a second time after 42 days of incubation had passed. Hatchlings were weighed shortly after they were out of the egg. All weights were rounded to the nearest 0.1 gm. Each egg in a particular clutch was numbered so that it could be recognized at a later date. Eggs were incubated in air filled plastic bags with damp paper towelling as a substrate. After the first clutch hatched, eggs were placed in individual bags so that hatchlings could be identified with egg numbers after hatching. Eggs were incubated at 28±2°C except for a one week period when an air conditioning failure allowed temperatures to often exceed 32°C. Carapace width and carapace length were measured and analyzed for hatchlings. Some turtles (3) pipped the eggs and then died; these were also weighed and measured. Living hatchlings were allowed to retract the yolk sac and expand the shell after which they were preserved. Hatchling measurements were made with vernier calipers and are rounded to the nearest 0.1 mm. The specimens on which this report is based are preserved in the research collections of J. K. Tucker and R. S. Funk. Two previously reported clutches (Tucker and Funk, 1977) are included in this study. Locality and collecting data are included in the appendix.

The statistics used in this paper include an F test and linear regression by the least squares method (Simpson et al., 1960). The term significant refers to statistical significance at a 95% level or greater in a two tailed test of statistical significance.

RESULTS

Chrysemys picta. - The variance of egg length was compared to that of egg width for 29 clutches of eggs (Table 1). In 20 of 29 tests the variance in egg length was significantly greater than that of egg width. Among larger clutches (9 eggs or more) egg length variance was significantly greater than egg width variance in 10 of 11 tests. Regression analysis of egg parameters was performed for the total sample (N = 29 clutches) and for 12 clutches taken from females living in one area of the lake. Correlation coefficients and their levels of significance for the comparisons made for the total sample and for the restricted sample are in Tables 2 and 3. Regression lines that are associated with statistically correlation coefficients are also statistically different from 0 at the 95% level (Fig. 1).

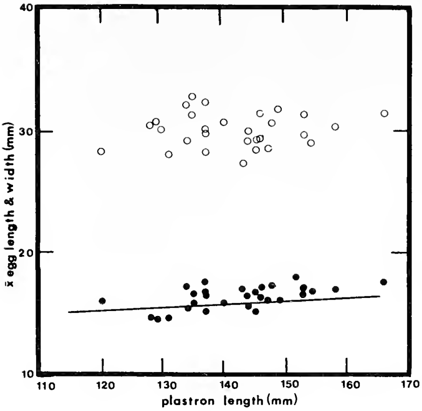


Figure 1. Relationship of female plastron length to mean egg length (open circles) and mean egg width (closed circles) in *Chrysemys picta*. Equation for line where Y = mean egg width and X = plastron length is $Y = 0.05X + 9.62$.

TABLE 1. Clutch size, F values and their significance, and average dimensions of 29 egg clutches of *Chrysemys picta* from Lake Sara. * Denotes turtles from the west end of the lake.

CLUTCH SIZE	F	P	MEAN EGG SIZE L X W (mm)		PLASTRON LENGTH (mm)
5	2.67	$p > 0.05$	30.6 X 14.6		129
5	2.38	$p > 0.05$	28.0 X 14.8		131
5	6.82	$p < 0.05$	28.4 X 16.0		120
5	2.50	$p > 0.05$	32.0 X 17.2		134
5	6.50	$p < 0.05$	30.4 X 14.8		128
6	1.49	$p > 0.05$	30.0 X 15.7		130
6	4.68	$p < 0.05$	31.1 X 17.0		135
7	26.86	$p < 0.05$	30.6 X 16.0		140
7	3.97	$p < 0.05$	32.4 X 16.7		137
7	3.28	$p > 0.05$	31.4 X 16.4		146
7	6.72	$p < 0.05$	32.6 X 16.6		135
7	6.00	$p < 0.05$	28.3 X 16.8	*	145
7	1.97	$p > 0.05$	29.7 X 17.6		137
7	11.50	$p < 0.05$	28.3 X 15.1		137
8	1.08	$p > 0.05$	30.0 X 16.6		137
8	1.46	$p > 0.05$	29.9 X 16.5	*	144
8	7.56	$p < 0.05$	28.4 X 16.1		147
8	11.36	$p < 0.05$	29.2 X 15.2		145
9	5.13	$p < 0.05$	29.4 X 17.2		146
9	7.83	$p < 0.05$	30.1 X 17.1	*	158
9	4.00	$p < 0.05$	27.2 X 17.1	*	143
10	3.63	$p < 0.05$	29.2 X 15.5	*	134
10	6.74	$p < 0.05$	30.6 X 17.4	*	148
11	6.56	$p < 0.05$	31.4 X 16.6	*	153
11	3.84	$p < 0.05$	31.7 X 16.2	*	149
12	3.32	$p < 0.05$	28.6 X 16.7	*	154
12	3.25	$p < 0.05$	31.3 X 17.7	*	166
12	5.28	$p < 0.05$	28.7 X 17.2	*	153
13	1.85	$p > 0.05$	29.1 X 15.7	*	144

TABLE 2. Correlation coefficients between egg parameters and female plastron length for 29 clutches of oviducal eggs of *Chrysemys picta.*

	CLUTCH SIZE	PLASTRON LENGTH	EGG WIDTH
EGG LENGTH	r = -0.09	r = 0.05	r = 0.22
EGG WIDTH	r = -0.30	r = 0.54*	
PLASTRON LENGTH	r = 0.78*		

*Denotes statistical significance.

TABLE 3. Correlation coefficients between egg parameters and female plastron length for 12 clutches of oviducal eggs of *Chrysemys picta* collected in the west end of Lake Sara.

	CLUTCH SIZE	PLASTRON LENGTH	EGG WIDTH
EGG LENGTH	r = 0.24	r = 0.45	r = 0.07
EGG WIDTH	r = - 0.10	r = 0.71*	
PLASTRON LENGTH	r = 0.22		

*Denotes statistical significance.

Terrapene carolina. - Since clutch size is relatively small in *T. carolina* as compared to *C. picta* no attempt was made to compare variances of egg widths and lengths within clutches. Regression analyses of egg parameters with those of the female parent and the hatchling were done. Female plastral length is positively correlated with mean egg weight and mean egg width but not mean egg length, mean hatchling weight, or clutch size (Table 4, Figs. 2-3). Egg weight is positively correlated with egg length and egg width (Table 5, Figs. 4-5). However, egg width is not correlated with egg length. The correlation coefficient for egg width on egg weight is significantly ($\underline{t}$ = 8.43, $p < 0.001$, 66 df) higher than that for egg length on egg weight. Correlation coefficients for comparisons involving egg parameters measured immediately after laying (or removal from oviducts) and hatchling measurements are in Table 6 and Figures 6-11. Egg width and egg weight are strongly correlated with each of the hatchling parameters. Egg length, however, showed no correlation with hatchling parameters. Hatchling parameters all showed strong correlations with each other (Table 8). Correlation coefficients for 17 eggs which were remeasured 42 days after starting incubation are very

TABLE 4. Correlation coefficients between plastron length and mean egg and hatchling parameters in *Terrapene carolina*.

$\overline{X}$ EGG WEIGHT	$\overline{X}$ EGG WIDTH	$\overline{X}$ EGG LENGTH	$\overline{X}$ CLUTCH SIZE	$\overline{X}$ WEIGHT HATCHLING
r = 0.60*	r = 0.60*	r = 0.14	r = 0.21	r = 0.31

*Denotes statistical significance.

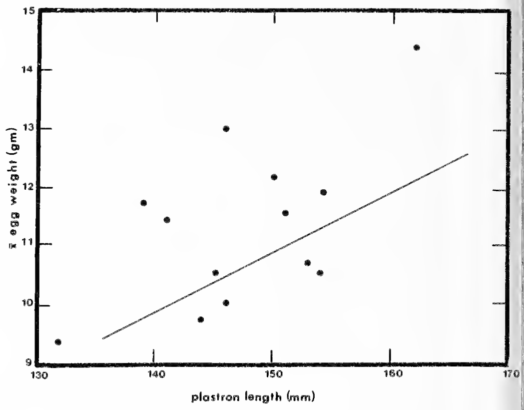


Figure 2. Relationship of female plastron length to mean egg weight in *Terrapene carolina*. Equation for line where Y = mean egg weight and X = plastron length is Y = 0.10X - 4.10.

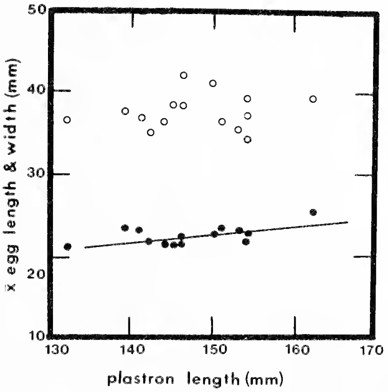


Figure 3. Relationship of female plastron length to mean egg length (open circles) and mean egg width (closed circles) in *Terrapene carolina*. Equation for line where Y = mean egg width and X = plastron length is Y = 0.09X + 9.02.

TABLE 5. Correlation coefficients between egg parameters measured in *Terrapene carolina*.

	EGG LENGTH	EGG WIDTH
EGG WEIGHT	r = 0.57*	r = 0.82*
EGG WIDTH	r = 0.10	

*Denotes statistical significance.

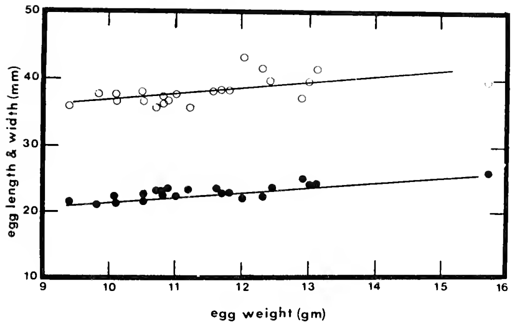


Figure 4. Relationship of egg weight to egg length (open circles) and egg width (closed circles) in *Terrapene carolina*. Equation for line (upper one) where Y = egg length and X = egg weight is $Y = 0.89X + 27.76$. Equation for lower line where Y = egg width and X = egg weight is $Y = 0.77X + 14.05$.

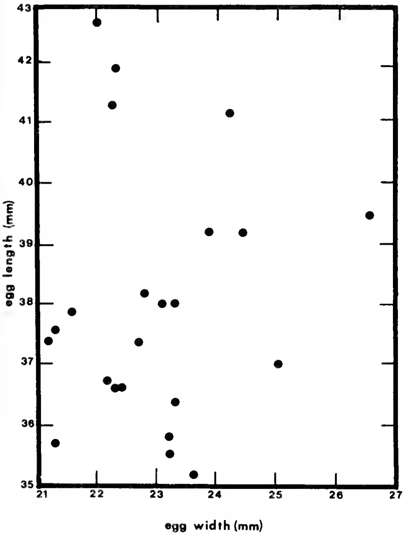


Figure 5. Scatter diagram of egg length and egg width in *Terrapene carolina*. Equation not given since correlation and regression coefficients are not significant.

TABLE 6. Correlation coefficients between egg parameters and hatchling parameters when measured shortly after laying or after removal from oviducts in *Terrapene carolina*.

	EGG WIDTH	EGG WEIGHT	EGG LENGTH
HATCHLING CARAPACE WIDTH	r = 0.55*	r = 0.68*	r = 0.35
HATCHLING CARAPACE LENGTH	r = 0.60*	r = 0.61*	r = 0.22
HATCHLING WEIGHT	r = 0.72*	r = 0.79*	r = 0.36

*Denotes statistical significance.

different from those made immediately after the eggs were removed from the oviducts (Table 7). Egg width is no longer correlated with any of the hatchling parameters (Figs. 6 - 8). Egg weight is correlated with hatchling carapace width and hatchling weight (Figs. 9-11) but not with hatchling carapace length. The correlation coefficients for egg weight on hatchling carapace width and hatchling weight are significantly lower than those for the first made measurements ($\underline{t} = 4.71$, $p < 0.001$, 38 df; $\underline{t} = 3.09$, $p < 0.001$, 38 df; respectively). Egg length is not correlated with any of the parameters. All regression lines for comparisons with statistically significant correlation coefficients are significant and do not contain 0 at the 95% level.

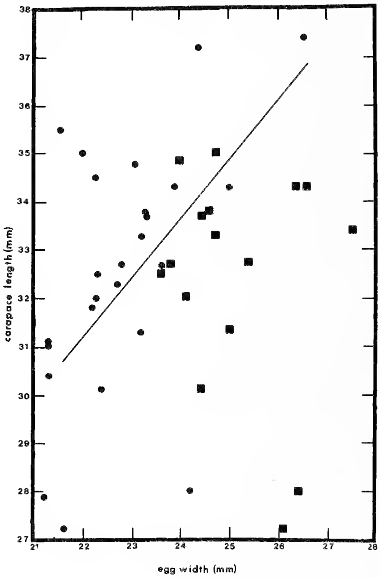


Figure 6. Relationship of egg width and hatchling carapace length at laying (circles) and 42 days post-laying (squares) in *Terrapene carolina*. Equation for line (at laying) where Y = hatchling carapace length and X = egg width is Y = 1.25X + 3.72.

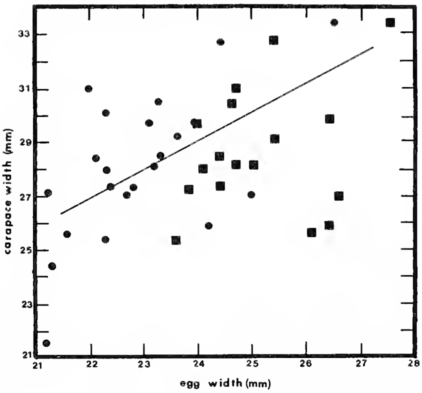
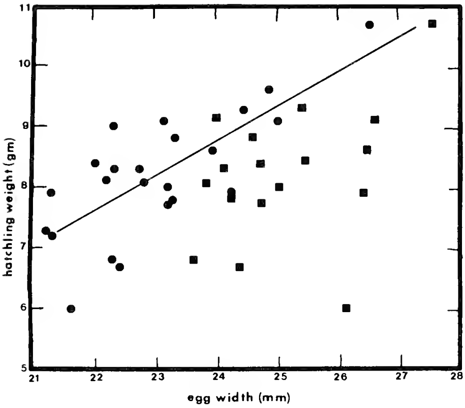


Figure 7. Relationship of egg width and hatchling carapace width at laying (circles) and 42 days post-laying (Squares) in *Terrapene carolina*. Equation for line (at laying) where Y = hatchling carapace width and X = egg width is Y = 1.20X + 0.60.

Figure 8. Relationship of egg width and hatchling weight at laying (circles) and 42 days post-laying (squares) in *Terrapene carolina*. Equation for line (at laying) where Y = hatchling weight and X = egg width is Y = 0.57X - 4.87.



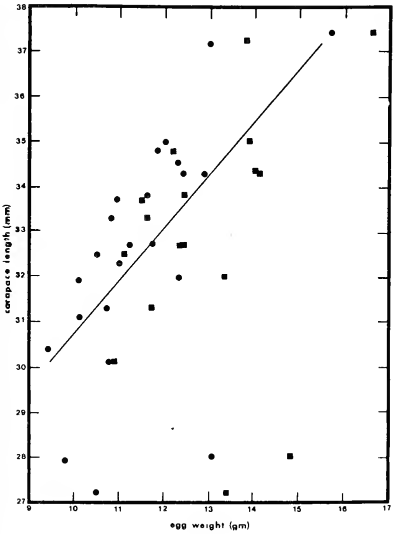
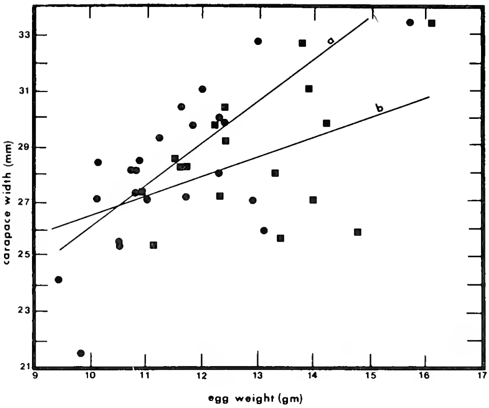


Figure 9. Relationship of egg weight and hatchling carapace length at laying (circles) and 42 days post-laying (squares) in *Terrapene carolina*. Equation for line (at laying) where Y = hatchling carapace length and X = egg weight is Y = 1.17X + 19.05.

Figure 10. Relationship of egg weight and hatchling carapace width at laying (circles) and 42 days post - laying (squares) in *Terrapene carolina*. Equation for line a (at laying) where Y = hatchling carapace width and X = egg weight is Y = 1.30X + 13.12. Equation for line b (42 days post-laying) where Y = hatchling carapace width and X = egg weight is Y = 0.70X + 19.55.



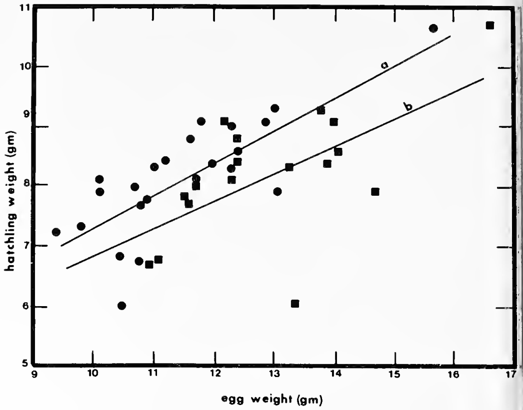


Figure 11. Relationship of egg weight and hatchling weight at laying (circles) and 42 days post-laying (squares) in *Terrapene Carolina*. Equation for line a (at laying) where Y = hatchling weight and X = egg weight is Y = 0.56X + 1.67. Equation for line b (42 days post-laying) where Y = hatchling weight and X = egg weight is Y = 0.45X + 2.34.

TABLE 7. Correlation coefficients between egg parameters and hatchling parameters when measured after 42 days of incubation in *Terrapene carolina*.

	EGG WIDTH	EGG WEIGHT	EGG LENGTH
HATCHLING CARAPACE WIDTH	r = 0.26	r = 0.46*	r = 0.04
HATCHLING CARAPACE LENGTH	r = 0.07	r = 0.28	r = 0.13
HATCHLING WEIGHT	r = 0.40	r = 0.62*	r = 0.28

*Denotes statistical significance.

TABLE 8. Correlation coefficients between hatchling parameters measured on *Terrapene carolina*.

	HATCHLING CARAPACE LENGTH	HATCHLING CARAPACE WIDTH
HATCHLING WEIGHT	r = 0.81*	r = 0.76*
HATCHLING CARAPACE WIDTH	r = 0.85*	

*Denotes statistical significance.

DISCUSSION

In *C. picta* the egg width is much less variable than the egg length within a given clutch. This was confirmed statistically for larger clutches and our raw data suggest that the same thing is true for smaller clutches of both *C. picta* and *T. carolina*. The exact cause or causes of this cannot be determined but one likely explanation that is consistent with our other results can be suggested. The size of the pelvic canal through which the eggs must pass could place a very important constraint on egg width at laying. It would be obviously maladaptive to produce eggs that are too large to pass through the pelvic canal. The positive correlation between egg width and plastron length in both *C. picta* and *T. carolina* apparently reflects this. The reduced amount of variation in egg width when compared to egg length may result from selection for maximal sized eggs which is limited on the upper extreme by selection against producing eggs that are too large to lay. This assumes that plastral length is an adequate though indirect measure of pelvic canal capacity. Maximizing egg width would also allow the largest sized follicles possible to be enclosed by the egg shell. Since the follicles are essentially spherical, the length of the egg would not be as critical as long as it surpassed the width of the egg.

Egg width is closely correlated with hatchling size in *T. carolina* and possibly in other turtles as well. Consequently, laying as wide an egg as is possible may offer a selective advantage because it allows larger hatchlings to be produced. Larger hatchlings might have an advantage over smaller ones in avoiding predators. Larger hatchlings may also be able to emerge from the nest more easily than smaller ones and would be able to store larger amounts of yolk upon hatching than smaller hatchlings. Larger hatchlings may also have an advantage in greater mobility and they may be able to subdue both larger and more kinds of prey items than smaller ones.

Gibbons and Tinkle (1969) found that *C. picta* lays fewer eggs, grow more slowly, and reach smaller sizes in areas where conditions are not as good as compared to areas where conditions are more favorable. Gibbons and Tinkle (1969) also found that clutch size and plastral length are not correlated with each other within a single area. If females from several areas are considered together, however, then clutch size is positively correlated with plastral length. In the *C. picta* we studied the total sample shows a positive correlation between clutch size and plastral length while turtles from only one area of the lake show no significant correlations between clutch size and plastral length. In the *T. carolina* we studied we found no correlation between clutch size and plastral length. These observations suggest that clutch size and plastral length are related to each other and to environmental conditions in a complex manner. The environmental conditions in a particular area appear to control the plastral length reached by females in that area (Gibbons and Tinkle, 1969). Follicle size which is correlated with plastral length is then maximized. If hatchling size were not important it would seem that turtles would lay larger numbers of smaller sized eggs thereby compensating for the reduction in size and energy availability in less favorable areas.

Plastron length while closely correlated with egg width and egg weight is not correlated with either clutch size or egg length. In *C.*

picta the total sample shows a positive correlation between clutch size and plastral length but this is an artifact identical to that reported by Gibbons and Tinkle (1969). If turtles from only one area of the lake are considered clutch size is not correlated with plastral length. Further notes on the reproductive potential of these two turtles will be presented in separate papers. In *T. carolina* clutch size is not correlated with plastral length. Iverson (1977) correlated clutch size and plastral length interspecifically based on data from Florida turtles. While the correlations he pointed out are valid in a general way, they are really of little value since 1) turtle reproductive potential is distinct from clutch size (see Moll, 1973) and 2) intraspecific variation is so great that to gather meaningful data individual populations must be studied and compared. Iverson (1977) also used an index to quantify egg size that was based on length and width of eggs and on maximum carapace length of the turtle species. Since we have shown that only width can be meaningfully compared to the parent, his index is probably useless and could possibly mask relationships if the lengths of other turtle eggs are as widely variable as they are in *C. picta* and *T. carolina*.

Turtle eggs have the ability to gain or loose water from the surrounding substrate (Cunningham and Hurwitz, 1936; Cunningham and Huene, 1938). This expansion in *T. carolina* occurs mostly in width rather than length. In the 17 fertile eggs that we measured twice few changed significantly in length but all eggs increased in width. This increase in width may not directly influence the size of the hatchling as is suggested by the lack of correlation of all 42 day egg parameters except weight with the hatchling parameters. We made no attempts, however, to control the water content of the incubation substrate. Since the eggs were incubated in bags which first contained entire clutches and then single eggs and since both the sizes of the clutches and no doubt the moisture content of the substrates varied allowing each bag to act as a separate system, any relationships between post-laying egg parameters and hatchling parameters could have been clouded by variation in the amount of water available to the eggs. More closely controlled systems could possibly yield different results. Packard *et al.* (1977) point out that it may be very difficult to adequately design systems to study water uptake by reptilian eggs. However, Cunningham and Huene (1938) suggested that little of the water absorbed by reptile eggs (including those of *C. picta* and *T. carolina*) is incorporated into the hatchling. Packard *et al.* (1977) found that in some cases water absorbed after eggs were laid was incorporated into hatchlings since newly hatched reptiles may weigh more than the freshly laid eggs from which they hatched. In all cases the *T. carolina* eggs we observed weighed more when freshly laid than did the hatchlings from those eggs. Apparently eggs must be measured and weighed immediately after being laid or removed from the oviducts to get measurements that will be comparable to those of the female and the hatchlings produce by the eggs. Although it is a small sample we were able to observe two eggs out of a clutch of three that were infertile when candled two weeks after laying. The measurements of infertile eggs (Table 9) did not increase to any great extent while those of the one fertile egg did. The lack of size increase in eggs without viable embroys suggests that swelling in *T. carolina* is not simply due to diffusion of water across the egg shell in a passive manner. It may indicate that some sort of active transport of water occurs. Other evidence for active transport of water into reptilian eggs is reviewed by Packard *et al.* (1977).

TABLE 9. Comparison of degree of change in egg parameters within a single clutch of *Terrapene carolina* eggs containing one fertile egg (*) and two infertile eggs.

EGG NUMBER	EGG LENGTH		EGG WIDTH		EGG WEIGHT	
	INITIAL	42 DAY	INITIAL	42 DAY	INITIAL	42 DAY
1*	37.9	38.1	21.6	26.1	10.5	13.4
2	39.2	39.4	21.3	21.3	10.7	10.5
3	38.9	40.0	21.0	21.0	10.5	10.5

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APPENDIX

Collecting data on female *T. c. major* studied in this report are as follows: 16 May 1977, 6.6 km SE of W end Fla. Hwy. 30, Gulf Co.; 16 May 1977, on Fla. Hwy. 71, 3.2 km NE jct. U.S. Hwy. 98 and Fla. Hwy. 71 in Port St. Joe, Gulf Co.; 17 May 1977, on Fla. Hwy. 30 2.4 km E Gulf Co. line, Franklin Co.; 17 May 1977, on Fla. Hwy. 71, 13.2 km NE Port St. Joe city limits; 12 June 1977, 3.4 km W of Gulf Co. line on Fla. Hwy. 30; 12 June 1977, 1.1 km E jct. Fla. Hwy. 385 and U.S. Hwy. 98 on Hwy. 98, Franklin Co.; 12 June 1977, 3.7 km E jct. Fla. Hwy. 385 and U. S. Hwy. 98 on Hwy. 98, Franklin Co.; 12 June 1977, 4.0 km W jct. Fla. Hwy. 30 and U.S. Hwy. 98 on Hwy. 30, Franklin Co.; 13 June 1977, 1.4 km W jct Fla. Hwy. 385 and U.S. Hwy. 98 on Hwy. 98, Franklin Co.; 8 June 1977, at jct Fla. Hwy. 385 and U.S. Hwy. 98, Franklin Co.; 12 June 1977, 1.3 km E. Franklin Co. line on Fla. Hwy. 30, Franklin Co.; 9 June 1977, at jct. U. S. Hwy. 98 and Fla. Hwy. 30, Franklin Co.; 10 June 1977, 0.2 km E Jct U.S. Hwy. 98 and Fla. Hwy. 385 on Hwy. 98, Franklin Co.; 11 June 1977, 4.3 km E jct. U.S. Hwy. 98 and Fla. Hwy. 30 on Hwy. 30, Gulf Co.; 11 June 1977, 0.3 km S jct. Coast Guard Station Rd. and Fla. Hwy. 30E, on Station Rd., Gulf Co.; 11 June 1977, 1.0 km N jct. Fla. Hwy. 385 and U. S. Hwy. 98, on Hwy. 385; Franklin Co.; 12 June 1977, at jct. U. S. Hwy. 98 and Fla. Hwy. 385 on Hwy. 98 Franklin Co.

Literature Cited

Carr, A. F.
1952. Handbook of turtles. *Comstock Publ. Co., Ithaca, New York,* 542 pp.

Cunningham, B. and E. Huene.
1938. Further studies on water absorption by reptile eggs. *Amer. Nat. 72*:380-385.

______________ and A. Hurwitz.
1936. Water absorption by reptile eggs. *Amer. Nat. 70*:590-595.

Ernst, C. W. and R. W. Barbour
1972. Turtles of the United States. *Univ. Press of Kentucky, Lexington,* 347 pp.

Gibbons, J. W. and D. W. Tinkle.
1969. Reproductive variation between turtle populations in a single geographic area. *Ecology 50*:340-341.

Iverson, J. B.
1977. Reproduction in freshwater and terrestrial turtles of north Florida. *Herpetologica 33*:205-212.

Milstead, W. W.
1969. Studies on the evolution of box turtles (genus *Terrapene*). *Bull. Florida State Mus. 14*:1-113.

Moll, E. O.
1973. Latitudinal and intersubspecific variation in reproduction of the painted turtle, *Chrysemys picta. Herpetologica 29*: 307-318.

Packard, G. C., C. R. Tracy, and J. J. Roth.
1977. The physiological ecology of reptilian eggs and embryos, and the evolution of viviparity within the Class Reptilia. *Biol. Rev. 52*:71-105.

Simpson, G. G., A. Roe, and R. C. Lewontin.
1960. Quantitative zoology, rev. ed. *Harcourt, Brace and World, Inc., New York,* 440 pp.

Smith, P. W.
1961. The amphibians and reptiles of Illinois. *Ill. Nat. Hist. Surv. Bull. 28*:1-298.

Tucker, J. K. and R. S. Funk.
1977. Eggs and hatchlings of the Gulf Coast box turtle, *Terrapene carolina major. Bull. Chi. Herp. Soc. 12*:53-57.

—105 E. Fayette, Effingham, Ill. 62401; Department of Biological Sciences Illinois State University, Normal, Ill. 61761.

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REPRODUCTIVE POTENTIAL OF THE GULF COAST BOX TURTLE
TERRAPENE CAROLINA MAJOR

John K. Tucker, Richard S. Funk and Gary L. Paukstis

ABSTRACT

The mean annual reproductive potential for *Terrapene carolina major* from Franklin and Gulf Counties, Florida was found to be 7.26 eggs/female/season utilizing a conservative estimate and 9.25 eggs/female/season utilizing a less conservative estimate. Examination of reproductive tracts suggests that *T. c. major* commonly lays more than one clutch per season and may lay lay up to 5 clutches within a single season. *T. c. major* appears to maximize the advantages of laying multiple clutches by laying small clutches of relatively large eggs. At least some aquatic emydids lay clutches that contain smaller, more numerous eggs than reported for *T. c. major*. Maximizing egg number laid per clutch at the expense of hatchling size and loss of the advantage of multiple nestings appears to explain this difference.

With the exception of comments on clutch size by Carr (1952) and on the eggs and hatchlings by Tucker and Funk (1976, 1977), nothing is known of the reproductive biology of *Terrapene carolina major*. For that matter very little is known of the reproductive biology of *T. carolina* as a whole except for notes on clutch size, egg size, and hatchling morphology. No studies similar to those on aquatic emydid turtles (see Gibbons, 1968; Gibbons and Tinkle, 1969; Christiansen and Moll, 1973; Moll, 1973 for example) have been done. Consequently, studies of *T. carolina* are of considerable interest since they allow comparisons of reproductive strategies of terrestrial and aquatic emydid turtles. The present paper reports data gathered on the reproductive potential of *T. c. major* from Gulf and Franklin Counties, Florida.

MATERIALS AND METHODS

Adult female box turtles were collected in May and June 1977 in Gulf and Franklin Counties, Florida. More detailed collecting data are in Tucker *et al.* (1978). Three individuals laid eggs after being returned to Illinois. Eggs were dissected from oviducts of the remaining females. All females were dissected. The ovaries were removed; corpora lutea were counted; enlarged follicles and preovulatory follicles were counted and measured. Nomenclature for follicles follows Moll (1973) with the following exceptions. Preovulatory follicles are those greater than 20 mm in diameter. Enlarged follicles are smaller than 20 mm but larger than 13 mm in diameter. The smallest ovulated follicle observed was 20 mm in diameter. Follicles were measured with dial calipers; measurements were rounded to the nearest 0.1 mm. Clutch size was estimated by egg counts, counts of corpora lutea, and counts of groupings of preovulatory and enlarged follicles. Since it appears that *T. c. major* usually lays more than one clutch per season, clutch size is not a measure of mean annual reproductive potential (*sensu* Christiansen and Moll, 1973; Moll, 1973). The number of clutches laid by each turtle was estimated in the same manner used by Moll (1973). In order of reliability these are multiple sets of corpora lutea and sets of preovulatory follicles. These were used to calculate a conservative estimate of annual reproductive potential. Since no information is available that pin points the end of the laying season in this turtle, it is doubtful that enlarged follicles measured in this study would have had time to reach ovulatory size and be laid in turtles collected in the last month of the laying season as it is now known. Consequently, we computed a less conservative estimate of annual reproductive potential by including data on sets of enlarged follicles. Multiple nestings by a single individual of *T. c. major* have not been observed but two sets of corpora lutea in a single turtle is good evidence for this (Moll, 1973). Annual reproductive potential is the total number of eggs produced by an average female per year (Christiansen and Moll, 1973).

RESULTS

Table 1 contains estimates of annual reproductive potential and number of clutches per year. Of 32 eggs observed 90.1% were fertile when laid as determined by candling the eggs within two weeks after the start of incubation. Of these fertile eggs 89.6% hatched.

Table 1. Estimates of annual reproductive potential and number of clutches produced by *Terrapene carolina major*. Upper estimate is conservative; lower one uses data from enlarged follicles.

$\bar{x}$ clutch size	N (♀♀ turtles)	No. clutches % ♀♀ producing 2	3	4	5	eggs/♀/yr
2.73	18	94	61	11	0	7.26
2.69	18	94	83	50	11	9.25

DISCUSSION

T. c. major, like many of the more widely studied aquatic emydid turtles, commonly lays more than one clutch of eggs per season. Some turtles laid at least three clutches and others would have laid four or five. The average annual reproductive potential of *T. c. major* in this area of Florida is 7.26 eggs/female/year. It is more likely that we have underestimated rather than overestimated the reproductive potential of *T. c. major*. This would be the case if corpora lutea for early clutches had had time to be obliterated before the turtles were collected. Altland (1951) and Moll and Legler (1971) found that corpora lutea of early clutches of *T. carolina* and *Pseudemys scripta*, respectively, may be obliterated before the end of the laying season. We also did not include enlarged follicles which may have represented clutches to be laid in this season assuming reproductive activity were to continue beyond the first week in June. If counts of these secondary follicles are included (Table 1) then the mean annual reproductive potential would be 9.25 eggs/female/season. The average annual reproductive potential of *T. c. major* probably lies between our conservative estimate and the estimate using enlarged follicles.

Iverson (1977) proposed a hypothesis that terrestrial turtles have differing reproductive strategies than do the aquatic turtles that he studied based on inferences about the reproductive potential of *T. carolina* and *Gopherus polyphemus*. Iverson (1977) suggested that these two species laid but one clutch per season. We doubt this for *T. carolina* in light of our findings. Iverson (1977) never stated whether he examined reproductive tracts or simply counted eggs in the small sample of *T. carolina* he studied. Legler (1958) who examined reproductive tracts of *T. carolina* from peninsular Florida and Mississippi found evidence of multiple clutches. As far as we can determine no published study reports data gathered on the reproductive tracts of *G. polyphemus* and Iverson (1977) did not examine any specimens of this species. Consequently, the reproductive potential of *G. polyphemus* is unknown. Considering that the reproductive activity of this species continues from April to mid-July (Ernst and Barbous, 1972) and thus parallels that of other turtles that are known to produce several clutches per season, it seems likely that study of the reproductive tracts of this species will disclose that it too lays multiple clutches. Iverson's (1977) hypothesis concerning low reproductive potential in terrestrial turtles is based on incomplete reproductive data and is therefore of questionable validity.

If our range of estimated annual reproductive potential is accurate, it is obvious that *T. c. major* has a lower reproductive potential than most of the other aquatic emydids which lay as many or more clutches per year and have larger average clutch sizes (see Iverson, 1977, for data on Floridean emydids and our Table 2). Although reproductive potential may be lower the adaptive strategy adopted by at least one terrestrial emydid may compensate for the reduced number of eggs layed. Terrestrial emydids are adapted for life on land while aquatic emydids are not. Thus when an aquatic emydid comes ashore for oviposition it is exposed to dangers that are not normally encountered, such as terrestrial predators, desiccation, overheating, and maintaining orientation. Consequently, it would be to the female's advantage to lay as many eggs as possible in as few trips as possible. Any tendency to lay large numbers of eggs at one time would be at least partially counterbalanced by the advantage of multiple nestings which may be to reduce the impact of nest predation on reproductive output for that particular season (Moll, 1973). Terrestrial emydids which spend their time on land anyway would not face similar unusual dangers and thus could deposit several smaller clutches of eggs to maximize the advantages of multiple nestings. Although *T. c. major* lays relatively small clutches, the eggs are relatively large compared to eggs of aquatic emydids. Even the larger emydids lay eggs that are either smaller than or about the same size as those of *T. c. major* and other *Terrapene* (Table 2). Tucker *et al.* (1978) have shown that egg size in at least *T. c. major* is strongly correlated with hatchling size. Larger hatchlings may be better able to survive than smaller ones for a number of reasons pointed out by Tucker *et al.* (1978). *T. c. major* while laying fewer eggs per clutch maximizes both the advantages of multiple clutches and the size of the hatchling which may compensate for differences between reproductive efforts between aquatic emydids and *T. c. major*. It seems to us that comparisons of reproductive strategies of more distantly related turtles would be premature until more data based on examination of reproductive tracts are available. Also the effects of latitude (see Moll, 1973) and environmental conditions (see Gibbons and Tinkle, 1969) on variation in reproductive potential within a species must be studied in many more species of turtles before any comprehensive understanding of the reproductive strategies of turtles can be achieved.

Table 2. Comparison of egg size, clutch size, and reproductive potential for some aquatic emydids and species of *Terrapene*.

SPECIES & (REFERENCE)	$\bar{x}$ EGG WIDTH (mm)	$\bar{x}$ EGG LENGTH (mm)	$\bar{x}$ EGG WEIGHT (gm)	$\bar{x}$ CLUTCH SIZE	EGGS/♀/YR	RANGE PLASTRON LENGTH MATURE ♀♀ (mm)
Terrapene carolina major (1)	21.3	37.8	11.2	2.69-2.73	7.26-9.25	132-162
Terrapene ornata ornata (2)	21.7	36.1	10.1	3.5-4.7	5.86*	107-139
Pseudemys scripta elegans-Ill. (3)	21.6	36.2	9.7	9.3	-	160-260
Chrysemys picta bellii-Wis. (4)	-	31.1	-	10.7	17.28	136-185
C. p. bellii X C. p. marginata-Ill. (4)	-	32.0	-	8.7	20.31	130-165
C. p. marginata X C. p. dorsalis-Tenn. (4)	-	31.8	-	4.8	14.74	108-151
C. p. dorsalis-La. (4)	-	30.0	-	4.1	12.92	100-131
C. p. marginata X C. p. bellii-Ill. (5)	16.4	30.4	-	8.1	-	120-166

*Calculated by us from Legler's (1960) data. References: 1, present paper; 2, Legler (1960); 3, Cagle (1944); 4, Moll (1973); 5, Tucker, unpublished).

ACKNOWLEDGMENTS

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Literature Cited

Altland, P. D.
1951. Observations on the structure of the reproductive organs of the box turtle. *J. Morph.* *89*:599-621.

Cagle, F. R.
1944. Sexual maturity of the female of the turtle *Pseudemys scripta elegans*. *Copeia 1944*:149-152.

Carr, A. F.
1952. Handbook of turtles. *Comstock Publ. Co., Ithaca, New York,* 542 pp.

Christiansen, J. L. and E. O. Moll.
1973. Latitudinal reproductive variation within a single subspecies of painted turtle, *Chrysemys picta bellii*. *Herpetologica 29*:152-163.

Ernst, C. H. and R. W. Barbour.
1972. Turtles of the United States. *Univ. Press Kentucky, Lexington,* 347 pp.

Gibbons, J. W.
1968. Reproductive potential, activity and cycles in the painted turtle, *Chrysemys picta*. *Ecology 49*:399-409.

__________ and D. W. Tinkle.
1969. Reproductive variation between turtle populations in a single geographic area. *Ecology 50*:341-342.

Iverson, J. B.
1977. Reproduction in freshwater and terrestrial turtles of north Florida. *Herpetologica 33*:205-212.

Legler, J. M.
1958. Extra-uterine migration of ova in turtles. *Herpetologica 14*: 49-52.

__________.
1960. Natural history of the ornate box turtle, *Terrapene ornata ornata* Agassiz. *Univ. Kansas Publ. Mus. Nat. Hist. 11*:527-669.

Moll, E. O.
1973. Latitudinal and intersubspecific variation in reproduction of the painted turtle, *Chrysemys picta*. *Herpetologica 29*: 307-318.

__________.
1971. The life history of a neotropical turtle, *Pseudemys scripta* (Schoepff) in Panama. *Bull. Los Angeles Co. Mus. Nat. Hist. Sci. 11*:1-102.

Tucker, J. K. and R. S. Funk.
1976. Twinning in the Gulf Coast box turtle, *Terrapene carolina major*. *Fla. Scientist 39*:238-239.

__________.
1977. Eggs and hatchlings of the Gulf Coast box turtle, *Terrapene carolina major*. *Bull. Chi. Herp. Soc. 12*:53-57.

__________ and G. L. Paukstis.
1978. The adaptive significance of egg morphology in two turtles (*Chrysemys picta* and *Terrapene carolina*). *Bull. Maryland Herp. Soc. 14*(1):-----

—105 E. Fayette, Effingham, Ill. 62401; Department of Biological Sciences, Illinois State University, Normal, Ill. 61761.

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PLANTS AS INDICATORS OF OCCURRENCE OF TWO SYMPATRIC *PLETHODON* SPECIES

Thomas K. Pauley

ABSTRACT

The percentage of occurrence of the two study salamanders, *Plethodon wehrlei* and *Plethodon cinereus*, was found to vary from east to west in the area studied. *P. wehrlei* was more abundant in the eastern 90 meters of the study area and its occurrence tended to correlate with an understory of red maple-sourwood and a ground cover of numerous shrubs rather than herbs. In contrast, *P. cinereus* was more abundant in the western area and its occurrence tended to correlate with an understory of sugar maple-beech and a ground cover of herbs rather than shrubs.

INTRODUCTION

Several investigators have studied the habitat of *Plethodon cinereus*. Heatwole (1962) compared two populations of *P. cinereus* occurring in different forest types, i.e., beech-maple forest and an oak-pine-aspen forest. He found that plant cover indirectly influenced the local distribution of *P. cinereus* by affecting the temperature and moisture content of the substrate. The literature is virtually devoid of any such studies on *P. wehrlei* or, more particulary, a comparison of microdistribution between two sympatric *Plethodon* species dissimilar in size.

The purpose of this present study was to assess the reliability of microdistribution of flora as *Plethodon* indicators.

DESCRIPTION OF THE STUDY AREA

This study was conducted two miles west of the Harrison - Doddridge County line in West Virginia. The elevation ranges from 274 meters to 366 meters. This area is well positioned within the overlapping ranges of *P. wehrlei* and *P. cinereus*.

The study area had five microreliefs: a bench near the bottom (Bench I), a slope with a 38° inclination (Slope I), a second bench (Bench II), a second slope with a 34° inclination (Slope II), and a third bench (Bench III) near the top of the study area. Hereafter, these microreliefs will be referred to as Bench I, Slope I, Bench II, Slope II, and Bench III respectively. Slope I encompassed the largest area and the biota showed the greatest diversity. Therefore, this slope was divided into an upper section, Slope I-A, and a lower section, Slope 1-B.

The total area studied (Fig. 1) was somewhat triangular in shape, approximately 137 meters at the bottom and 198 meters at the top. Horizontally, the eastern 122 meters to 145 meters faced northwest and the western 15 meters to 53 meters faced north. The eastern area was bordered by a right-of-way that lead to a hollow which was approximately 154 meters in width; because of these physical conditions, insolation and drying, due to wind, are greater in this area. The western edge was shaded by an adjacent hill; these two areas were separated by a steep, narrow ravine. The moisture content of the western section was greater than that of the eastern section due to this shade effect and by the fact that approximately 75 percent of the area drained toward the west. The remaining 25 percent of the area drained north or downhill. Near the bottom of Slope I-B was a small cliff that gradually leveled off into Bench I. As a result of this abrupt drop, water drainage was greater here. Because the first three meters of elevation were grassland, it was not included in this study.

The western substratum was soil with rocks evenly distributed. The substratum of the eastern area was mainly sandstone rocks, thus rendering a rockier soil.

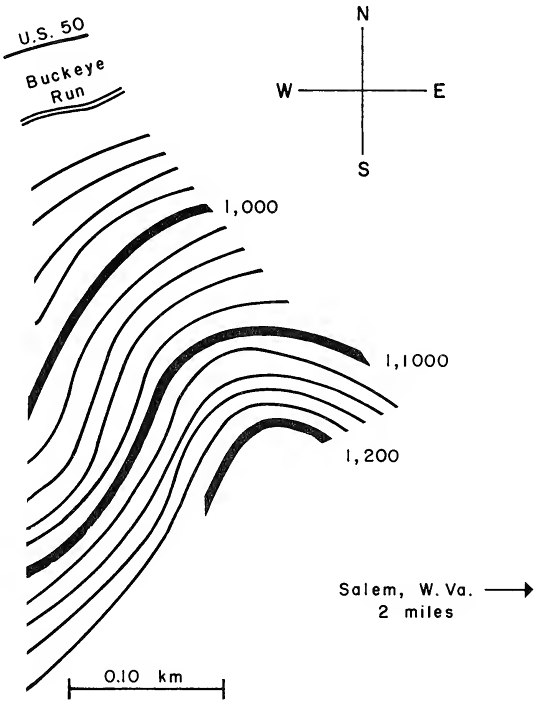

Fig. 1. An outline of the study area showing 20-foot contour lines. Enlargement from U. S. Geological Survey topographic map, Smithburg quadrangle.

METHODS AND MATERIALS

The composition of the floral community was divided into four strata, according to the classification systems of Dumas (1956), i.e., trees, shrubs, herbs, and mosses. For shrubs, herbs, and mosses, transects 6 meters long and 1.5 meters wide were arranged horizontally every 30 meters and vertically every 15 meters. These transects assured a survey of the vegetation for each microrelief in this study. Trees were identified and counted by the true census method in horizontal transects at 15-meter intervals. The floral study was made from the first of May to the end of July, and required 360 manhours.

Salamanders were collected by turning every rock and log in belt transects 2 meters wide. Collections were made from 1971 to 1976 during all hours of the diel cycle and in all weather conditions (both rainy and sunny days) during the months *P. wehrlei* and *P. cinereus* are known to be active, i.e., March, April, May, June, September, and October. In order to keep bias to a minimum, all collecting was done by experienced collectors. This extensive method of collecting involved 972 manhours or 27 manhours for each month the salamanders were active.

RESULTS

In the study of plants, only the leading dominants were computed. The flora percentage of distribution showed a transition from east to west. In the upper three microreliefs, the characteristic understory growth changed from a sourwood (*Oxydendrum arboreum*)-red maple (*Acer rubrum*) growth in the east to a sugar maple (*Acer saccharum*)-beech (*Fagus grandifolia*) growth in the west (nomenclature for all plants according to Strausbaugh & Core, 1952). The tree cover for the entire area was predominately chestnut oak (*Quercus montana*).

Shrubs, except dockmackie (*Viburnum acerifolium*), were more abundant in the eastern 90 to 120 meters. Dockmackie was more abundant in the western 60 meters, where the only other shrub to occur was the common greenbrier (*Smilax rotundifolia*).

The herbaceous plants, except *Solidago* spp., which was concentrated in the most eastern transect adjacent to a right-of-way, showed a higher percentage of distribution in the western 90 meters, replacing the shrub growth. The moss cover (*Dicranum scoparium* and *Leucobryum glaucum*) was abundant in the eastern 30 meters but disappeared 120 meters west.

A greater percentage of *Plethodon wehrlei* was found in the eastern 90 meters of the upper three microreliefs (Bench III, Slope II, and Bench II) than *Plethodon cinereus*, which was more abundant on the western 90 meters (Table 1). On Slope I, *P. wehrlei* occurred more frequently on the eastern 140 meters and *P. cinereus* occurred more frequently on the western 40 meters. On Bench I, distribution was somewhat even for the first 90 meters, with only *P. cinereus* being found in the western 60 meters. In the remainder of this paper, the eastern area will be referred to as the *P. wehrlei* type habitat and the western area as the *P. cinereus* type habitat.

These percentage distribution results show *P. wehrlei* to be more abundant in the area facing northwest and *P. cinereus* to be more abundant in the area facing north (Fig. 2).

Slope I-A had a longer horizontal distribution of *P. wehrlei* than the former three microreliefs. As above, the distribution corresponded with the understory tree growth of red maple and sourwood. Only in the western 30 meters did sugar maple and beech prevail. The shrubs dominated for the first 120 meters after which herbs were prevalent. Also, for

Table 1. Percentage distribution of *Plethodon wehrlei* and *Plethodon cinereus*. Each set of parallel lines represents the greater and lesser population concentration for the respective species of salamanders.

				------EAST		WEST------		
		0 meters	30 meters	60 meters	90 meters	120 meters	150 meters	180 meters
Bench III	Plethodon wehrlei		87.5%				26.4%	
	Plethodon cinereus		12.5%				73.5%	
Slope II	Plethodon wehrlei			100.0%			21.4%	
	Plethodon cinereus			0.0%			78.5%	
Bench II	Plethodon wehrlei		84.6%				8.6%	
	Plethodon cinereus		15.4%				91.3%	
Slope I*	Plethodon wehrlei			77.5%				0.0%
	Plethodon cinereus			22.4%				100.0%
Bench I	Plethodon wehrlei		45.8%			0.0%		
	Plethodon cinereus		54.1%			100.0%		

*The first 130 meters represents Slope I-A and the last 50 meters, Slope I-B.

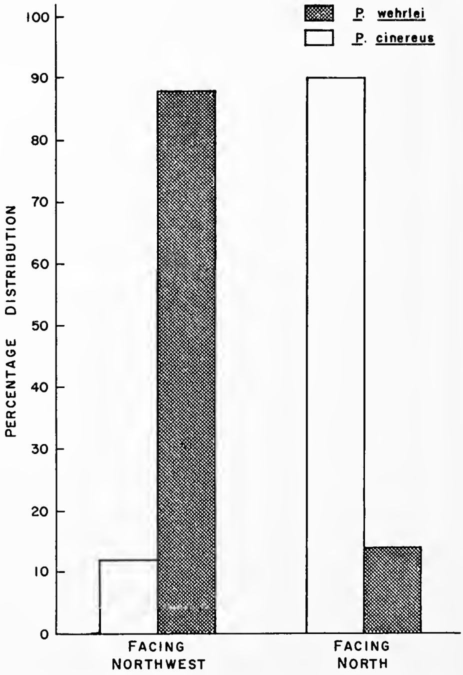

Fig. 2. Percentage distribution for the two species of *Plethodon* in reference to slope direction.

the first 120 meters the ground was moss-covered, the substratum was mostly sandstone rocks, and the pH was fairly constant (Table 2). These characteristics created a condition very similar to the eastern part of the first three microreliefs.

The eastern 94 meters of Slope I-B were very steep and neither the dominant plant types nor the study plethodontids were found. The last 40 meters of Slope I-B were considerably less steep, but there was a great amount of drainage and therefore it was very moist. Herbs were the most abundant plant growth. Understory tree growth in this section was exclusively sugar maple and beech. The leading dominant shrubs in the upper microreliefs were absent, as were mosses.

On the first 90 meters of the last microrelief (Bench I), the leading plant dominants changed from those found in the upper microreliefs. The tree cover was white oak (*Quercus alba*) and shagbark hickory (*Carya ovata*) with red maple as the understory tree. Shrubs were common greenbrier, dockmackie, and blackberry (*Rubus* spp.). The leading dominant herbs were a mixture of grasses. No mosses were found. As in the upper microreliefs, the western 30 meters were devoid of most shrubs but abounded with herbs. On Bench I and the western part of Slope I-B, the substratum was the same as was found in the upper western areas. The two study plethodontids were evenly distributed for the first 90 meters, from east to west, while *P. cinereus* was the only species found in the last 30 meters.

	Soil Sample Area						
Microrelief	30	60	90	120	150	180	210
Bench III	4.6	4.3	4.6	5.0	4.5	6.1	5.8
Slope II	4.9	4.6	4.3	4.6	5.5	6.1	6.2
Bench II	4.2	4.2	4.8	5.0	4.8	5.3	6.2
Slope I-A	4.6	4.2	4.2	4.6	4.7	5.2	-
Slope I-B	5.0	4.6	4.5	4.4	4.8	-	-
Bench I	5.4	5.5	4.5	5.0	-	-	-

Table 2. The pH average for each microrelief. Four soil samples were taken every 30 meters and the average computed for each sample.

DISCUSSION

The direction a mountain slope faces is a major controlling factor in the variety and abundance of living organisms. South and west facing slopes receive a greater amount of solar energy than do the north and east facing slopes. The amount of insolation on a slope inversely controls the moisture content and the heat budget. Thus, high temperature and low vapor pressure increase the evaporation and transpiration of moisture from the soil (Smith, 1966).

The vegetation pattern in this study area suggested a north-south slope pattern. Smith (1966) states that the dominant tree growth of the lower north slopes of the Cumberland Plateau is beech, sugar maple, and yellow poplar, and the characteristic understory is the umbrella tree and redbud. The forest of the upper south slope is predominantly chestnut oak, pitch pine, and shortleaf pine, whereas the characteristic understory tree is sourwood. He further states that red maple is an irregular understory tree of the north slope but is abundant on the south. Smith found blueberry, huckleberry, and laurel were the indigenous shrubs of the south slope with maple-leaf vibernum found mostly on the north slope. Greenbrier is shown to be distributed on both slopes.

The north-south vegetation pattern of the Cumberland Plateau is somewhat similar to the east-west pattern of vegetation found in the upper four microreliefs on the study area under investigation; i.e., the eastern section resembled a south slope and the western section resembled a north slope.

The dominants for the four vegetation strata, i.e., trees, understory, shrubs, and herbs for the eastern part of the present study area were characteristically more xeric than the western area. The moss, *Leucobryum glaucum*, inhabits dry areas (Bordenberg, 1954), and was the predominant ground cover in this xeric *P. wehrlei* type habitat. The western damper area lacked this moss and the ground cover was composed of the more succulent herbaceous plants.

Ectopoikilothermic animals such as salamanders have a critical relationship with their environment, thus affecting their microdistribution or the partitioning of habitats. For the two study species, *P. wehrlei* was more abundant in the more xeric eastern area whereas *P. cinereus* was more abundant in the more mesic western area. Throughout the study area where moist microreliefs were located, such as at the base of deep slopes, tree throws, and seepages, *P. cinereus* was more dominant.

The occurrence of sugar maple-beech as the understory, the abundance of herbaceous plants and the absence of shrubs tended to correlate with the high populations of *P. cinereus*. In contrast, the occurrence of sourwood-red maple as the understory, the prevalence of shrubs rather than herbaceous plants, tended to correlate with the high population of *P. wehrlei*.

Literature Cited

Bordenberg, E. T.
1954. Mosses, a new approach to the identification of common species. *Burgess Publishing Company, Minneapolis*, p. 47.

Dumas, P. C.
1956. The ecological relations of sympatry in *Plethodon dunni* and *Plethodon vehiculum*. *Ecology 37*:484-495.

Heatwole, H.
1962. Environmental factors influencing local distribution and activity of the salamander, *Plethodon cinereus*. *Ecology 43*: 360-472.

Smith, R.
1966. Ecology and field biology. *Harper & Row, New York,* p. 686.

Strausbaugh, P. D. and Earl L. Core.
1952. Flora of West Virginia. *West Virginia University Bulletin,* Volumes 1-4.

Department of Natural Science, Salem College, Salem, West Virginia 26426.

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REPRODUCTIVE DATA ON *Lampropeltis triangulum temporalis* FROM MARYLAND

Reproductive data on the established eastern subspecies of *Lampropeltis triangulum (L. t. triangulum, L. t. elapsoides)* have appeared several times in the literature. Summaries have been published for *L. t. triangulum* by Wright and Wright (1957) and Williams (1970) (see also Minton, 1972; Dyrkacz, 1977). Information on *L. t. elapsoides* has appeared less frequently, and was also summarized by Williams (1970), but see also Duellman and Schwartz (1958), Groves and Sachs (1973), and Groves and Assetto (1976). No such data are known, however, for the problematical subspecies *L. t. temporalis*. While some authorities (e.g. Conant, 1975; Williams, 1970) regard the central-Atlantic seaboard populations of milk snakes as intergrades, *L. t. triangulum* X *elapsoides*, most Maryland workers (e.g. McCauley, 1941, 1945; Harris, 1975) believe *L. t. temporalis* to be valid. Nomenclatural considerations aside, reproductive data is presented for the first time on this perplexing and continually debated form.

On 13 May 1973, one of us (G. G.), while working a slab pile in a wooded tract 4.5 miles (7.2 km) SE Leonardtown, St. Mary's County, Maryland, uncovered a pair of coastal plain milk snakes, *Lampropeltis triangulum temporalis*. It was not known for certain at the time of collection whether copulation was taking place, for in the process of discovery the snakes tumbled to the ground and were not noted to be joined. Copulation was, however, witnessed on 14 May at approximately 7:00 am (EDT) while the snakes were being temporarily kept in a collecting bag. Further copulation was not noted after the pair was transferred to a cage later the same day, although once so placed the male almost immediately grasped the nape of the female's neck in his jaws. Courtship behavior, however, was not seen to progress past this point.

Commencing at about 7:30 pm (EDT) on 16 June (1973), the female (total length ca. 23 inches [585 mm]) laid five elliptically-shaped eggs. If fertilization occurred during the 14 May observation, a developmental period (copulation to oviposition) of 33 days resulted. The eggs were deposited at roughly 25-minute intervals and had lengths ranging from 1.4 - 1.6 inches (35 - 41 mm). They were then incubated in a plastic bowl filled with sawdust, and periodically moistened with water and sprayed with a fungicide to discourage the growth of mold.

The first snake hatched on 7 August; three more emerged on 8 August, and the fifth on 9 August. The hatchlings' total lengths ranged from 7.50-7.75 inches (191-197 mm). Their sizes were intermediate between newborn *L. t. triangulum* and *L. t. elapsoides*, according to the summary of Wright and Wright (1957) for *triangulum*, and data provided by Dyrkacz (1977) for Illinois *triangulum*, Palmer (1961) for North Carolina *doliata* (=*elapsoides*), and Groves and Sachs (1973) for Florida *elapsoides*. Clutch size was much closer, however, to the mean for *L. t. elapsoides*. Natal sheds were cast on 15 August (hatchling of 7 August), 16 August (8 August -- two), 17 August (9 August), and 18 August (8 August). The incubation period (oviposition to hatching) thus ranged from 52 - 54 days, and the "gestation" period (copulation to hatching -- again assuming that fertilization occurred on 14 May) 85-87 days.

The juveniles fed only on lizards (*Eumeces fasciatus, Scinella lateralis*), and refused consistent offerings of newborn mice. Two of the five young succumbed in captivity (one consumed another resulting in the deaths of both); the other three were released at the capture site. The adult female and male are catalogued AR-1933-TSU and AR-1934-TSU, respectively, in the vertebrate collection of Towson State University, Towson, Maryland.

We would like to thank Don C. Forester and Arnold W. Norden for reading the manuscript and offering suggestions.

Literature Cited

Conant, Roger.
1975. A field guide to reptiles and amphibians of eastern and central North America. 2nd ed. *Houghton Mifflin Co., Boston,* xviii + 429 pp.

Duellman, William E. and Albert Schwartz.
1958. Amphibians and reptiles of southern Florida. *Bull. Florida State Mus. Biol. Sci. 3*(5):181-324.

Dyrkacz, Stanley.
1977. The natural history of the eastern milksnake (Reptilia, Serpentes, Colubridae) in a disturbed environment. *J. Herp. 11* (2):155-159.

Groves, John D. and Robert J. Assetto.
1976. *Lampropeltis triangulum elapsoides. Herp. Rev. 7*(3):114.

_______________ and Peter S. Sachs.
1973. Eggs and young of the scarlet king snake, *Lampropeltis triangulum elapsoides. J. Herp. 7*(4):389-390.

Harris, Herbert S., Jr.
1975. Distributional survey (Amphibia/Reptilia): Maryland and the District of Columbia. *Bull. Maryland Herp. Soc. 11*(3):73-167.

McCauley, Robert H., Jr.
1941. A redescription of *Lampropeltis triangulum temporalis* (Cope). *Copeia 1941*(3):146-150.

_______________.
1945. The reptiles of Maryland and the District of Columbia. *Published by the author, Hagerstown,* vi + 194 pp., 46 figs., 48 pls.

Minton, Sherman A., Jr.
1972. Amphibians and reptiles of Indiana. *Indiana Acad. Sci.* Monograph No. 3, v + 346 pp.

Palmer, W. M.
1961. Notes on eggs and young of the scarlet kingsnake, *Lampropeltis doliata doliata. Herpetologica 17*(1):65.

Williams, Kenneth L.
1970. Systematics of the colubrid snake *Lampropeltis triangulum* Lacepede. *Xerox University Microfilms, Ann Arbor*, xiii + 371 pp.

Wright, Albert Hazen and Anna Allen Wright.
1957. Handbook of snakes of the United States and Canada. Vol. 1. *Cornell University Press, Ithaca*, xviii + 564 pp.

—Robert Miller, *Department of Herpetology, Natural History Society of Maryland, 2643 North Charles Street, Baltimore, Maryland 21218* and George Grall, *6142 Parkway Drive, Baltimore, Maryland 21212.*

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A NEW RECORD OF *Xantusia vigilis extorris* FROM DURANGO, MEXICO

Two specimens of *Xantusia v. extorris* were collected by Claude Grenot on 30 October 1976, 30 km NE of Ceballos, Durango, in the Cerro San Ignacio, 1300 m (latitude 26 40' N, longitude 103 45' W). This locality extends the range of the subspecies approximately 150 km NNW from the nearest known localities (fig. 1). One specimen (NMSU 4905) is deposited in the Amphibian and Reptile Collection at New Mexico State University, Las Cruces, and the other (MHNP 1977-57) is in the Museum National d'Histoire Naturelle, Paris (fig. 2).

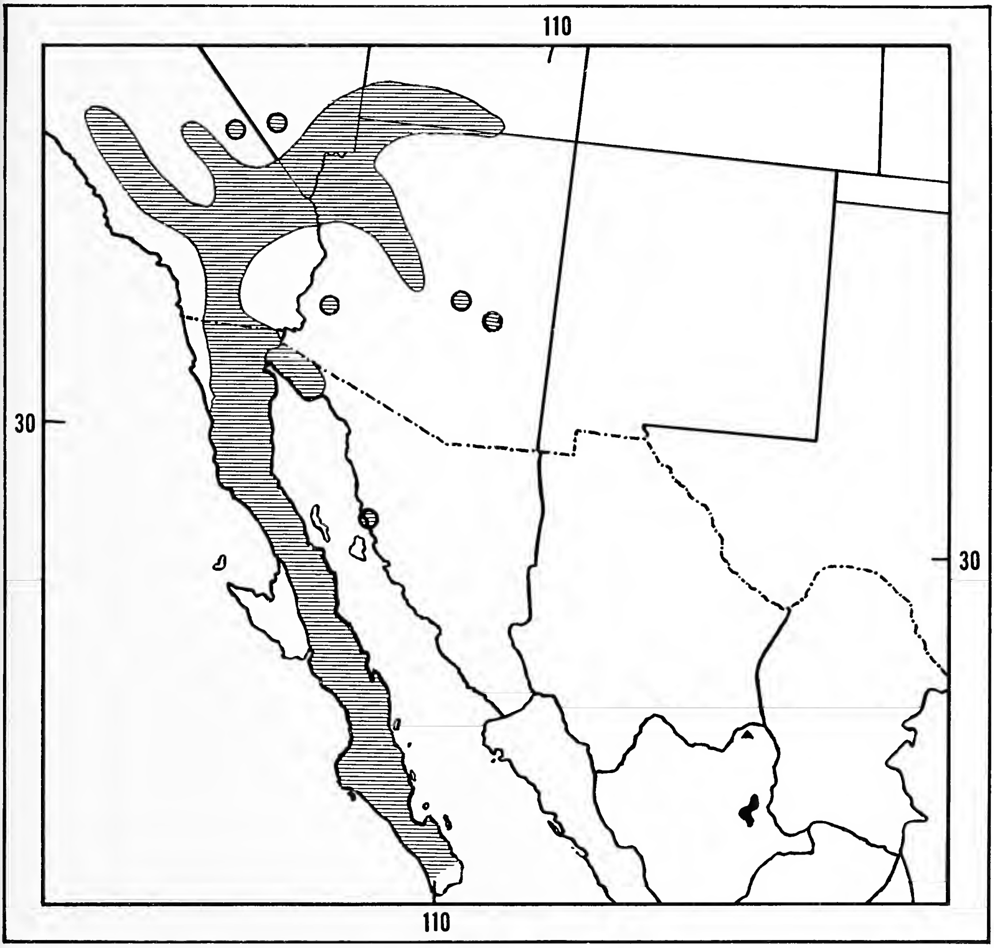

Fig. 1. Map of southwestern United States and northwestern Mexico showing the known range of *Xantusia vigilis extorris* (solid black) and distribution of other members of the genus *Xantusia* (adapted from Webb, 1965). The solid black triangle represents the record reported here.

Fig. 2. *Xantusia v. extorris* from Durango, Mexico. NMSU 4905 (top) and MHNP 1977-57 (bottom). (photo by Jack DeAngelis)

NMSU 4905 is a male and MHNP 1977-57 a female, based on internal examination. All characteristics of the two specimens fall within the ranges described by Webb (1965) except as follows:

Measurements (preserved): the male measures 43 mm snout-vent length and the female 47.7 mm; tail length is 52 mm (regenerated part 11 mm) and 46 mm respectively; head length from tip of snout to anterior margin of ear opening is 8.2 mm and 8.6 mm; length of large-scaled part of the head is 9.6 mm and 9.9 mm; diameter of the eye is 2 mm for both specimens and the length of the leg is 16.5 mm for the female. The tail length/body length ratio for the male is 1.2 and 0.96 for the female.

Squamation: the nasals, prefrontals, frontals and post-parietals are all separate from each other in both specimens; the anterior loreal touches the 2nd and 3rd supralabials below and the posterior loreal touches the 2nd, 3rd and 4th supralabials below in the male, whereas in the female the anterior loreal touches the 1st, 2nd and 3rd supralabials below and the posterior loreal touches the 3rd supralabial only on the right side and the 3rd and 4th supralabials on the left side; the lower loreolabial touches the 4th supralabial only in both specimens, in the female only on the left side; there are 6 auricular scales in both specimens; there are 9 enlarged gular scales in the male and 10 in the female.

Coloration and Pattern: there is a distinct lateral white stripe the length of the body in both specimens; it involves dorsal scale rows 4-6 on the right side of the male and 3-5 of the female.

Gonadal Aspects: Hudson (1973) and Miller (1948) report that parturition takes place from mid-September to early October in California populations of *Xantusia v. vigilis*. Female gonads are then relatively inactive throughout the winter and fat bodies are reduced to their smallest size in late summer and early fall, when they may be absent or so small as to be unrecognizable as such. Male testicular recrudescence begins in early August, there is considerable spermatogonial activity in September which slows somewhat in October, maintaining a relatively constant level until March when there is an increase in activity which lasts throughout April and May to reach a maximum just before copulation in late May-early June. The left testis of NMSU 4905 measures 5.1 mm X 2.3 mm, equivalent to the maximum values reported by Hudson (1973) and Miller (1948), and the ovaries of MHNP 1977-57 are completely regressed although the fat bodies are quite extensive, indicating possible differences in the timing of the reproductive cycles between the Durango and California populations of *Xantusia vigilis*.

The vegetation of the Bolsón de Mapimi is a matorral dominated by creosote bush, *Larrea diviricata* (Martinez and Morello, 1977). This matorral appears as a mosaic due to marked changes in soil conditions over very short distances. The principal vegetation in the foothills includes *Agave asperrima*; in the plains *Opuntia rastrera* occurs principally on bajadas whereas *Hilaria mutica* and *Suaeda nigrescens* occur in playas (fig. 3).

Fig. 3. General view of Cerro San Ignacio showing flatplain (playa) in foreground with *Hilaria mutica* and *Suaeda nigrescens*. (photo by C. Grenot)

Xantusia v. extorris has been found in the north front of Cerro San Ignacio; it occurs in cracks and crevices of igneous outcrops (andesite and rhyolite) where a reviviscent plant association (*Selaginella lepidophylla, Jatropha dioica* and *Yucca thomsonia*) develops (fig. 4).

Fig. 4. Habitat of *Xantusia v. extorris*. Cerro San Ignacio showing *Yucca thomsonia* in foreground and the flatplains (playa) in background. (photo by C. Grenot)

The two specimens were collected in the same horizontal crevice with a rock dwelling lizard, *Sceloporus poinsetti*. The day of capture was preceded by two rainy days (3.30 cm) during which maximal temperature was 11°C. Maximal air temperature of 23°C was reached at 4 pm the day of capture. Maximal and minimal average temperatures were 28.6°C and 11.4°C during October 1976.

It seems that in this area *Xantusia v. extorris* is bound to rocky habitats with *Yucca* where the most abundant populations of *Sceloporus poinsetti* are found. This is contrary to the habitat preference farther south, however, in that the rest of the specimens reported from Durango were found on the ground underneath dead agaves and fallen tree-yuccas (not in rock crevices). The most common reptiles in the area are *Sceloporus poinsetti, Holbrookia texana, Cnemidophorus scalaris, Phrynosoma modestum, Crotaphytus collaris, Masticophis taeniatus* and *Crotalus atrox* (Grenot et Barbault, 1977).

Literature Cited

Grenot, C. et R. Barbault.
1977. Contribution à la connaissance de l'herpetocenose du Bolsón de Mapimi (désert de Chihuahua, Mexique). *Soc. Biogéog. France,* (sous-presse).

Hudson, D. M.
1973. Seasonal lipid cycles in the yucca night lizard, *Xantusia vigilis*, with special reference to the adaptive significance of the tail as a fat storage organ in lizards. M.S. Thesis, California State University, Fullerton, 87 pp.

Martinez, Ojeda E. and J. Morello.
1977. El medio fisico y las unidades fisonomico- floristicas del Bolsón de Mapimi. *Publ. Instituto de Ecologia, Mexico,* No. 3, 63 pp.

Miller, Malcolm R.
1948. The seasonal histological changes occuring in the ovary, corpus luteum, and testis of the viviparous lizard, *Xantusia vigilis*. *Univ. Calif. Publ. Zool. 47*:197-222.

Webb, Robert G.
1965. A new night lizard (Genus *Xantusia*) from Durango, Mexico. *Amer. Mus. Novitates* 2231:1-16.

—Claude J. Grenot, *Laboratoire de Zoologie, Ecole Normale Supérieure, 46 rue d'Ulm, 75230 Paris Cedex 05, France and Instituto de Ecologia, A. P. 18-845, Mexico 18, D. F.*, and Andrew H. Price, *Department of Biology, Box 3AF, New Mexico State University, Las Cruces, New Mexico 88003, U.S.A.*

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SPIDER PREDATION ON AMPHIBIANS AND REPTILES

Various arachnids, including spiders, have long been known to prey on amphibians and reptiles. Gudger (1925) summarized the early accounts of spider predation on small vertebrates including amphibians and reptiles. More recent accounts have been published by Goin (1943), Neill (1948), Burt (1949), Swanson (1952) and others. Although this behavior is well documented, the following observations and notes may be of interest.

In 1971 and 1972, while engaged in observations of several populations of gray treefrogs, *Hyla versicolor*, in Maryland, one of us (JDG) found four recently transformed gray treefrogs in webs of the golden spider, *Argiope aurantia*.

Two of these treefrogs were found in the same web on 13 September 1971 at a temporary pool along River Road, Anne Arundel County, Maryland. One appeared to have been recently caught in the web of the spider. It was rolled neatly, but tightly, into a ball of web material. The other specimen was black in color and decomposed, indicating an earlier death. An additional juvenile gray treefrog was found in a garden spiderweb in September 1972, at this same locality. These webs were positioned between the stems of two cattails emerging from the water and were between four and five feet above the surface of the water.

On 14 September 1971, a single juvenile gray treefrog was found in the web of a golden garden spider in an abandoned quarry along Baltimore County Road, Baltimore County, Maryland. The web was located between two branches of a small tree along the shore of a large pool in this quarry. The frog was wrapped into a ball similarly as the frogs found in Anne Arundel County.

At both localities, many juvenile gray treefrogs were observed emerging from the water. These frogs were observed to immediately climb the emergent and nearby vegetation, climbing as high as was possible. It is believed that these frogs entered the spider's web accidently and became entangled in the sticky web material. The garden spider then rushed down the web and wrapped many strands of webbing around the disabled frogs, forming a cyst, thus ensuring their fate. These frogs probably died, shortly after becoming entangled, from dissecation rather than by injury caused by the spider.

Although the evidence of a prey-predator relationship is not conclusive, eight instances of eastern ringneck snakes, *Diadophis punctatus edwardsi*, trapped in spider webs are of interest. These data, from the files of the Baltimore Zoo, are derived from telephone queries from the public seeking the identity of the snakes.

The first report, dated 1960 only, simply states that an unidentified woman found a ringneck snake caught in a spider web in the basement of her home, with no mention as to whether the snake was dead or alive. Seven other instances occurred between 4 and 30 August 1973, all involving newly hatched snakes. Five of these were struggling in webs when found, one was trailing strands of web as it crawled across the floor and another was inactive in a web and thought to be dead, whereupon it was sprayed with insecticide to insure its death. All but one were found in basements or at ground floor level, the exception being caught in a web on a ledge along the outside of a house three feet above the ground. The fact that the ledge joined the top of the steps leading to the first floor perhaps explains how the snake reached that height. None of the spiders involved were identified, but from the rather vague descriptions of those who reported these incidents, most were probably a species of the house spider, *Theridion*.

One of us (FG) was able to investigate one of these incidents. This was in the basement of a home in Hanover, Anne Arundel County, Maryland. The snake was on the floor with the posterior quarter of its body in a web, thought to be that of *Theridion*, which was strung between a commode, the adjacent wall and the floor. The snake was observed in the web at 1030 hr. and was released at 1315 hr. alive and unharmed.

Although salamanders and earthworms are the preferred food items of the eastern ringneck snake, spiders and insects of various kinds are also eaten (McCauley, 1945; Fitch, 1975). Dead insects were in several of the webs reported above and may have lured the snakes into entrappment. Another possibility is that the snakes may have been attracted to the webs by spider odor.

Various species of predacious spiders are common in habitats occupied by small amphibians and reptiles. These spiders are probably important predators of some of the young of these animals, as well as an important prey item of the adults.

Literature Cited

Burt, C. E.
1949. Baby gartersnake victim of garden spider. *Herpetologica 5*: 127.

Fitch, H. S.
1975. A demographic study of the ringneck snake (*Diadophis punctatus*) in Kansas. *Misc. Publ. Univ. Kansas Mus. Natur. Hist. 62*:1-53.

Goin, C. J.
1943. The lower vertebrate fauna of the water hyacinth community. *Proc. Florida Acad. Sci. 6*:143-154.

Gudger, E. W.
1925. Spiders as fisherman and hunters. *Bull. New York Zool. Soc. 28*:261-275.

McCauley, R. H., Jr.
1945. The reptiles of Maryland and the District of Columbia. *Private printing, Hagerstown,* vi + 194 pp., 46 figs., 48 pls.

Neill, W. T.
1948. Spiders preying on reptiles and amphibians. *Herpetologica 4*:158.

Swanson, P. L.
1952. The reptiles of Venango County, Pennsylvania. *Amer. Midl. Nat. 47*:161-182.

—John D. Groves, *Reptile Department, Philadelphia Zoological Garden, Philadelphia, Pennsylvania 19104* and Frank Groves, *Reptile Department, Baltimore Zoo, Baltimore, Maryland 21217.*

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NEW LOCALITIES AND A STATE RECORD FOR *Chelydra s. rossignoni* (TESTUDINEA-CHELYDRIDAE) IN MEXICO

Chelydra serpentina rossignoni has previously been reported from the Mexican States of Veracruz, Tabasco, Campeche, Chiapas, and based on one record, from Yucatán (Alvarez del Toro, 1960; Baur, 1893; Casas, 1965, 1967; Conant, 1975, and Cooper Blake, 1967). At this time, I can add the following new localities from the State of Veracruz: Rio Playa Vicente, Laguna de Guerrero and Tesechoacan, Mp. of Isla; Laguna Escondida, Rio Máquina and Rio Cold (Montepio) Mp. of San Andrés Tuxtla; Rio Yugualtajapan, Rio Coscoapan and Laguna Verde Mp. of Catemaco; observing that the presence of *Chelydra* is generally related to the presence of the crocodile. In the Region of Los Tuxtlas, Veracruz, it is normally found together with the species *Crocodylus moreletii.*

In addition to the above, I can also report the capture of an adult specimen in the State of Oaxaca, which represents a new state record:

Chelydra serpentina rossignoni (Tortuga lagarto). Mexico, Oaxaca: Laguna Campana, 7 Kms. W of Valle Nacional (17°50' Lat. N. and 96° 15' long. W). Gonzalo Perez Higareda, 1976 - Terrarium of the Estación de Biologia Tropical "Los Tuxtlas", U.N.A.M. No. 011.

Literature Cited

Alvarez del Toro, M.
1960. Los reptiles de Chiapas. *Inst. Zool. del Edo. Tuxtla Gutiérrez, Chiapas, Mex.,* 204 pp.

Baur, G.
1893. Notes on the classification and taxonomy of the Testudinata. *Proc. Amer. Phil. Soc. 31*:210-225.

Casas, A. G.
1965. Estudio preliminar sobre las tortugas de agua dulce en México. *Ans. Inst. Nac. Invest. Biol. Pesq. 1*:363-401.

__________.
1967. Contribución al conocimiento de las tortugas dulceaquicolas de México. *Tesis Profesional, U.N.A.M.,* 96 pp.

Conant, Roger.
1975. A field guide to reptiles and amphibians of eastern and central North America. *Houghton Mifflin Company, Boston,* xviii + 429 pp.

Cooper Blake, C. C.
1967. Monografía de los quelonios y su importancia para el Laboratorio de Fisiología. *Tesis Recepcional Fac. de Med. Vet. y Zoot. Universidad Veracruzana,* pp. 6-18.

—Gonzalo Perez Higareda, *Estación de Biología Tropical "Los Tuxtlas" (U.N.A.M). San Andrés Tuxtla, Ver. Mexico.*

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A CASE OF TWINNING IN THE RINGNECK SNAKE, *Diadophis punctatus edwardsi*

Records of twinning in turtles are fairly common in the literature (Derickson, 1927; Townsend, 1928; Hildebrand, 1938; Crooks and Smith, 1958; Horning, 1964; Hunsaker, 1968 and Yntima, 1970). I can find only two citations, however, for lizards (Sabnis, 1967; Carpenter and Yoshida, 1967), one for crocodilians (Reese, 1906) and one for snakes (Curtis, 1950). The following account, although incomplete in detail, seems worth adding to this scant body of information.

On 25 May 1977, a female ringneck snake, *Diadophis punctatus edwardsi*, was collected under a rock along Skyline Drive, Page County, Virginia. A second specimen under the same rock escaped.

On 31 May, the above female laid three eggs which were placed in an incubating jar shortly after deposition. One egg hatched sometime during the day of 10 July and the remaining two during the following night. When the eggs were checked on the morning of 11 July, however, there were four hatchlings in the jar. Obviously, one of the eggs had contained twins.

The four hatchlings were carefully measured within 24 hours of hatching. Two were 148 and 136 mm, total length; the other two were 110 mm each. Presumably, the two smaller specimens were the twins.

The small size of the hatchlings precluded immediate sexing and recording of meristic data. While being transferred by automobile to another facility where the latter data could be noted under magnified viewing, the jar containing the snakes was accidentally broken. By the time the accident was discovered, all four snakes had escaped. Without this data, any speculation as to whether the twins were identical or fraternal is meaningless.

Acknowledgement

I wish to thank John D. Groves for searching the literature in connection with this note.

Literature Cited

Carpenter, C. C. & Yoshida
1967. One egg twins in Agama agama. *Herpetologica 23*(1):57-59.

Crooks, F. D. & Smith
1958. An instance of twinning in the box turtle. *Herpetologica 14* (2):170-171.

Curtis, L.
1950. A case of twin hatching in the rough green snake. *Copeia 1950* (3):232.

Derickson, S. H.
1927. A twin turtle. *Sci. Monthly 25*:562-565.

Hildebrand, S. F.
1938. Twinning in turtles. *J. Heredity 29*(7):243-253.

Horning, E.
1964. Twin snapping turtles - a rarity. *Bull. Phila. Herp. Soc.* *11*(1-2):9.

Hunsaker, D.
1968. Twinning in tortoises. *Internat. Turtle and Tortoise Soc.* *2*(6):38.

Reese, A. M.
1906. A double embryo of the American alligator. *Anat. Anz. 28:* 229-231.

Sabnis, J. H.
1967. A case of monzygotic twins in the lizard Calotes versicolor. *J. Biol. Sci.* *10*(1-2):28-29.

Townsend, C. H.
1928. A double turtle. *Bull. N. Y. Zool. Soc.* *31*(1):35-36.

Yntima, C. C.
1970. Twinning in the common snapping turtle, Chelydra serpentina. *Anat. Rec.* *166*(3):491-498.

—Frank Groves, *Baltimore Zoo, Druid Hill Park, Baltimore, Maryland 21217.*

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NEWS & NOTES

A BIOGEOGRAPHICAL ANALYSIS OF THE CHIHUAHUAN DESERT THROUGH ITS HERPETOFAUNA. By David J. Morafka. 1977. Dr. W. Junk B.V., Publishers, P.O. Box 13713, 2501 ES The Hague, Netherlands. 320 pp., col. frontis., 14 figs., 10 pls., 32 tables, 158 maps. 95 Dutch Guilders ($39.43 as of Oct., 1977).

The publication of this book has to rank as (1) the most momentous event in the history of Mexican herpetology in the past several decades; (2) the most outstanding biogeographical study of all time in the Chihuahuan Desert; and (3) an importantly original exercise in biogeographic methodology. The material basis is (1) a collection of over 1200 specimens of amphibians and reptiles (now in Carnegie Mus.) collected by the author and his associates over a period of 6½ mo. in 1970 - 71, as they travelled some 25,000 km. over roads traversing the Chihuahuan Desert in 9 Mexican states; (2) lists of herpetological species found in 24 private and institutional collections examined by him; and (3) a thorough survey of the literature, through about 1973, with a few selected titles from subsequent years, even 1977. Analyses were based upon all 3 material sources. No completion date was specified, but apparently it approximates 1973.

The collections made and examined provide the bases for a list of 170 species (subspecies are not dealt with) of amphibians and reptiles occurring within or immediately adjacent to the Chihuahuan Desert, and for 143 spot distribution maps for those species. No gazetteer or list of localities are provided, but are promised for a separate account. The dots depicting locality records for each species are enclosed by a boundary line suggestive of projected range, on a base map bearing an outline of the Chihuahuan Desert, thus providing an excellent representation of degree of correlation. The biogeographical discussion carefully and commendably disdains attention to any political boundaries, and accordingly the maps do not show them, except for one (map 2, p. 62) in which they are superimposed over the base map developed for the Chihuahuan Desert.

The explicit and precise multivariate delimitation-definition of the Chihuahuan Desert is one of the most important contributions of Morafka's monograph. Another major contribution is a 12 page discourse on systematic philosophy and on 32 specific systematic topics in herpetology, on each of which an arbitrary decision was required to provide a base of action.

In a time when a ponderous organization creaks into action to focus attention upon research on the Chihuahuan Desert, Morafka has stolen a march taking virtually everyone by surprise with his doctoral dissertation, pursued under the direction of Dr. Jay Savage. In one fell swoop it accomplishes much of the organizational objectives, without its support or guidance. Angels need no longer fear to tread the same route, independently or not, as Morafka's dissertation proves by precedent.

The avowed purposes of the monograph are (1) to define the Chihuahuan Desert in biologically and physiographically realistic terms; (2) to translate that definition into an explicit geographical base map and to test quantitatively the predictive value of that map against a specific set of biological systems, the amphibians and reptiles; (3) to assess the relative differentiation and affinities of the Chihuahuan herpetofauna; and (4) to reconstruct the history of the Chihuahuan Desert and its herpetofauna through geological time to the present.

The frontispiece is a color photograph of the Bolson Tortoise, *Gopherus flavomarginatus*. A 2-p. Acknowledgments is followed by a 2-p. Introduction and an 8-p. chapter on Sources, Methods and Analytical Procedures, including a map of routes traversed by the author in performance of field work. A 13-p. chapter on Climate follows, with comparison of all North American deserts. Physiography is described (12 pp.) and the Vegetation (20 pp.). These chapters are then analyzed and synthesized in another giving Definitions, Terminology and Base Map of the Chihuahuan Desert. The following 18-p. chapter on The Herpetofauna is divided into 4 parts: a statement of taxonomic philosophy; a discourse justifying the necessarily arbitrary decision on controversial systematic problems; a list of extant species occurring within the Chihuahuan Desert; and a list of extant species occurring in areas adjacent to that desert. Whether or not one agrees with the several stands described, this section makes fascinating reading. The next 3 chapters contain most of the theoretical meat of the book: The Ecological Affinities of the Chihuahuan Herpetofauna, 28 pp.; A Spatial Analysis of the Chihuahuan Herpetofauna, 46 pp.; and A Historical Biogeography of the Chihuahuan Herpetofauna, 57 pp. A 5-p. Summary, 10-p. Literature, a set of 10 plates illustrating selected biogeographical features, and 143 half-page spot distribution maps for 166 species terminate the book. There is no index.

Such an extensive scope of treatment, and such careful exploration of detail, results in profuse speculation argumentative at virtually every point. Nevertheless, speculation is inherent in biogeographical analyses, and progress is enhanced by the existence of a base given in sufficient detail to permit focus of attention to small segments. The base provided by Morafka's analysis is amazingly and overwhelmingly detailed, and will certainly constitute a classic that will be examined, point by point, for many years to come. Its existence will assure a maximally effective, focussed expenditure of effort by workers in the future, as opposed to the haphazard discordant development that would otherwise be likely to occur. Appearance of this monumental landmark of biogeographic analysis must, in this context, be regarded as extraordinarily fortunately timed.

It is not the intent of this review to enter into the virtually limitless controversies that will ensue from this publication, or to suggest how it might have been improved, however tempting it is to do so. The work is an extensively original, finished product whose ideas will profitably be pursued for many years. Suffice it to say that this monumental work is one that must be reckoned with by such a broad spectrum of biologists - biogeographers, ecologists, herpetologists - that it must be widely available for their reference, either in personal or institutional libraries.

—Hobart M. Smith, *Department of Environmental, Population and Organismic Biology, University of Colorado, Boulder, Colorado 80309.*

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S.O.S.

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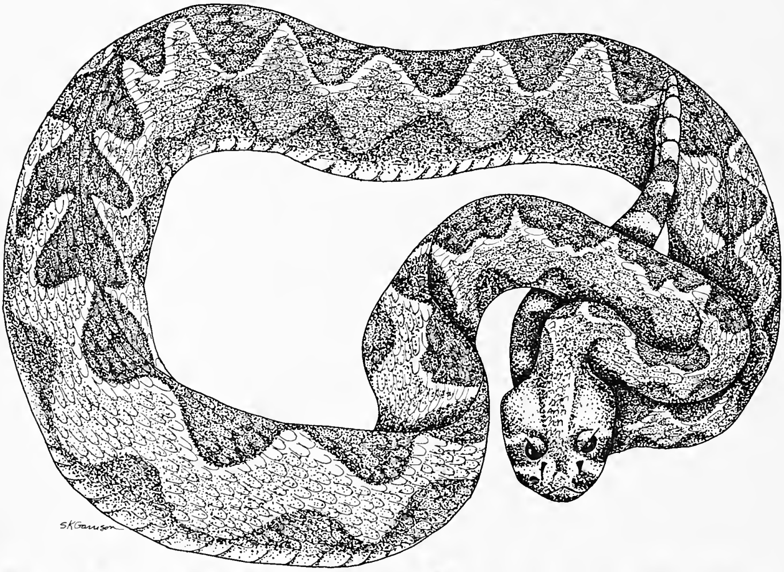

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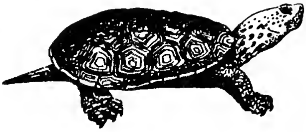

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JUNE 1978 VOLUME 14, NUMBER 2

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Volume 14 Number 2 June 1978

CONTENTS

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Donald Broadley, Jerry D. Hardy, Jr., Robert G. Webb, and John Wright.

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BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

VOLUME 14 30 JUNE 1978 NUMBER 2

BUFO WOODHOUSEI IN CENTRAL TEXAS

Ottys Sanders

ABSTRACT

Hybridization between *Bufo woodhousei* and *Bufo valliceps* in Central Texas is two fold in nature. Infertile males, heretofore considered hybrids between the two species, are regarded as demihybrids, morphologically similar to juvenile *B. valliceps*. A second component of hybridization between the two species is production of *woodhousei-valliceps* intermediates which occur in a sufficient number to cause polymorphism in populations where the two coexist. Application of the classical criterion of infertility to the *valliceps-woodhousei* hybrids yields a prime example of fallibility of the biological species concept.

The major population of *Bufo w. woodhousei* in Texas extends through the central part of the state, bounded by the Red River on the north, the Trinity River on the east, and the counties of Kimble, Gillespie, Comal and Bexar on the southwest. In addition, scattered populations are found in the Texas Panhandle, in the Rio Grande area, in southern Texas, and in a few localities of East Texas; but, as Axtell (1963) has pointed out, the range of the species is not state-wide as generally depicted on range maps. This present distribution of the species in Texas has been formulated after examining specimens from 70 counties in the collections of the Strecker Museum and of Bryce C. Brown of Baylor University, the Biology Department of Stephen F. Austin State University, the Department of Wildlife Management of Texas A. & M. College, the author's own collection, and is supplemented by the checklists of Brown (1950), Raun and Gelbach (1972), and Axtell (1963).

The ranges of *Bufo w. woodhousei* Girard and *Bufo velatus* Bragg and Sanders meet and overlap in counties along the Trinity River from Dallas County south to the Gulf of Mexico. Northward, along the Red River, there is a marked transition from western *Bufo w. woodhousei* to eastern *Bufo velatus* in Fannin County (Bonham. OS3301-6; 3311-12). A similar population change was noted by A. P. Blair (1941; 398-417) at Yuba, Bryan County, Oklahoma, immediately north of Fannin County, Texas. From Fannin County eastward the dominant species is *Bufo velatus*, but at the terminus of the Red River in Texas (Bowie County) and also in adjacent Cass County whose Sulphur River drains into the Red River in Arkansas, a few specimens of *Bufo w. woodhousei* have been collected (SM4370, 5263, 5265). Since these are separated from the normal range of the species and few in number, it seems likely that they have been brought to this area downstream by the Red River. Other pockets of *B. w. woodhousei* in east Texas may in some instances be similarly explained but also it is likely that they have been distributed through human agencies, probably in the transport of goods and belongings in the constantly shifting human population, especially so since Woodhouse's toad is a frequenter of habitation.

Bufo w. woodhousei populations in central Texas are polymorphic in many ways: color, dorsal pattern, and structural features. Dorsal color varies from drab green to straw yellow to a mottling of greenish brown on a creamy background. Dorsum spots vary from mere margins around one or two medium-size warts to irregular broad or long dark patches enclosing a number of warts of mixed sizes. A lightcolored middorsal stripe extending into the interorbital area is generally present but varies in its breadth from narrow to very broad. Lightcolored paravertebral splotches on either side of the middorsal stripe are uncommon but may be present. Lateral stripes are of varying length and distinctness, while a row of large light-colored tubercles bordering these stripes is also variable in length and prominence. There are semicircular bands both anterior and posterior to the tympanum. Ventrally, the abdomen and pectoral are normally unmarked except for a pectoral spot and, in males, a dark throat. However, a small percentage of specimens, more so in some areas than in others, have dark rounded venter spots both on the pectoral and anterior portion of the abdomen.

The normal position of the parotoid gland in *Bufo w. woodhousei* is in contact with the postorbital crest, but a good percentage of central Texas specimens have the gland located more posteriorly and separated from the postorbital crest by a supratympanic ridge. One of the more distinguishing morphological features of Texas *B. woodhousei* is crenulation of the interorbital crests, more notably so when the crests are broad but discernible even when sharper. Generally interorbital crests of *B. woodhousei* terminate where they meet the postorbital crests, either abruptly or with the formation of irregular finger-like processes. Those of central Texas differ by a tendency to extend the interorbital crests beyond this junction, forming parietal spurs, which may either be straight or incurved on the occiput.

Varying morphological characters in Texas *B. woodhousei* have often caused misidentification, in particular its confusion with *Bufo fowleri*, since some individual *B. woodhousei* have large dorsum spots with numerous warts as does *B. fowleri*. Furthermore, a supratympanic ridge between the parotoid gland and postorbital crest and/or spots on the venter is atypical of either *B. fowleri* or *B. woodhousei* but many *B. woodhousei* of central Texas have one or both of these features.

In order to determine the prevalence of abnormal morphological features in populations of *B. woodhousei* of central Texas, a large series was checked for venter spots, supratympanic ridges, and large dorsum spots with 4-7 or more warts. Specimens from seventeen counties distributed throughout the area had such abnormalities, indicating that these features were widespread. A number of other counties were represented by too few specimens to show up these aberrations. Two counties having the largest series of *B. woodhousei* available for study were McLennan County of south central Texas and Dallas County of north central Texas, and collections from these counties provided an adequate sample.

McLennan County, Texas (243 specimens)

Supratympanic ridges present	20	(14 males, 6 females)
Venter spots present	13	(7 males, 6 females)
Large dorsum spots, 4-7 or more warts	12	(9 males, 3 females)
Total	46	Approximately 19%

Dallas County, Texas (98 specimens)

Supratympanic ridges present	25	(20 males, 5 females)
Venter spots present	17	(13 males, 4 females)
Large dorsum spots, 4-7 or more warts	16	(15 males, 1 female)
Total	58	Approximately 59%

It was of interest that these aberrations generally were not linked but appeared separately in individual toads, as is illustrated by the Dallas County series where combined characters were scarce.

With supratympanic ridges and large dorsum spots	5
With supratympanic ridges and venter spots	3
With large dorsum spots and venter spots	2
With supratympanic ridges, venter spots, and large dorsum sports with numerous warts	0

Disparity in the percentage of variants in the two counties is due in part to withholding from the McLennan County series several toads which will be discussed later in this paper, and it also reflects a difference in collecting areas. Those from Dallas County were secured from shallow limestone creeks and black dirt pools where *B. woodhousei* and *B. valliceps* are sympatric and often breed together. Those from McLennan County were collected over a broader area, a portion of which has a hiatus between populations of *B. woodhousei* and *B. valliceps*, according to Bryce C. Brown (personal communication). Therefore, while the above percentages are not exact and may vary regionally, the type of polymorphism cannot be explained as normal variation, since the factors studied are alien to the morphological qualities of *Bufo woodhousei*. It will be shown that they have been acquired through hybridization with *B. valliceps*, a species that has these qualities and is sympatric with *Bufo woodhousei* through much of its range in Texas.

Thornton (1955: 455-468) studied hybridization between *Bufo woodhousei* and *Bufo valliceps* both by laboratory crosses and the collection of hybrids in nature. From his experiments and study he concluded that hybridization between these two species from "the evidence now available suggests that there is little possibility of gene exchange between the two species, because of zygote inviability in one of the original crosses and in backcrosses to the parent species." Volpe (1956) in a study of hybridization between *B. valliceps* and *B. fowleri* reached a similar conclusion. That hybridization between *B. valliceps* and *B. woodhousei* results only in sterile males has been widely accepted by W. F. Blair (1959: 446), Volpe (1956: 73), Mayr (1963: 115), and others. Thornton, on the other hand, made allowance for further investigation and noted that one metamorphosed young toad survived the backcross to *B. woodhousei* (1955: 468).

Thornton (1955) found only one type of hybrid, a bisexed male resulting from the cross of male *B. valliceps* with female *B. woodhousei*. He compared laboratory-reared hybrids with eleven similar hybrids collected in the field and concluded that they were essentially alike. The Strecker Museum collection and my own include six such hybrids which hereafter will be referred to as "demihybrids," (using the Latin term, "demi," to connote something less than "hybrid"). The significant thing about the demihybrids described by Thornton and those we have examined is that they are endowed essentially with the morphological features of *Bufo valliceps* alone except for their cranial crests, which enclose an area more triangular than hexagonal in contour (a compromise probably between the broad interorbital valley in *B. valliceps* and that less broad in *B. woodhousei*).

Two characters thought by Thornton and Volpe to show intermediacy between *B. woodhousei* and *B. valliceps* belong entirely to *B. valliceps*. They are, in fact, juvenile attributes of *B. valliceps* which are retained in the adult demihybrid. In juvenile *B. valliceps* the venter is densely spotted or pigmented (Fig. 1) but this pigmentation tends to disappear in the normal adult, progressing postero-anteriorly, though some adults may retain spots on the pectoral and abdomen. Furthermore, juvenile *B. valliceps* have the dorsum marked with oblong spots containing a number of small warts (Fig. 2), while in the adult these dorsum spots are often obliterated by a darker suffusion. Both of these juvenile characters are prominent in male demihybrids described by Thornton (1955) and Volpe (1956). Male demihybrids have other *B. valliceps* features: a broad mid-dorsal stripe, somewhat triangular parotoid glands separated by a supratympanic ridge from the postorbital crest, and generally a yellow throat. Normal characteristics of *B. woodhousei*, on the other hand, include small dorsum spots, generally with a single medium-size wart, oblong parotoid glands not separated from the postorbital crest, and clear venters. The demihybrids, therefore, show little intermediacy between the two species.

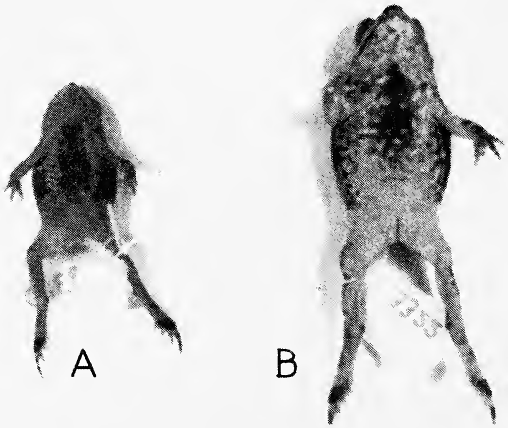

Fig. 1. Juvenile *B. valliceps* (Dallas, Texas) showing typical pigmented venter. A, 24 mm. snout-vent length; B, 37 mm.

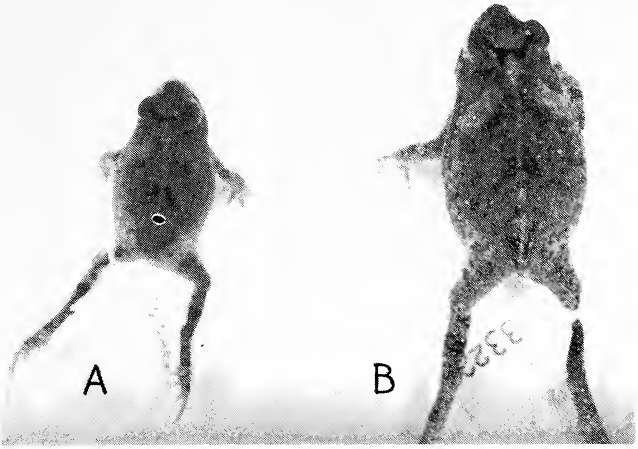

Fig. 2. Dorsal view of same juvenile *B. valliceps* as in Fig. 1. Note oblong spots.

On the contrary, the genetic incompatibility that produces them initiates in its *valliceps*-like product the retention or recrudescence of juvenile characters that persist throughout adulthood. This might also explain the anomalous condition of the gonads, for such specimens, while adult in size, retain the morphological and probably the genetic characteristics of juveniles.

I have examined six such demihybrid males from various Texas counties: three from McLennan County (SM1968, 6252, 11970), one from Bosque County (SM11992), one from Dallas County (OS3310) and one from Harris County (BCB5449), (Fig. 3). These vary among themselves in the extent of dorsum spotting, width of the middorsal stripe, shape of parotoid glands (roughly triangular), and other features, but all have similar interorbital crests, supratympanic ridges, short paratoids and, except for SM6252, venter spots. (Thornton also found some natural demihybrids with clear venters). Variation in two of the specimens is noteworthy. The interorbital crests of SM11970, while similar in shape to others of the group, are broad and very high so that a deep interorbital valley is formed between them. These crest, like those of OS3310, extend beyond their juncture with the postorbital crests to create a prominent parietal, enhancing its *valliceps*-like features. While demihybrid males have short parotoid glands, generally somewhat subtriangular in shape, this specimen, as well as the one from Harris County (BCB5449), has oval parotoid glands. Lauren Brown (1971: 189) had difficulty in distinguishing morphologically between demihybrid male *B. valliceps* and those hybrid between *B. valliceps* and *Bufo houstonensis*. Since the Harris County specimen is from a locality where *B. houstonensis*, as well as *B. woodhousei* and *B. valliceps*, occur sympatrically, it could be a hybrid of either combination. Not only was Brown unable to recognize morphological differences between hybrids involving *B. valliceps*, *B. woodhousei*, and/or *B. houstonensis*, but Volpe (1956: 61 - 75; 1959: 335 - 342) considered hybrids between *B.*

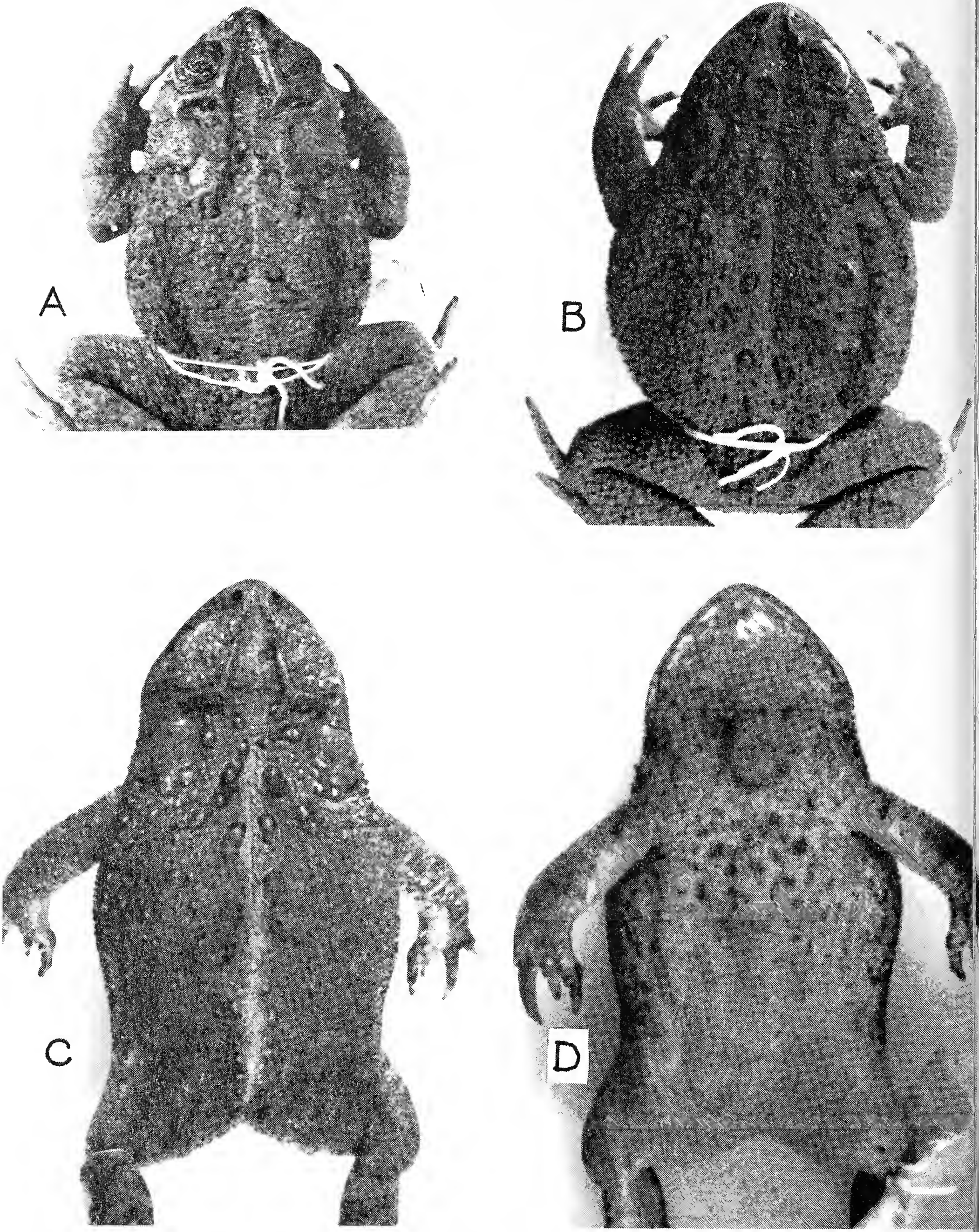

Fig. 3. Demihybrid males. A, SM11970 (McLennan Co.), 74 mm. snout-vent length; B, SM11992 (Bosque Co.), 73 mm.; C, OS3310 (Dallas Co.), 69 mm.; D, ventral view of "C" showing venter spots.

valliceps and *B. fowleri*, *B. woodhousei*, *B. americanus*, or *B. terrestris* all to be the same. This is understandable only with the realization that this sameness is due to genetic failure to produce intermediates between *B. valliceps* and these other species and to retention of *B. valliceps* features in a juvenile anomalous state in the specimens they examined. There is a striking resemblance between photographs of *B. valliceps-americanus* hybrids published by Volpe (1959: 340) and our juvenile *B. valliceps* (Figs. 1 and 2)

Heretofore only sterile male hybrids such as those discussed above were thought possible in crosses between *B. valliceps* and *B. woodhousei* (Thornton, Volpe, Blair, and others). That this is not so is illustrated by a hybrid female from Brazos County, Texas (BCB11574, Fig. 4) which has the morphological attributes of the demihybrid males with one exception. The major phenetic difference between this female and hybrid males, aside from sex, is its oblong *woodhousei*-like parotoid glands in contact with the postorbital crests. The specimen therefore is a significant example of an atypical *B. valliceps* hybrid, representing an emergence of limited *B. woodhousei* characters in an otherwise dominant *B. valliceps* individual. As in other female toads, the thumb is not encrusted and dissection shows ovary folds with developing eggs. Condition of the ovary has been compared with that of female *B. valliceps*, *B. woodhousei*, and *B. cognatus* and there is no reason to suspect its being other than normal. Coincident with the phenomic expression of intermediacy between the two species, genetic normalcy has been attained.

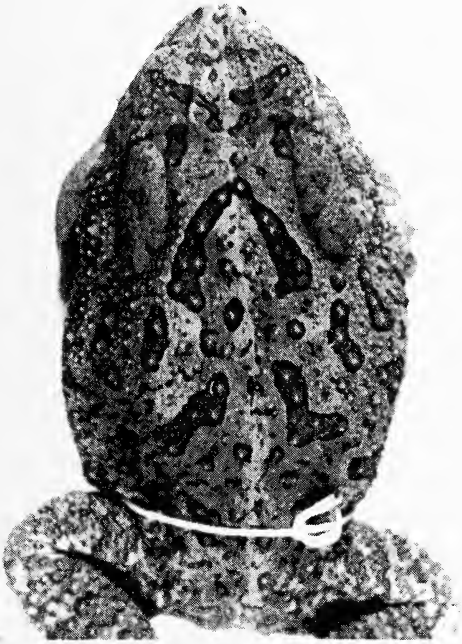

Fig. 4. An atypical *B. valliceps* hybrid female, BCB11574 (Brazos Co.), 63 mm. snout-vent length. Dissection showed developing eggs.

Such a female hybrid through its propagules theoretically could induce polymorphism in populations of *B. valliceps* as well as in those of *B. woodhousei*, but evidence is lacking to sustain this. However, while such a heuristic possibility could exist, paucity of fertile hybrids of the above nature so far uncovered casts doubt on its validity in explaining the widespread acquisition of *valliceps*-like features in populations of *B. woodhousei* in central Texas. The more likely explanation is that hybridization between the two species manifests itself in a variety of ways, not by the production of a single intermediate type.

In this study, several specimens have been selected to demonstrate the penetration of *B. valliceps* characters into the gene pool of *B. woodhousei*. An emphasis has been placed on individuals with two or more such characters on the assumption that they are of recent acquisition and have not had the chance to be diluted by back crossing, as appears to be the case in the general population. To recapitulate, these characters include venter spots, supratympanic ridges and dorsum markings enclosing numerous warts. The broad triangular interorbital area typical of sterile male hybrids is not characteristic of the *B. woodhousei* intermediates. While it is possible that hybridization with *B. valliceps* could result in expansion of the interorbital area in normal *B. woodhousei*, any slight deviation would go unnoticed, since their interorbital crests frequently diverge. Conversely, the type of cranial modification noteworthy in some specimens of *B. woodhousei* is their very high interorbital crests, parallel in position to each other, with a sharp valley between. A comparable situation exists in *B. valliceps* except that the area separating the crests is greater. While such an analogy may be made, the phenomic effect of gene flow is not clear when one recalls that similar high, parallel crests are typical of interorbitally-bossed *B. woodhousei* after loss of the boss. *B. valliceps* has a prominent maxillary groove, but neither the demihybrids nor the *B. woodhousei-valliceps* intermediates have the groove fully developed. The demihybrids examined generally had the groove better developed on one side of the head than on the other. The *B. woodhousei-valliceps* intermediates similarly show unequal development but also much weaker grooves with lower suborbital ridges when they occur. In both demihybrids and intermediates, some dark pigmentation of skin in the maxillary groove was observed, contrasting with its absence in *B. valliceps*. This morphological feature of *B. valliceps*, therefore, is largely supplanted in the hybrids and it may be assumed that hybridization has been a factor in its deletion. There can be little doubt, however, about the transfer of other *valliceps*-like features to the *B. woodhousei* population, as the following tables and Figure 5 illustrate.

Specimens in Table 1 illustrate a high degree of intermediacy between the two species, combining as they do *valliceps*-like characters with those of *B. woodhousei*. Those in Table 2 illustrate how *B. valliceps* characters may be distributed in the general *B. woodhousei* population of counties where the two species are sympatric.

While only a few specific traits have been used to demonstrate the phenome effect of *B. valliceps* genes in hybrid populations of *B. woodhousei*, it follows as a corollary that these are not inclusive and that alleles for other factors went along in the exchange. The aftermath of

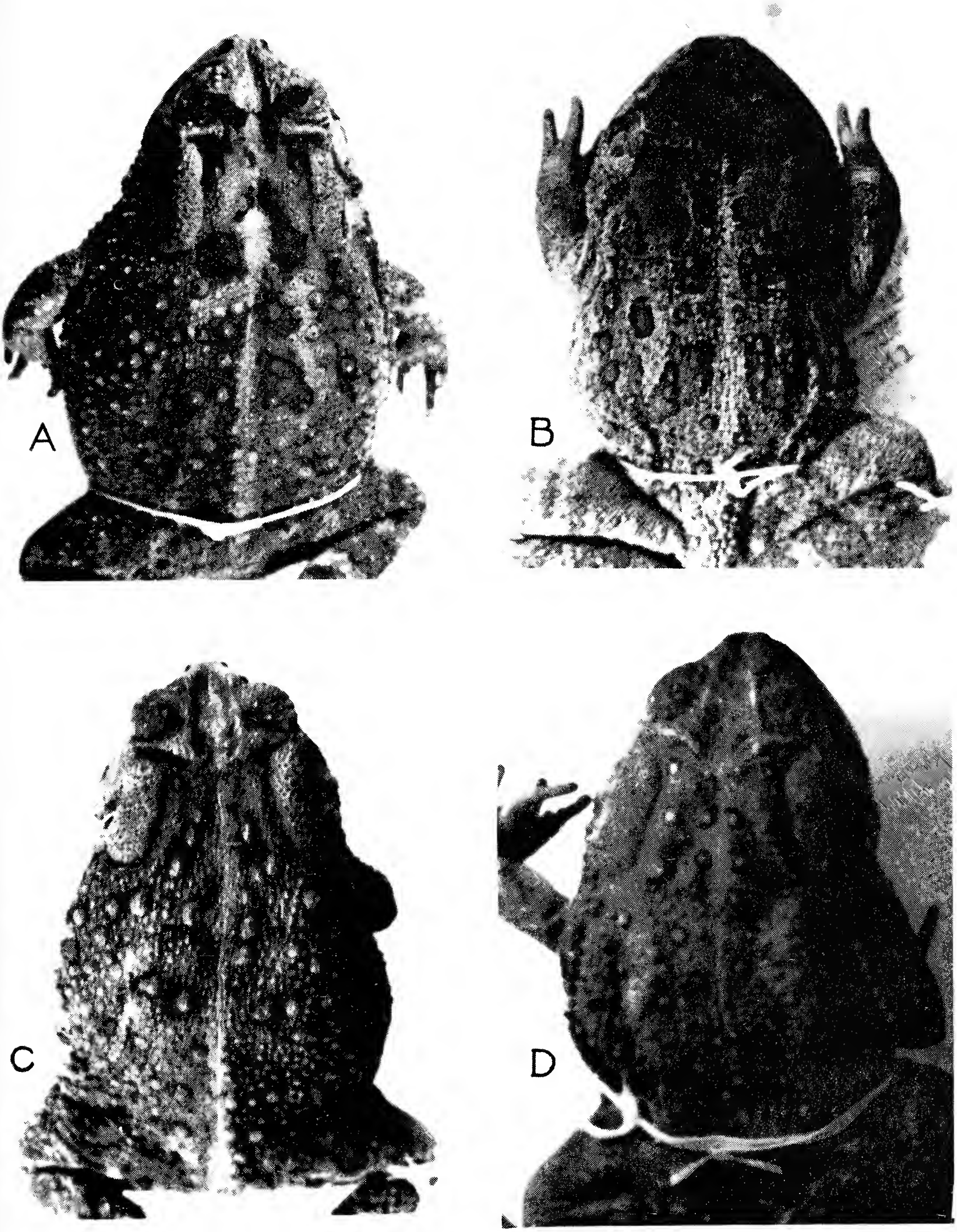

Fig. 5. *B. woodhousei-valliceps* intermediates. A, SM6255 ♂ (McLennan Co.), 63 mm. snout-vent length; B, SM6406 ♂ (McLennan Co.), 70 mm.; C, SM8561 ♀ (Tyler Co.), 72 mm.; D, SM2756 ♀ (Dallas Co.), 59 mm.

Table 1. Character Analysis of *B. woodhousei-valliceps* Intermediates *

Tag No.	County	Dorsum spots	Supra-tympanic	Venter spots	Max. groove	Other characters
2685 ♀	McLennan	-	+	+	+	High interorbital crests
6255 ♂	"	+	+	+	+	High interorbital crests
6406 ♂	"	+	-	-	+	Parotoids subtriangular
8563 ♂	"	+	+	-	+	Skin and color like *B. valliceps*
8564 ♂	"	+	-	-	+	
6389 ♀	"	-	+	+	+	
5497 ♀	Falls	+	-	+	+	Parotoid divided one side
8561 ♀	Tyler	+	+	+	+	Broad parallel interorbital crests; bony interorbital valley
2756 ♀	Dallas	-	+	+	+	Sharp interorbital crests

*Dorsum spots generally large with four or more warts; supratympanic ridge between parotoid and postorbital; faint maxillary groove. Numbers refer to Strecker Museum specimens.

Table 2. Example of Occurrence of *B. valliceps* Character-states in *B. woodhousei* Phenomes *

Tag no.	County	Dorsum spots	Supra-tympanic	Venter spots	Other Characters
309	Milam	+	+	+	Short parotoids; sharp interorbital crests
1788	Burleson	-	-	+	
2123	Brazos	+	+	-	
2011	"	+	-	+	Broad middorsal
2153	"	+	+	-	High crests; lg. dorsum spots, only 1-2 warts
2155	"	+	+	-	Color and skin like *B. valliceps*
8480	Ellis	-	-	+	Color, skin like *B. valliceps*; broad middorsal
6824	Navarro	+	-	-	Parietal spur better developed
17062	Limestone	-	+	+	Crests high; enlarged parietal spur
11990	Coryell	+	+	-	Broad middorsal
17064	Bosque	+	-	-	
10478	"	+	-	-	
6961	Johnson	+	-	-	Smooth interorbital crests
2973	Hays	-	+	+	High, broad interorbital crests
8593	Bexar	+	-	-	Broad middorsal
3060	Kennedy	+	+	-	Bony interorbital valley

*See Table 1 for explanation of characters. Above numbers are from Strecker Museum except No. 2123 from Texas A. & M. College, Department of Wildlife Management.

introgressing *B. valliceps* genes into *B. woodhousei* and their consolidation and modification through backcrossing within the *B. woodhousei* population can best be measured, as was done earlier, by the polymorphism of the group and its overall variance from populations outside the influence of *B. valliceps*. Traits in addition to those studied which could be attributed to the *B. valliceps* influence, but which have not been tested, include varied coloration, increase of dorsal markings, divergence of interorbital crests with added interorbital area, and development of parietal spurs, to name but a few.

This population study between two currently sympatric toad species that are diverse both morphologically and in geographic origin has shown that hybridization between them is of a dual nature in its products. Populations of *B. woodhousei* become polymorphic because some individuals acquire variant morphological traits through introduction of *B. valliceps* genes into their gene pool. These *valliceps*-like traits include smaller warts, larger dorsum spots enclosing several warts, supratympanic ridges, and venter spots. A second product of hybridization between the two species is the so-called demihybrid that, when adult, is only slightly modified from the condition that exists in juvenile *B. valliceps*. The chromosomal rearrangement that produces these demihybrids is presumably unknown.

According to Sokal and Crovello (1970: 141), "Laboratory experiments on infertility could be carried out but would indicate neither whether such interbreeding would take place in the field nor whether the offspring of such unions would be viable and reproduce under field conditions......"Clearly, first consideration must be given to observations of nature as it is." (p. 132) The number of crossings possible under laboratory conditions are slight compared to those possible in nature. An exotic laboratory product which may also be found in nature cannot decide the matter, as this study has shown. Application of the classical criterion of infertility to the *B. valliceps-woodhousei* hybrids yields a prime example of fallibility of the biological species concept.

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Literature Cited

Axtell, Ralph.
1963. A reinterpretation of the distribution of *Bufo w. woodhousei* Girard, especially on the southeastern margin of its range. *Herpetologica 19:* 115-122.

Blair, A. P.
1941. Variation, isolating mechanisms and hybridization in certain toads. *Genetics 26:* 398-417.

Blair, W. F.
1959. Genetic compatibility and species groups in U.S. toads (Bufo). *Texas J. Sci. XL*(4):427-453.

Brown, Bryce C.
1950. An annotated check list of the reptiles and amphibians of Texas. *Baylor Univ. Studies. Baylor Univ. Press, Waco, Texas* xii + 259.

Brown, Lauren E.
1971. Natural hybridization and trend toward extinction in some relict Texas toad populations. *Southwestern Naturalist 16* (2):185-199.

Mayr, Ernst.
1963. Animal species and evolution. *Harvard Univ. Press, Cambridge, Mass.*

Raun, G. G., and F. R. Gelbach.
1972. Amphibians and reptiles in Texas. *Bull. 2, Dallas Museum of Natural History,* ii + 62, 140 maps.

Sokal, Robert R., and T. J. Crovello.
1970. The biological species concept: a critical evaluation. *American Naturalist 164*(736):127-153.

Thornton, W. A.
1955. Interspecific hybridization in *Bufo woodhousei* and *Bufo valliceps. Evolution IX*(4):455-468.

Volpe, E. Peter.
1956. Experimental F_1 hybrids between *Bufo valliceps* and *Bufo fowleri. Tulane Studies in Zoology. Tulane Univ. 4*(2):61-75.

________________.
1959. Hybridization of *Bufo valliceps* with *Bufo americanus* and *Bufo terrestris. Texas J. Sci. XI*(3)335-342.

Research Associate, Strecker Museum, Baylor University, Waco, Texas 76703. (Mailing address of author: *5712 West Ledbetter Drive, Dallas, Texas 75236).*

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REPTILES AND AMPHIBIANS FROM THE ESTACIÓN DE BIOLOGÍA TROPICAL "LOS TUXTLAS" (U.N.A.M.), VERACRUZ, MEXICO

Gonzalo Perez Higareda

These notes record observations on the reptiles and amphibians of the region known as "Los Tuxtlas," comprising a large tropical mountain zone in the southeastern portion of the state of Veracruz, Mexico, between the basins of the Río Coatzacoalcos and the Río Papaloapan. The Estación de Biología Tropical "Los Tuxtlas," where the study was conducted, is located at km 30 along the Catemaco-Montepio road (Fig. 1), in the Municipio of San Andrés Tuxtla. Observations were limited largely to an area of approximately 175 hectares in the eastern part of the Estación, covering almost a third of its total area, and bounded at the north, south and east by the limits of the Estación, at the west by the Río Cárdenas (Fig. 2).

There were two objectives of the present study: first, to collect representatives of all the species of reptiles and amphibians of this area, since there had been no previous systematic attempt to survey them anywhere in that general area; and second, to sample the snake fauna re-

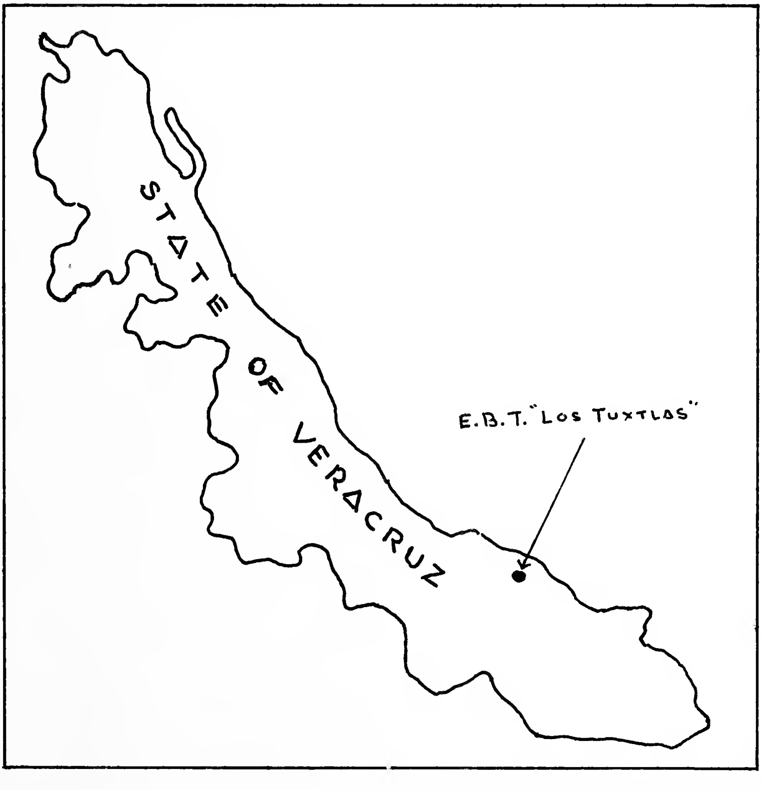

Fig. 1. General location of the Estacion de Biologia Tropical "Los Tuxtlas."

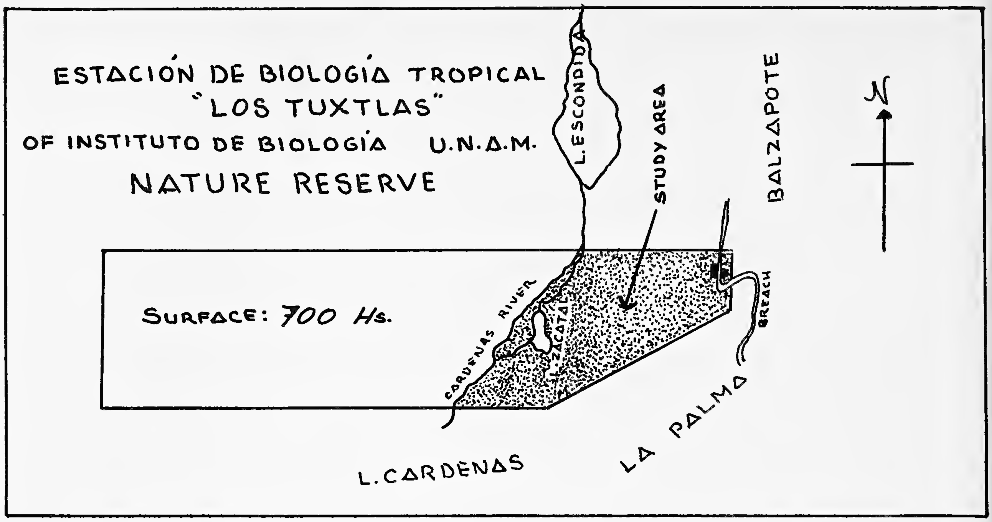

Fig. 2. General lay-out of the Estacion de Biologia Tropical "Los Tuxtlas," showing (stippled) the area of study for the report herewith.

peatedly throughout the period of one year, inorder to obtain knowledge of their seasonal and relative abundance.

General herpetological collecting was initiated in April, 1976, and samples of the snake populations began in May, 1976. Both activities were concluded in April, 1977, having encompassed the full annual cycle.

DESCRIPTION OF THE AREA

The area is characterized by uneven terrain over predominately a lava (basalt) bedrock with an accumulation of leaf litter, mainly covered by tropical rainforest although in some small areas secondary vegetation is found. The climate is classified as warm-humid, maximum and minimum temperatures of 33°C and 25°C respectively occurring from March to September, and 20°C and 12°C during November, December and January. The average annual temperature is 23°C, the average annual precipitation 4565 mm. Nine or ten months of the year have almost incessant rain, with a relative ambient humidity of 99 to 99.5% (data registered in the Est. Biol. Trop.). The elevation above sea level varies within the study area from 160 m near the building of the Station to 530 m at the top of Cerro Vigia. For a more complete description see Gomez-Pompa *et al.* (1976).

PRELIMINARY CHECKLIST OF THE HERPETOFAUNA OF THE NATURE RESERVE "LOS TUXTLAS"

REPTILIA

TESTUDINES - CRYPTODIRA

Fam. CHELYDRIDAE

Chelydra serpentina rossignoni (Bocourt)

Fam. KINOSTERNIDAE

Kinosternon l. leucostomum (Duméril and Bibron)
Kinosternon acutum Gray
Staurotypus triporcatus (Wiegmann)

Fam. EMYIDAE

Pseudemys scripta venusta (Gray)

SQUAMATA - SAURIA

Fam. IGUANIDAE

Anolis barkeri Schmidt
Anolis lemurinus bourgeaei Bocourt
Anolis sericeus Hallowell
Anolis tropidonotus Peters
Anolis petersi Bocourt
Anolis sp. (two species)
Basiliscus vittatus Wiegmann
Laemanctus serratus Cope
Corytophanes hernandezi (Wiegmann)
Ctenosaura similis similis (Gray)
Iguana iguana (Linnaeus)
Sceloporus salvini Günther
Sceloporus teapensis Günther

Fam. XANTUSIIDAE

Lepidophyma flavimaculata Duméril
Lepidophyma pajapanense Werler
Lepidophyma sp.

Fam. TEIIDAE

Ameiva undulata amphigramma Smith and Laufe
Cnemidophorus deppei deppei Wiegmann

Fam. SCINCIDAE

Eumeces sp.

SQUAMATA - SERPENTES

Fam. BOIDAE

Boa constrictor Linnaeus

Fam. COLUBRIDAE

Adelphicos q. quadrivirgatus Jan
Clelia clelia clelia (Daudin
Coniophanes imperialis clavatus (Peters
Dendrophidion vinitor Smith
Drymarchon corais melanurus (Duméril, Bibron and Duméril)
Drymobius m. margaritiferus (Schlegel)
Ficimia publia Cope
Imantodes cenchoa leucomelas (Cope
Lampropeltis triangulum polyzona Cope

Leptodeira annulata cussiliris Duellman
Leptophis mexicanus mexicanus Duméril, Bibron and Duméril
Leptophis occidentalis praestans (Cope)
Masticophis mentovarius mentovarius (Duméril, Bibron and Duméril)
Mastigodryas melanolomus veracrucis (Stuart)
Ninia diademata diademata Baird and Girard
Ninia sebae sebae (Dumeril, Bibron and Dumeril)
Oxybelis aeneus (Wagler)
Pliocercus elapoides Cope
Pseustes poecilonotus argus (Bocourt)
Rhadinaea decorata (Gunther)
Sibon nebulatus (Linnaeus)
Spilotes pullatus mexicanus (Laurenti)
Stenorrhina degenhardti mexicana (Steindachner)
Tantilla phrenitica Smith
Tropidodipsas sartorii sartorii Cope
Xenodon mexicanus Smith
Natrix rhombifera blanchardi Clay

Fam. VIPERIDAE

Bothrops atrox (Linnaeus)
Bothrops nummifer (Rüppell)

CROCODYLIA - (LORICATA)

Fam. CROCODYLIDAE

Crocodylus moreleti Duméril and Duméril

AMPHIBIA

CAUDATA

Fam. PLETHODONTIDAE

Bolitoglossa rufescens (Cope)

ANURA

Fam. BUFONIDAE

Bufo cavifrons Firschein
Bufo marinus Linnaeus
Bufo valliceps Wiegmann

Fam. RANIDAE

Rana palmipes Spix

Fam. LEPTODACTYLIDAE

Eleutherodactylus loki Shannon and Werler
Eleutherodactylus rugulosus (Cope)
Syrrhophus leprus Cope

Fam. HYLIDAE

Hyla ebraccata Cope
Hyla sp.

Agalychnis callidryas (Cope)
Smilisca baudini baudini (Duméril and Bibron)
Smilisca cyanosticta (Smith)

GYMNOPHIONA

Fam. CAECILIDAE

Dermophis sp.

COMMENTS

Testudines

In the study area almost all the streams present bedrock and rolling declivities; for this reason very few turtles were found.

Chelydra serpentina rossignoni, *Pseudemys scripta venusta*, *Kinosternon acutum* and *Staurotypus triporcatus* were found in Laguna Escondida, Laguna Azul and Río Cárdenas, near the Nature Reserve, and in some streams within the study area. One specimen of *Kinosternon leucostomum* was taken in a stream.

Sauria

Saurians present greater difficulty for observations than any other group since almost all of them are cryptically colored and live near the tree tops.

The genera *Anolis*, *Corytophanes* and *Lepidophyma* are apparently the more abundant in the shadow zones. *Basiliscus*, *Sceloporus*, *Ameiva* and *Cnemidophorus* prefer more disturbed habitats. Some specimens of a green *Sceloporus* were captured, but their identity remains uncertain in the absence of a sufficiently large series from all elevations in the "Los Tuxtlas" area, despite Stuart's review (1970).

Serpentes

Thirty-one species, two still not determined, were captured in the study area of the Nature Reserve (Table 1). These represent 30% of the total ophidiofauna of the State of Veracruz (reported by Smith and Taylor, 1945).

The snake fauna of the Nature Reserve is clearly comprised of neotropical genera, except *Natrix*, which is nearctic; this is of aquatic habits and is only found in some lakes.

Some arboreal species are easy to find on the forest floor during the dry season, such as *Spilotes pullatus mexicanus* and *Leptophis occidentalis praestans*. The latter, during the dry months, is even found in houses of the Station; during the wet season, it disappears and can only be seen in the branches of high trees. A few other species, such as *Boa constrictor* and *Bothrops atrox*, appear scarce during the dry season, but the flooding of their abodes during the wet season makes them "seem" to appear all over the place. During the winter rainy season, the snake fauna is largely hidden.

Specimens were found which appear to possess characteristics of two

	HOT SEASON 33°C max. - 25°C min.							COLD SEASON 20°C max. 12°C min.					
	DRY SEASON			RAINY SEASON				CONTINUAL RAINS					
SPECIES	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Boa constrictor	6	3	2	3	6	2	1	-	1	-	-	3	27
Adelphicos q. quadrivirgatus	-	-	-	-	-	-	-	-	1	-	-	-	1
Clelia c. clelia	1	2	1	2	1	2	1	-	1	-	-	-	11
Coniophanes i. clavatus	-	-	-	-	-	-	-	-	-	-	-	1	1
Dendrophidion vinitor	2	5	3	4	4	5	9	1	1	-	-	-	34
Drymarchon c. melanurus	4	1	-	2	1	1	1	-	-	-	-	2	12
Drymobius m. margaritiferus	-	2	2	1	2	3	1	-	-	-	-	-	11
Ficimia publia	-	-	-	-	1	-	-	-	-	-	-	-	1
Imantodes c. leucomelas	1	-	-	-	-	1	-	-	-	-	-	-	2
Lampropeltis t. polyzona	4	5	7	7	6	6	2	-	-	-	-	2	39
Leptodeira a. cussiliris	-	1	-	-	-	-	-	-	-	-	-	-	1
Leptophis m. mexicanus	6	7	12	12	11	9	10	-	2	-	-	3	72
Leptophis o. praestans	12	18	22	29	19	27	14	-	-	-	-	5	146
Masticophis m. mentovarius	1	6	6	12	3	7	2	2	-	-	-	-	39
Mastigodryas m. veracrucis	3	1	1	2	2	2	1	2	2	-	-	-	16
Ninia d. diademata	2	1	-	-	-	-	1	-	-	-	1	1	6
Ninia s. sebae	12	22	33	24	15	38	29	7	10	2	2	12	206
Oxybelis aeneus	12	14	17	20	17	18	3	1	5	-	-	7	114
Pliocercus elapoides	-	-	1	-	-	1	-	-	-	-	-	-	2
Pseustes p. argus	-	-	-	2	-	-	-	-	-	-	-	-	2
Rhadinaea decorata	-	2	-	11	-	1	-	-	2	-	2	-	18
Sibon nebulatus	1	-	-	-	-	-	-	-	-	-	-	-	1
Spilotes p. mexicanus	4	2	3	7	5	3	2	-	-	-	-	2	28
Stenorrhina d. mexicana	-	-	-	-	-	-	-	-	-	1	1	-	2
Tantilla phrenitica	-	-	1	-	-	-	-	-	-	-	-	-	1
Tropidodipsas s. sartorii	-	2	3	2	2	-	-	1	1	-	-	-	11
Xenodon mexicanus	-	-	-	-	1	-	-	-	-	-	-	-	1
Natrix r. blanchardi	-	-	-	1	-	-	-	-	-	-	-	-	1
Bothrops atrox	6	11	19	26	27	7	4	-	2	2	2	6	112
Bothrops nummifer	-	-	-	1	-	-	-	-	-	-	-	-	1
Species not determined	-	-	-	1	-	1	(1)	(1)	-	-	-	-	4
Total individuals counted	77	103	131	156	122	133	82	15	27	5	5	44	923

Table 1. Number of snakes captured in the Study Area "Los Tuxtlas" between April 1976 and April 1977.

subspecies of *Tropidodipsas: T. sartorii sartorii* Cope and *T. sartorii annulatus* (Peters). Additional material is required to establish whether these taxa are inseparable or constitute distinct species.

Contrary to expectation, no species of *Micrurus* was encountered, in spite of the fact that *M. elegans* and *M. diastema* are known from the vicinity of San Andrés Tuxtla and Catemaco, Veracruz.

For the entire region of "Los Tuxtlas", *Bothrops atrox asper* stands out as the most abundant representative of the genus *Bothrops*. Our largest specimen is 2.5 m in total length. *Bothrops nummifer* is found at higher elevations. In the study area, only one specimen was found, at the top of Cerro Vigia, 530 m, the highest point within the Nature Reserve.

Crotalus d. durissus is found in adjacent regions, but because of the excessive humidity of the study area it is doubtful that it occurs there.

It is recognized that the present work is preliminary and must be extended over a much longer period. The work completed up until now, however, does serve as a valid preliminary data base from which a definitive understanding can be derived. Obviously many more species and genera can be expected as work progresses. The most likely additions are *Leptotyphlops, Typhlops, Conophis* (which has been taken previously only on the coast), *Oxyrhopus* and *Micrurus*.

Crocodylia

Only one young specimen of *Crocodylus moreleti* was captured in Río Cárdenas.

Gymnophiona

On several occasions caecilians have been observed in perennial streams of this locality, possibly representing *Dermophis*, although that genus is generally regarded as strictly terrestrial. However, no specimen has yet been captured.

Anura

Smilisca b. baudini is the most abundant species of hylid frog. Laguna del Zacatal lies in the westward part of the study area (Fig. 2), occupying an area of approximately 350 m^2. During the rainy season it received from the mountains a large volume of water, but during the dry season it becomes completely dry. On this lake, after the second summer rain, many thousand *S. b. baudini* suddenly appeared, amazing in both their abundance (30-40 frogs/m^2) and their deafening chorus. The rain stopped on the third day, and the shallow water accumulated over the preceeding two days disappeared completely. On the fourth day many large, black, oily spots marked the sites where the frogs died in an enormous mass extinction. Not a single live specimen was seen subsequently. This may be interpreted as a natural phenomenon regulating abundance.

In all streams and lakes, *Rana palmipes* is the common species.

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Literature Cited

Gomez-Pompa, A., S. del Amo Rodríquez, C. Vázquez-Yanes and A. Butanda Cervera (editors).
1976. Investigaciones sobre la regeneración de selvas altas en Veracruz, México. *Mexico, D. F., Comp. Edit. Continental*, 676 pp., ill.

Smith, Hobart M. and Edward H. Taylor.
1945. An annotated checklist and key to the snakes of Mexico. *Bull. U.S. Nat. Mus.*, (187):1-239.

Stuart, Laurence C.
1970. A brief review of the races of *Sceloporus serrifer* Cope with special reference to *Sceloporus serrifer prezygus* Smith. *Herpetologica, 26*:141-149.

Estación de Biología Tropical "Los Tuxtlas," Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 94, San Andrés Tuxtla, Veracruz, Mexico.

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OBSERVATIONS ON THE HUSBANDRY AND BREEDING OF THE RUFOUS-BEAKED SNAKE, *RHAMPHIOPHIS OXYRHYNCHUS ROSTRATUS*, AT THE NATIONAL ZOOLOGICAL PARK

Trooper Walsh and Sam Davis

ABSTRACT

This paper describes the husbandry and breeding of the Rufous-beaked snake, *Rhamphiophis oxyrhynchus rostratus*, at the National Zoological Park. Descriptions of breeding behavior and incubation procedures are included as well as measurements of eggs and young. The information in this paper is compared with literature reports.

INTRODUCTION

The Rufous-beaked snake, *Rhamphiophis oxyrhynchus rostratus*, is a medium sized, rear-fanged colubrid found commonly throughout South Africa and Rhodesia (Pitman, 1974). It is a burrowing ground dweller which frequents savanna-type habitats and has been discovered living in gerbil burrows and termite mounds (Fitzsimons, 1970). The sharply beaked snout of *Rhamphiophis* is used to tunnel and root in sandy soil. In the wild, *Rhamphiophis* feed on a variety of small animals such as rodents, lizards, birds, beetles, and other snakes (Fitzsimons, 1970; Isemonger, 1968; Pitman, 1974; Sweeney, 1971). The venom of this species is said to be harmless to humans, although experiments on small rodents have shown that death results soon after envenomation, (Pitman, 1974; Sweeney, 1971). Very little else is known about this snake in the wild and there appears to be no literature concerning the breeding of *Rhamphiophis* in captivity.

The purpose of this paper is to discuss the husbandry and breeding of *Rhamphiophis* at the National Zoological Park.

SPECIMENS

An adult male was obtained in March of 1975. A female was acquired in June of 1976 and laid a clutch of nine eggs while in quarantine. The eggs averaged 6.9 gm in weight and 42.5 x 14.8 mm in length and width. The clutch was determined infertile by candling and spoiled after several days of artificial incubation. The female was placed on display with the male in October of 1976.

HOUSING AND HUSBANDRY

The glass-fronted exhibit cage is constructed of molded fiberglass with hinged double doors at the rear. The top is screen wire mesh, and additional ventilation is provided by four rows of small holes in the lower half of the service door. The cage measures 94 x 63 x 100 cm. Ten centimeters of pea gravel are used as substrate and is a suitable burrowing medium. Originally, sand was used as substrate, but abrasions and infections resulted when grains of sand collected under belly scutes. Half of a hollow log rests diagonally on the substrate and serves as shelter. Plastic plants are attached to the log for cover and appearance. Above the log, at a height of 65 cm, a dried thorny branch with plastic foliage is attached to the cage walls. The specimens often climb and rest on this thorn branch.

The temperature of the exhibit fluctuates about 6 C between day and night. The average annual daytime high is 26.7°C while at night the temperature drops to an average of 21°C. Extreme daytime high temperatures of 32.2°C occur in late July and early August, and extreme nighttime lows of 17°C have been recorded in November and April.

Skylights provide a natural photoperiod for the Washington D.C. Area. Florescent Chroma-50 lights are suspended 61 cm above the screened exhibit top for direct cage illumination and to supply ultraviolet radiation. During the summer months, the florescent lights are on from 7:00 a.m. to 7:00 p.m. In the fall, winter, and spring, they are on from 8:00 a.m. to 4:30 p.m. In addition, a heatlamp-spotlight is positioned in one corner of the cage to produce a thermal gradient. The heatlamp goes on and off with the other artificial illumination.

The exhibit cage is misted daily with water. Fresh drinking water is available at all times from a small bowl.

Each specimen is generally fed one mouse per week. During the winter, feeding may be less enthusiastic and mouse pups may be more readily accepted than adult mice. When a food item is attacked, the snake retains hold of its prey and chewing motion is observed. This motion may be associated with the rear fang venom mechanism.

COURTSHIP AND COPULATION

On the morning of 15 February 1977, the male and female were observed copulating. The snakes were stretched out on the substrate with the male on the back of the female. The head of the male was on top of the female's, and their bodies twitched every few seconds. The male's tail was loosely wrapped around that of the female, bringing their cloacas in contact. The courtship involved head jerking on the part of both snakes and tongue flicking by the male. Copulation lasted for several hours and then both specimens retreated to the cover of the hollow log. Similar courtships and copulations were observed during daylight hours on 22 March and 19 April. On 11 April the female's prelaying shed was recorded. Her last meal before laying was accepted on 29 March.

EGGS AND INCUBATION

On the morning of 21 April 1977, seven freshly laid eggs were discovered under the hollow log in the exhibit cage. The eggs were removed, weighed, measured (Table 1), and set up for artificial incubation.

A styrofoam box measuring 60 x 60 x 30 cm was used as an incubator. A 30 cm layer of pea gravel covered the bottom of the box to keep the egg containers off the subterranean heat source. The pea gravel also retains heat when the incubator is opened. The eggs were placed on top of 4 cm of potting soil in two plastic containers measuring 15 x 10.5 x 7.5 cm.

Heat was provided by two lengths of a 125 watt plumber's heat tape which were spaced 25 cm apart under a metal plate. The styrofoam incubator was then placed on the metal plate. The plate helps distribute the heat in a uniform manner. A temperature of 28° - 29° C was maintained throughout incubation.

When the eggs were initially set up, two cups of water were added to the pea gravel on the bottom of the incubator. The heat caused condensation and resulted in moderate humidity within the incubator. No moisture was added to the potting soil during the incubation period.

On 23 April the eggs were candled and all but one appeared fertile. On 3 May the eggs were again candled and five appeared to contain living embryos. One of the remaining eggs was definitely infertile, while the other was questionable.

On 26 June five eggs had begun to collapse, indicating that they were losing water. They were then all placed in individual pint jars half filled with pea gravel and one quarter filled with water. Lids with holes were put on the jars and the jars were placed back in the incubator. Within a day, the eggs filled out again and 4 July the first began to hatch. By 6 July, the five eggs had hatched. Two eggs were opened and found to be infertile. All hatchling *Rhamphiophis* made slits and emerged from the ends of the eggs. This is unlike our experience with other colubrid hatchlings which emerge from the top of the eggs.

HATCHLINGS

The hatchlings appeared in good condition. Juvenile coloration was quite different from the adult solid tan dorsal color, having light flecking on a brown background. The young were weighed and measured at hatching (Table 1).

Table 1. Measurements of *Rhamphiophis oxyrhynchus* eggs and hatchlings with means and ranges.

	EGGS		HATCHLINGS	
EGG	WEIGHT (gm)	LENGTH X WIDTH (mm)	WEIGHT (gm)	LENGTH
A	12.0	51.9 x 18.6	10.8	30.5
B	12.5	48.3 x 19.0	9.0	30.0
C	13.1	50.2 x 18.8	-	-
D	14.0	57.5 x 18.5	10.0	30.3
E	14.2	53.1 x 19.5	8.2	29.6
F	13.9	52.0 x 19.1	-	-
G	13.7	51.7 x 19.2	10.2	33.0
Mean	13.3	52.0 x 18.9	9.8	30.6
Range	(12.0-14.2)	(48.3-57.5) x (18.5-9.5)	(8.2-10.8)	(29.6-33.0)

Three of the hatchlings fed voluntarily; two on newborn mice, and one on a dead salamander (*Plethodon cinereus*). The other two specimens were force-fed mouse tails dipped in liquid vitamins.

DISCUSSION

Clutch sizes recorded in the literature range from 6 to 17 and eggs are reported to be laid over a period of days (Fitzsimons, 1962; Pitman, 1974; Sweeney, 1971). In this paper clutches were small (7 to 9 eggs) and were laid within a 24-hour period. There may be a relation between the clutch size and the laying period, but more data is needed to confirm this.

Eggs found in natural habitats are reported to range from 34 - 44 mm in length to 20 - 22 mm in width (Fitzsimons, 1962). In this paper, the eggs of the infertile clutch averaged smaller, (42.5 x 14.8 mm) and lighter (6.9 gm) than those of the fertile clutch (52.0 x 18.9 mm and 13.3 gm). Egg size and weight may be related to fertility, but again, more data is needed to confirm this.

Pitman (1974) reports an incubation period of approximately three months. This corresponds reasonably well with the 73 day period in this paper. The time difference is probably a result of different incubation temperatures.

Rhamphiophis are good exhibition animals due to their diurnal activity and gentle, hardy nature. Our experience in breeding this species and caring for the young should help us improve our techniques and increase our future success with *Rhamphiophis*.

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Bibliography

Fitzsimons, U.F.M.
1962. Snakes of Southern Africa. *Purnell and Sons, Ltd., Johannesburg*, pp. 215-217.

________________.
1970. A field guide to the snakes of Southern Africa. *Collins, London*, pp. 130-131.

Isemonger, R. M.
1968. Snakes of Africa. *Cape and Transvaal Printing, Ltd., Capetown*, p. 167.

Pitman, C. R. S.
1974. A guide to the snakes of Uganda. *Robert MacLehose & Co., Ltd., Glasgow*, pp. 151-152.

Sweeney, R. C. H.
1971. Snakes of Nyaasaland. *A. Asher & Co., N.V., Amsterdam*, pp. 70-72.

Division of Reptiles and Amphibians, National Zoological Park,
Smithsonian Institution, Washington D.C. 20008.

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FOOD TYPES AND DISTRIBUTION AS A *PLETHODON* HABITAT PARTITIONING FACTOR

Thomas K. Pauley

ABSTRACT

Food types and distribution were studied in an attempt to assess the influence of food on habitat partitioning between *Plethodon wehrlei* (a large eastern *Plethodon*) and *Plethodon cinereus* (a small eastern *Plethodon*).

Both *P. wehrlei* (adults and juveniles) and *P. cinereus* were found to feed almost exclusively on the same kind and size of invertebrates. The three major taxa of invertebrates were somewhat abundant throughout the study area. The distribution of *P. wehrlei* and *P. cinereus* in the study area did not seem to be in any way related to the distribution of invertebrates.

Food is most likely an object of competition between *P. wehrlei* and *P. cinereus*, but food abundance and non-coincidental feeding probably prevents the densities of either species from ever reaching competition levels.

INTRODUCTION

Jaeger (1972) hypothesized that food is the limiting resource for which salamanders are in competition and thus is an important factor in habitat partitioning. He found that the slightly larger *Plethodon nettingi shenandoah* consumes larger prey than *P. cinereus*, but when in sympatry with *P. cinereus* of a comparable size, the two species did compete for food of the same size.

Fraser (1974), in his studies of *P. cinereus* and *P. hoffmani*, found that habitat dryness could promote competition for food, but it probably does not occur. He based his conclusion on the fact that the animals simply do not feed at the same time.

The purpose of this study is to test the hypotheses that food distribution, food taxa groups, and food size are not factors in the habitat partitioning of *P. wehrlei* and *P. cinereus*.

DESCRIPTION OF THE STUDY AREA

This study was conducted two miles west of the Harrison County-Doddridge County line in West Virginia. The elevation ranges from 274 meters to 366 meters. This area is well positioned within the overlapping ranges of *P. wehrlei* and *P. cinereus*.

The total area studied was somewhat triangular in shape, approximately 137 meters at the bottom and 198 meters at the top. Horizontally, the eastern 122 meters to 145 meters faced northwest and the western 15 meters to 53 meters faced north.

In the eastern 90 meters of the study area, *Plethodon wehrlei* comprised 87.4 percent of the *Plethodon* population, while *P. cinereus* comprised only 12.6 percent. In the western 90 meters of the study area, the opposite was the case. Here, *P. cinereus* comprised 85.8 percent of the population, whereas *P. wehrlei* comprised only 14.2 percent.

METHODS AND MATERIALS

Plethodontids prey almost exclusively on invertebrates, so it is important to study the distribution of the prey in the study area, the kinds of prey consumed, and the size of the prey in relation to the head width of the salamander. Both laboratory and field studies were completed to collect these data.

A survey of the invertebrates was done by systematically walking through the study area and collecting all invertebrates within reach. Each specimen was identified and its exact location recorded in established transects. If identification was questionable, the invertebrates were put in vials containing 75 percent ethyl alcohol and returned to the laboratory for identification. Samples of soil were taken from each transect and returned to the laboratory where the soil invertebrates were filtered out by use of a Berlese funnel.

Sixty-one adult *P. wehrlei*, 22 juvenile *P. wehrlei*, and 86 adult *P. cinereus* were collected from the study area, put in vials containing 10 percent formalin, and returned to the laboratory for stomach content studies. The width of each salamander's head at the widest point, behind the eyes, and the snout-vent length were measured to the nearest tenth of a millimeter using a verner caliper. The stomach contents were sorted and identified by the taxonomic order. The length and width of each item was measured to the nearest tenth of a millimeter using a dissecting scope with an ocular micrometer.

RESULTS

Three major invertebrate groups were found in the study area (Table 1). Their distribution did not correspond to the distribution of plethodontids in the study area.

Because the two *Plethodon* studied were dissimilar in size, stomach content analyses and head width/prey comparisons were made between the adults of the smaller species, *P. cinereus*, and juveniles of the larger, *P. wehrlei*, as well as between the adult *P. cinereus* and adult *P. wehrlei*. Ninety-five percent of the 169 salamanders examined had a food item in their stomachs. Ants (Formicidae) were the major food ingested by adults of both species as well as the juveniles of *P. wehrlei* (Table 2). Regardless of head width, the majority of adults of both species and the juveniles of *P. wehrlei* ingested prey that ranged from 0.5 mm to 1.0 mm wide (Figure 1).

DISCUSSION

If food plays an important role in the microdistribution of *P. wehrlei* and *P. cinereus*, then the distribution in the study area of both

	Meters	
	East	West
	0 - 90	91 - 180
Formicidae	47.4	52.4
Acaria	60.6	39.3
Coeloptera	44.8	55.1

Table 1. Percentage distribution of the major invertebrates groups found in the study area.

	P. wehrlei (adults)			P. cinereus (adults)			P. wehrlei (juveniles)		
	Number of prey eaten	Number of salamander containing prey	Percent of prey in salamander	Number of prey eaten	Number of salamander containing prey	Percent of prey in salamander	Number of prey eaten	Number of salamander containing prey	Percent of prey in salamander
Formicidae	124	38	56.1	147	64	48.8	44	12	48.9
Acaria	20	11	9.1	78	36	25.9	7	6	7.8
Araneidae	10	9	4.5	12	8	4.0	2	2	2.2
Coeloptera	28	24	12.7	11	11	3.7	2	2	2.2
Collembola	4	2	1.8	12	8	4.0	21	5	23.3
Others	35	29	15.6	41	33	13.6	14	10	15.5

Table 2. Major taxonomic groups of invertebrates found in the stomachs of both adult *P. wehrlei* and *P. cinereus* and juvenile *P. wehrlei*.

size and kind of prey should be similar to the plethodontid distribution. The distribution of invertebrates did not appear to be similar to the distribution of *P. wehrlei* and *P. cinereus*. Therefore, no relationship can be assumed between the occurrence of the two plethodontids and the occurrence of food.

Stomach content studies revealed that 160 of 169 (95.0 percent) salamanders had ingested some food item. This would indicate that food was abundant and available to all individuals throughout the study area.

Adult *P. wehrlei* and *P. cinereus* as well as juvenile *P. wehrlei* were shown to prefer prey of nearly the same size and kinds. The consumption of prey of the same kind and size range would indicate that food is an object of competion. While this may be true, the extent of this competition would be reduced because of the non-coincidental feeding behavior of plethodontids; i.e., they have staggered feeding schedules. This staggered feeding schedule reduces interspecific competition for food and thereby renders food more available per individual. In addition, the stomach content analysis indicated that food is abundant throughout the study area. It is therefore concluded that neither kind nor size of food is important in habitat partitioning.

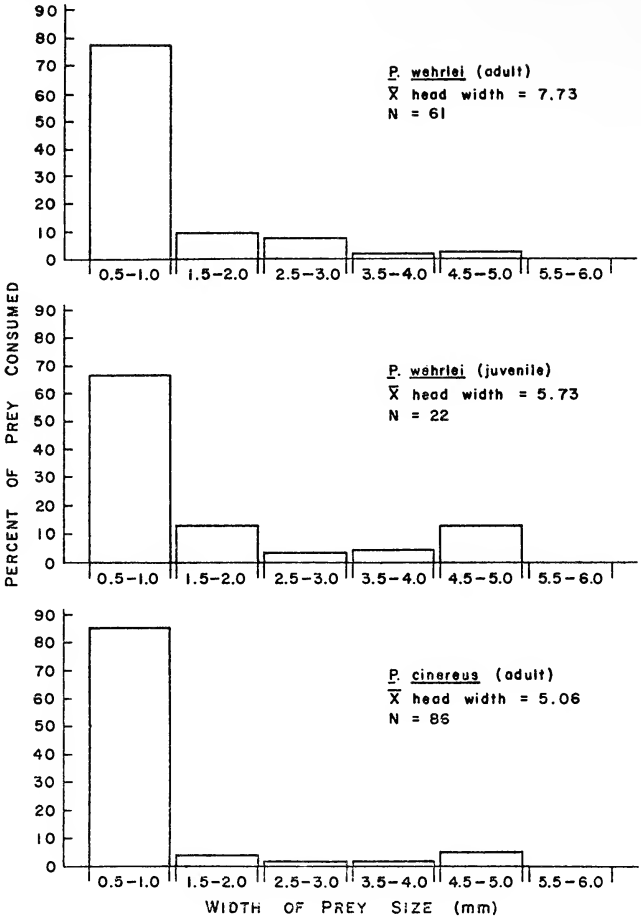

Figure 1. Percentage of food consumption by adult and juvenile *P. wehrlei* and adult *P. cinereus* in relation to head and width.

Literature Cited

Fraser, D.
1974. Interactions between salamanders of the genus *Plethodon* in the central Appalachians. *Ph. D. Thesis, University of Maryland.*

Jaeger, R.
1969. Competitive exclusion and environmental tolerences in the distribution of two species of salamanders (genus *Plethodon*) in Virginia. *Ph. D. Thesis, University of Maryland*

Department of Natural Science, Salem College,
Salem, West Virginia 26426, USA

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REPRODUCTION IN A PAIR OF CAPTIVE ARIZONA RIDGE-NOSED RATTLESNAKES, *Crotalus willardi willardi* (REPTILIA, SERPENTES, CROTALIDAE)

Until recent years, information on reproduction in the *Crotalus willardi* complex has been scant in the literature. For eight previously reported broods, five were *C. w. willardi* (Klauber, 1949, 1972; Martin, 1975 a, 1975b; Quinn, 1977), one was *C. willardi meridionalis* (Klauber 1972), one *C. willardi obscurus* (Martin, 1976), and one *C. willardi silus* (Klauber, 1949, 1972). Of these, only one brood of *C. w. willardi* (Martin, 1975b) and one brood of *C. willardi obscurus* (Martin, 1976) were conceived in captivity. The present report deals with an additional captive breeding of *C. w. willardi*. Included are notes on copulation, gestation, and hibernation with a description of the neonates. Presented is evidence that at least a biennial reproductive cycle occurs in *C. w. willardi* from Arizona.

MATERIALS AND METHODS

An adult female *C. w. willardi* (total length 495 mm, weight 108.0 g, post-partum), collected 20 July 1974, Huachuca Mountains, Cochise Co., Arizona, and an adult male (total length 548 mm, weight 177.7 g), received as a juvenile 20 November 1973 from the Huachuca Mountains, Cochise Co., Arizona, were periodically placed together in 38 l and 76 l aquaria. Paper toweling was used as a substrate and hiding boxes were provided for the security of the snakes. Water was always available but the cages remained dry. Humidity varied from approximately 50 percent in summer to approximately 30 percent in winter. Lighting was provided through large, south-facing windows which enabled the snakes to experience a year-around natural photoperiod for the Fort Worth, Texas area. Artificial lighting was not used, and no attempt was made to darken the enclosures during the winter months.

Temperatures varied between approximately 20-32°C year-around until 1975. On 1 December of 1975 and 1976 the temperature was allowed to drop gradually over a period of one week until lows of 9-12°C were achieved. Daily recordings were taken at 7 am and 6 pm for lows and highs, respectively. No attempt was made to maintain a constant temperature, and variations of approximately 2-5°C were observed on most days. An attempt was made, however, to keep low temperatures at 9°C or above. Seasonal warming occurred in March and April of each year.

Feeding occurred every 10-20 days during active periods on 15-20 g laboratory mice. Feeding was discontinued approximately three weeks prior to cooling. Although temperatures during mid to late March were conducive to much activity, feeding was not initiated until approximately 20 April of each year.

Adults and neonates were measured for snout-vent length and total length using the squeeze-box technique (Quinn and Jones, 1974), and weighed on a triple-beam balance 48 h after the birth of the brood.

RESULTS

The pair was separated during hibernation, and the female was introduced into the male's enclosure periodically throughout the warm months. No attempt was made to analyze ritualized courtship. If the female appeared particularly un-receptive she was removed shortly after introduction, and if not, she remained for up to 10 days or until copulation occurred. Upon introduction, the male immediately began courting with rapid, longitudinal chin-rubbing (1 sec) and tongue flicks (2-3 sec) against the female dorsally and dorso-laterally. If un-receptive, she reacted with an immediate, rapid slapping of the tail from side to side and an attempt to escape, or she assumed a tight coil. Receptiveness was indicated by a lack of tail-slapping and the female slowly crawled about the enclosure which intensified the male's courtship attempts. Once the male assumed a position of loose coils on and paralled to the female's body, she raised her tail slightly and ceased forward momentum. The male then looped his tail under hers and attempted to align the cloacae with several anterior-posterior strokes. If intromission was not accomplished the sequence of chin rubbing, tail tightening and cloacal search began again (see Chiszar, et al., 1976). Once intromission was accomplished, most movement subsided in both snakes for approximately 1-2 min, whereupon chin rubbing and tongue flicking was periodically initiated by the male. Entire body movement was reduced during actual coitus. On several occasions, a rapid head bobbing movement was observed in the female during coitus. This, in turn, accelerated chin rubbing behavior in the male. Time elapsed between chin rubbing episodes lengthened proportionally to copulatory duration.

Copulation was effected 19 June 1975 and 22 June 1976. The female had shed several hours prior to the initiation of each coitus. Non-receptivity by the female was observed until actual ecdysis occurred. This closely paralled observations by Martin (1975b) who reported that copulation occurred shortly after female ecdysis on 16 June. These were the only female sheddings since the collection date until 29 May 1977. At this time, the female was introduced but male courtship activities were reduced and female non-recptivity was extreme. Although introductions occurred on numerous occasions, female receptivity and eventual coitus seemed determined by her summer ecdysis.

Klauber (1972) reported that normal copulatory durations in *Crotalus* varied from 6-12 h, but mentioned a pair of *C. r. ruber* that remained *in copulo* for at least 22.75 h. Copulatory durations herein varied from 15-24 h and may have been longer as complete sequences were not observed. Because the snakes were not placed together for extended periods when observations could not be made, it is extremely doubtful that additional copulation took place. Intense courtship was not observed after actual copulation had occurred in either year.

The pair was cooled from 1 December 1976 until warming occurred in March and April 1977. From the initiation of cooling until approximately mid March, the female was only once observed out of the hiding box, although occasionally high temperatures of 15-17°C were recorded during February and early March. During late March and early April, activity slowly increased and she was seen drinking water on numerous occasions.

Laboratory mice were first offered 20 April 1977 (temperature 22°C) and were refused by the female though readily accepted by the male. The female continued to fast until 4 August 1977.

Partruition occurred in the hiding box on 1 August 1977 and was not observed. Investigation revealed three living neonates and one infertile mass. Total length varied from 166-172 mm ($\overline{x}$ = 169.3 mm) and weight varied from 4.4 -5.8 g ($\overline{x}$ = 5.2 g). Sex was determined by percentage of tail length to total length. For two females, tail length percentage was 7.5 and 7.6, and for one male was 9.0. Mean total length of the neonates was 34.2 percent of the female parent's total length

Coloration at birth contrasted to descriptions given by Martin (1975a, 1975b) of broods from Santa Rita Mountain parents, and agreed with those given by Quinn (1977) for a Huachuca Mountain brood. Overall ground coloration was dark chocolate brown with dark tails. No evidence of yellow tail coloration was noted. Ecdysis occurred six and eight (two snakes) days after birth. At this time, overall ground coloration was a light brownish gray.

DISCUSSION

Although it is well known that reproductive events observed in captive reptiles do not necessarily correlate with what might be expected in the wild (see Fitch, 1970), the events reported herein are consistant with previous accounts.

Copulation has not been observed in this species in the field, however, copulation dates given for captive specimens are 16 June and 28 July (Martin, 1975b), and "July" and "early August" (Martin, 1976). This agrees with the summer mating pattern (19, 22 June) described herein. Birth dates of broods conceived in the wild have been 14 August (Quinn, 1977) and 18 August (Martin, 1975a), while those that were the result of captive breeding were 1 August (this paper), 2 August (Martin, 1976) and 10 September (Martin, 1975b).

Biennial reproductive cycles have been proposed for a number of pitvipers (Harris and Simmons, 1972; Rahn, 1942; Tinkle, 1962; Wharton, 1966). An even longer (triennial) cycle may be present in *C. horridus atricaudatus* in certain parts of it's range (Gibbons, 1972), and St. Girons (1957) reported biennial and triennial cycles present in *Vipera aspis* which were dependant upon particular climatic conditions. Obviously climate and geographical area effect reproductive cycling, but many other factors are involved (Fitch, 1970). *C. willardi* is mainly a resident of pine-oak woodland occurring from the Transition Zone downward into the Upper Sonoran Life Zones (Harris and Simmons, 1976; Lowe, 1964). The elevational distribution of this species in Arizona varies from ca. 1550-2750m. At these elevations, activity periods (ie, reproductive periods) are reduced. Extended periods of hibernation plus limited activity periods might lend themselves to a biennial reproductive cycle in this species in southern Arizona and perhaps elsewhere where similar climatic conditions prevail. Also, in addition to data presented herein, the gestation periods for reported captive bred *C. willardi* have been approximately 13 months (Martin, 1975b, 1976) which indicates the presence of at least a biennial cycle in this species.

Martin (1975b) stated that cooling preceeding the birth of his brood could not at that time be determined as influential. Personal observation of a multitude of forms has shown that while many temperate species do not require a cooling period for reproductive cycling, a hibernation period will assure successful reproduction in most cases. All reported captive breedings of *C. willardi* have employed hibernation. In addition, in cases where hibernation did not occur, copulation has been observed year after year without subsequent production of young. It can be said that most probably, a cooling period is not only influential, but is required for reproductive cycling in this species.

Most observations of reproduction in *C. willardi*, and for that matter many other relatively rare species, have been made under captive conditions. If attention is focused on duplicating natural conditions of photoperiod and most particularly temperature as closely as possible for captive specimens, the reproduction of many forms once considered difficult may become commonplace. In addition, observed reproductive cycling may be close if not identical to that which occurs in nature. For these reasons, properly conducted studies of captive reptiles by zoo personnel and private individuals are valuable. Not only can they assertain behavioral and reproductive characteristics, but studies of this nature may aid in clarifying the status of threatened and endangered species, such as certain members of the *Crotalus willardi* complex.

Figure 1. Newborn *Crotalus willardi willardi*

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Literature Cited

Chiszar, D., K. Scudder, H. M. Smith, and C. W. Radcliffe.
1976. Observations of courtship behavior in the western massassauga (Sistrurus catenatus tergeminus). *Herpetologica 32*:337-338.

Fitch, H. S.
1970. Reproductive cycles in lizards and snakes. *Misc. Publ. Univ. Kan. Mis. Nat. Hist. 52*:1-247.

Gibbons, J. W.
1972. Reproduction, growth, and sexual dimorphism in the canebrake rattlesnake (Crotalus horridus atricaudatus). *Copeia 1972*: 222-226.

Harris, Herbert S., Jr. and Robert S. Simmons.
1972. An April birth record for *Crotalus lepidus* with a summary of annual broods in rattlesnakes. *Bull. Md. Herp. Soc. 8* (2):54-56.

______________________________.
1976. The paleogeography and evolution of *Crotalus willardi*, with a formal description of a new subspecies from New Mexico, United States. *Bull. Md. Herp. Soc. 12*(1):1-22.

Klauber, L. M.
1949. The subspecies of the ridge-nosed rattlesnake, (Crotalus Willardi). *Trans. San Diego Soc. Nat. Hist. 11*(8):121-140.

__________.
1972. Rattlesnakes, their habits, life histories, and influence on mankind. Vol. 1 and 2. *Univ. Calif. Press, Berkeley and Los Angeles*. 1: xxx + 740 pp., 2: xvii + 741-1533 pp.

Lowe, C. H.
1964. Part 3. Amphibians and reptiles of Arizona. *In*: the vertebrates of Arizona, C. H. Lowe, ed. *Univ. Arizona Press, Tucson,* x + 270 pp.

Martin, B. E.
1975a. Notes on a brood of the Arizona ridge-nosed rattlesnake, *Crotalus willardi willardi*. *Bull. Md. Herp. Soc. 11*(2):64-65.

__________.
1975b. A brood of Arizona ridge-nosed rattlesnakes, *Crotalus willardi willardi*, bred and born in captivity. *Bull. Md. Herp. Soc. 11*(4):187-189.

__________.
1976. A reproductive record for the New Mexican ridge-nosed rattlesnake (*Crotalus willardi obscurus*). *Bull. Md. Herp. Soc. 12* (4):126-128.

Quinn, H.
1977. Further notes on reproduction in *Crotalus willardi* (Reptilia, Serpentes, Crotalidae). *Bull. Md. Herp. Soc. 13*(2):111.

______., and J. P. Jones.
1974. Squeeze box technique for measuring snakes. *Herp. Rev. 5*(2):35.

Rahn, H.
1942. The reproductive cycle of the paririe rattler. *Copeia 1942:* 233-240.

St. Girons, H.
1957. Le cycle sexual chez *Viper aspis* (L.) dou l'ouest de la France. *Bull. Biol. de la France et de la Belgique 91*:284-350.

Tinkle, D. W.
1962. Reproductive potential and cycles in female *Crotalus atrox* from north-western Texas. *Copeia 1962:*306-313.

Wharton, C. H.
1966. Reproduction and growth in the cotton-mouths, *Agkistrodon piscivorus* Lacepede, of Cedar Keys, Florida. *Copeia 1966:* 149-161.

—Bern W. Tryon, *Department of Herpetology, Fort Worth Zoological Park, 2727 Zoological Park Drive, Fort Worth, Texas 76110.*

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LARGEST REPORTED TIGER SALAMANDER

The tiger salamander, *Ambystoma tigrinum*, is found in larval, neotenic and terrestrial forms and, typical of urodeles, is carnivorous in all three stages. In some cases, neotenic animals express the trait of cannibalism and grow to unusually large sizes. Powers (1903, 1907) described physical characteristics of animals exhibiting the cannibalistic trait. In his comments about the cannibals of *A. tigrinum*, Reese (1975) reiterated Powers' conclusion that large size is commonly associated with the cannibalistic trait. Smith and Reese (1968) described an animal collected near Denver, Colorado which was the largest living *A. tigrinum* known up to that date. Its diet consisted of earthworms and small larvae of the same species. The association of large size with the cannibalistic trait appears to be the case for the animals described below.

Included in Table 1 are measurements of the three largest neotenes collected on 23 August 1975 via seining of a pond near Jamestown, Colorado (elevation: 2100 m). All three exhibit characters typical of cannibals including large overall size and wide heads. The measurements of Reese's largest neotene (RWR 131) and his examples of normal neotenes (RWR 40, 41 and 34) are added for comparison.

Table 1. Measurements of Record Size and Normal Tiger Salamanders.

Animal	Snout-vent (mm)	Tail (mm)	Head-width (mm)	snout-vent/head Ratio	weight (g)
1 (Snow)	168.6	151.5	64.5	2.61	434.0
2 (Snow)	159.2	167.4	56.5	2.81	298.0
3 (Snow)	151.5	152.0	48.2	3.14	172.8
RWR 131	145.0	146.0	56.7	2.56	333.5
Normal					
RWR 40	110.0	117.0	33.3	3.30	77.2
RWR 41	114.0	104.4	30.2	3.77	62.1
RWR 34	114.2	92.7	30.8	3.71	88.6

Apparently, the trait of cannibalism in *A. tigrinum* results in the observed abnormal large sizes. Normal animals consume a diet of mostly small insects, insect larvae and molluscs which inhabit the pond with them (Dodson and Dodson, 1971). The cannibal, by consuming one large meal, expends less energy in foraging and digestion than does the normal animal which consumes many small items of prey containing proportionately greater amounts of non-digestible material than does the single large meal of a cannibal.

Neotenic tiger salamanders can be induced to metamorphose if given injections of thyroxin (Norris and Platt, 1973a) or thyroid stimulating hormone, TSH (Norris and Platt, 1973b). This artificially induced transfornation can be inhibited via injections of prolactin (Gona and Etkin, 1970). Choun and Norris (1974) stated that animals given injections of prolactin with TSH readily accepted food. This effect may be due to the increased level of circulating prolactin since it is commonly observed that transforming animals, presumably having low levels of circulating prolactin, cease eating.

Giant neotenic cannibals may have a high level of circulating prolactin which causes an increased feeding drive. Conversely, the ample supply of food may result in an increase in circulating prolactin which, in turn, inhibits metamorphosis. It would be of interest to determine the cause and effect relationship between these two factors.

Literature Cited

Choun, J. L. and Norris, D.O.
1974. The effects of prolactin dose on rate of TSH-induced metamorphosis, weight loss and feeding frequency in larval tiger salamanders, *Ambystoma tigrinum*. *J. Colo.-Wyo. Acad. Sci.* *7*(5):68.

Dodson, S.I. and Dodson, V.E.
1971. The diet of *Ambystoma tigrinum* larvae from western Colorado. *Copeia 1971*:614-624.

Gona, A. G. and Etkin, W.
1970. Inhibition of metamorphosis in *Ambystoma tigrinum* by prolactin. *Gen. Comp. Endocrinol 14*:589-603.

Norris, D. O. and Platt, J.E.
1973. The effects of thyroxin and triiodothyronine doses on metamorphosis of immature and sexually mature larval tiger salamanders, *Ambystoma tigrinum*. *J. Colo.-Wyo. Acad. Sci.* *7*(4):39-40.

Powers, J. H.
1903. The causes of acceleration and retardation in the metamorphosis of *Ambystoma tigrinum:* a preliminary report. *Amer. Nat.* *37*:385-410.

____________.
1907. Morphological variation and its causes in *Ambystoma tigrinum*. *Nebraska Univ. Studies* *7*:197-272.

Reese, R. W.
1975. The "cannibals" of the tiger salamander. *Bull. Md. Herp. Soc.* *11*(4):180-184.

Smith, H. M. and Reese, R. W.
1968. A record tiger salamander. *Southwest Nat.* *13*:370-372.

—George E. Snow, *Department of Biological Sciences, Mount St. Mary's College, Los Angeles, California 90049.*

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A NOTE ON FOOD AND YOUNG IN *Natrix rigida*

Natrix rigida continues to be a secretive aquatic snake about whose biology little seems to be known. This note is intended merely to add two small items of information.

FOOD: In 18 Louisiana stomachs of *Natrix rigida*, Clark (1949) found seven fish, nine frogs (*Rana* and *Acris*) and two crayfish. Hamilton and Pollack (1956) noted a *Gastrophryne* in a stomach of a specimen from western Georgia. Crayfish alone were reported by Neill (1951), Schwartz and Etheridge (1954), Tinkle (1959) and Palmer and Whitehead (1961) from 11, 1, 1 and 1 specimens, respectively. Cook (1943) reported a snake attempting to eat a crayfish.

Incidentally, the first specimen of *Natrix rigida* I ever saw was a small one from southern Louisiana. It contained two intact dragonfly naiads.

Between 1955 and 1967 I encountered only five specimens of this snake in the North Carolina coastal plain (Brunswick County). One of these Carolina specimens had three Libellulid dragonfly naiads in its stomach and remains of one Libellulid and a Hydrophilid beetle larva in its gut. The intestine of another specimen disclosed gastroliths of three different crayfishes.

Albert Sanders, of the Charleston Museum, kindly permitted me to check the alimentary tracts of two dozen specimens from the fine series of this snake in that institution. Unfortunately many of these snakes were collected during flood times and apparently had not taken food for several days. Five specimens contained identifiable food remains: three crayfish and three dragonfly naiads.

Hence, combining these results with the two items from Schwartz and Etheridge (1954) and Palmer and Whitehead (1961) above, nine snakes from North and South Carolina have contained remains of 16 food items: eight crayfish, seven dragonfly naiads and one Hydrophilid beetle larva.

BROOD: Information is available on few broods of this snake. Huheey (1959) mentioned from Louisiana a 529 mm female with nine eggs, a 660 mm female with 14 eggs, and a brood of 11 young from unspecified female. Clark (1949) noted seven embroys in a Louisiana specimen of unstated size. Abercrombie (1973) reported eight young from a 432 mm (TL) south Georgia snake.

About midnight on a rainy 29 August, I found a freshly killed (DOR) *Natrix rigida* in Brunswick County, North Carolina 9 mi NW of Supply. This snake was a gravid female, 560 mm snout-vent length (680 mm TL). Its brood of nine young, so far as I could estimate, would have been born during the next week or 10 days. Five of the young averaged 138 mm (range 130 to 148) in snout-vent length and 176 mm (range 165 to 188) in total length. These five young together weighed 14 g (mean 2.8 g). The female without the young weighed 118 g.

Incidentally, the five older snakes noted earlier from Brunswick County had ventral-caudal scale counts as follows: one male with 131-58; four females with 135-55, 135-52, 134-54 and 133-54. The five young of one brood (from the second female noted above) had these counts: 133-61, 136-59, 134-51, 134-59 and 133-54.

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Literature Cited

Abercrombie, C. L., III
1973. [Life history]: *Regina r. rigida*. *HISS News-J.* *1*(3):91.

Clark, R. F.
1949. Snakes of the hill parishes of Louisiana. *J. Tenn. Acad. Sci.* *24*(4):244-261.

Cook, F. A.
1943. Snakes of Mississippi. *Miss Game & Fish Comm., Survey Bull.*, 73 pp.

Hamilton, W. J., Jr. and J. A. Pollack.
1956. The food of some colubrid snakes from Fort Benning, Georgia. *Ecology* *37*(3):519-526.

Huheey, J. E.
1959. Distribution and variation in the glossy water snake, *Natrix rigida* (Say). *Copeia* *1959*(4):303-311.

_____________ and W. M. Palmer.
1962. The eastern glossy water snake, *Regina rigida rigida*, in North Carolina. *Herpetologica* *18*(2):140-141.

Palmer, W. M. and D. E. Whitehead.
1961. Herpetological collections and observations in Hyde and Tyrrell Counties, North Carolina. *J. Elisha Mitchell Sci. Soc.* *77*(2):280-289.

Neill, W. T.
1951. Notes on the role of crawfishes in the ecology of reptiles, amphibians and fishes. *Ecology* *32*(4):764-766.

Schwartz, A. and R. Etheridge.
1954. New and additional herpetological records from the North Carolina coastal plain. *Herpetologica* *10*(3):167-171.

Tinkle, D. W.
1959. Observations of reptiles and amphibians in a Louisiana swamp. *Amer. Midland Natur.* *62*(1):189-205.

—E. E. Brown, *Box 343, Davidson North Carolina 28036.*

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AN ADDITIONAL LOCALITY FOR JEFFERSON'S SALAMANDER, *Ambystoma jeffersonianum*, IN MARYLAND

Published localities for Jefferson's salamander, *Ambystoma jeffersonianum*, in Maryland are few. First reported from the state on Plummer's Island, Montgomery County by Brady (1937), this piedmont record, based solely on egg masses, has not been fully accepted by any subsequent worker, owing to the absence of larvae or metamorphosed specimens from the locality and the apparent restriction of this salamander in Maryland to the Appalachian Province. [A locality shown by Uzzell (1967) for an area in very close proximity to Plummer's Island is based on USNM 83433 from Dead Run Swamp, Fairfax County, Virginia (Thomas M. Uzzell, Jr., pers. comm).]

Netting (1946) supplied the first reliable documentation of *Ambystoma jeffersonianum* in Maryland, and since that time only two other specific localities for the state have appeared in print (Stine and Simmons, 1952; Hahn and Goodwin, 1966). The most recently published distributional map of this species (Harris, 1975) indicates that at least seven populations are now known (or known to have existed) in three western Maryland counties: three in Allegany County, one in Washington County, and three in Frederick County. While *A. jeffersonianum* has previously been recorded from the Valley and Ridge Province of Allegany County, it seems worthwhile to note an additional locality, particularly since this salamander is considered by some authorities to be an endangered species in Maryland (Committee ..., 1973).

In connection with a study on the red-spotted newt, *Notophthalmus viridescens*, by one of us (Hershey), a drift fence was erected in late July and early August 1977 around a roughly circular, man-made pond (circumference ca. 75 m) situated near the junction of Mertens Avenue and Twigg Road, Green Ridge State Forest, Allegany County, Maryland (elevation 300 m). Weekly trips were made to the locality by Hershey and others from August to November (1977). On 15 October, eight adult *Ambystoma jeffersonianum* were discovered in an equal number of can traps on the outside of the barrier. The spacing of the salamanders in the containers suggested a convergence on the site, possibly for the purpose of winter hibernation. While it is generally assumed that *A. jeffersonianum* hibernates underground, literature specific on this point is not known to us. The salamanders were removed from the cans and placed on the pond side of the fence. One week later (22 October) a single adult individual (80 mm SVL, 158 mm TL) was found dead in a container inside the barrier; this specimen is catalogued AR-1997-TSU in the vertebrate collection of Towson State University. No further *A. jeffersonianum* were noted between 22 October and 19 November, when study of the area was terminated for the year and the cans inverted.

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Literature Cited

Brady, M. K.
1937. Natural history of Plummers Island, Maryland. VI. Reptiles and amphibians. *Proc. Biol. Soc. Washington* 50(36):137-139.

Committee on Rare and Endangered Amphibians and Reptiles of Maryland.
1973. Endangered amphibians and reptiles of Maryland. *Bull. Maryland Herp. Soc.* *9*(3):42-100.

Hahn, Richard A. and Peter S. Goodwin.
1966. Collecting notes from Frederick County, Maryland, with two new county records. *Bull. Maryland Herp. Soc.* *2*(2):8-9.

Harris, Herbert S., Jr.
1975. Distributional survey (Amphibia/Reptilia): Maryland and the District of Columbia. *Bull. Maryland Herp. Soc.* *11*(3):73-167.

Netting, M. Graham.
1946. Jefferson's salamander in Maryland. *Maryland J. Nat. Hist.* *16*(3):60-61.

Stine, Charles J. and Robert S. Simmons.
1952. A new county record for Jefferson's salamander in Maryland. *Maryland Nat.* *22*(3-4):45-47.

Uzzell, Thomas.
1967. *Ambystoma jeffersonianum. Cat. Amer. Amphib. Rept.*:47.1-47.2.

—Robert Miller, *P.O. Box 21, Brooklandville, Maryland 21022,* and J. L. Hershey, *Department of Biology, Towson State University, Towson, Maryland 21204.*

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NOTES ON WORM-EATING IN THE PRAIRIE RINGNECK SNAKE, *Diadophis punctatus arnyi*

INTRODUCTION

The prairie ringneck snake, *Diadophis punctatus arnyi*, is a small snake which ranges from Iowa and eastern Nebraska south through south-central Texas. It characteristically inhabits rocky hillsides in open woods where it secretes itself under stones, logs and other surface litter. Food includes earthworms, insects, frogs, toads, salamanders, snakes and lizards (Blanchard, 1942). Fitch (1975) found that earthworms were the most common food item of the prairie ringneck snake in Kansas. Many researchers, including Hudson (1942), Anderson (1965) and Henderson (1970), have observed that earthworms are eaten readily in captivity. The peculiar observation that earthworms crawl down the throats of snakes has been reported for *Clonophis kirtlandi* (Smith, 1965; Tucker, 1977), *Thamnophis radix* (Tucker, 1977) and *Storeria dekayi texana* (Mary Horst, pers. comm.). This paper reports observations made on the ingestion of worms by two captive *Diadophis punctatus arnyi*.

MATERIALS AND METHODS

The snakes were collected under a log on a rocky creek bank in Tarrant Co., Texas on 13 November 1977. On 24 December the snakes measured 101 and 138 mm in total length. Blanchard (1942) reports 4 hatchlings varied from 98 to 108 mm in total length. The snakes were offered 1-2 worms at approximately weekly intervals. Detailed observations were made on the ingestion of 15 worms during a three month period.

RESULTS AND DISCUSSION

There was no apparent attempt by the snake to initially secure a hold at either the anterior or posterior end of the worm. Rather, the worm was attacked at any point along it's length. Henderson (1970) stated that "several times it seemed that the snakes hesitated in order to strike at a particular end of the worm, but it was not determined which end was sought." The worm usually writhed violently and often wrapped several coils around the snake's head and neck. The snake moved backward; the tail moved rapidly from side to side as if searching for a secure hold. Ingesting an earthworm may require that the snake firmly anchor itself to keep the worm from escaping. The backward motion may also assist in dislodging the worm from the head and neck and in keeping the worm stretched out in front of the snake. After the initial struggle, the worm lost, or released, it's hold on the snake and attempted to crawl off. At this point the snake initiated jaw movements which slowly moved the worm into it's throat. This caused the worm to be doubled over and the short end quickly disappeared into the snake due to contractions of the worm. On four occasions the worm was seized within 1-2 mm of an end and a few jaw movements quickly moved that end into the mouth cavity. On two other occasions a grip on the posterior end of the worm was attained in several minutes due to both jaw movements by the snake and attempts by the worm to crawl forward.

If the anterior end was initially engulfed, the worm usually disappeared into the snake with 1-6 contractions within 2-15 seconds. If the posterior end was engulfed, the subsequent ingestion process usually took 2-3 minutes, but on one occasion it took nearly ten minutes. The worm attempted to escape by crawling forward and usually only short contractions occurred within the area of the snake's mouth cavity. These contractions were used to advantage by slow jaw movements and the worm was slowly moved posteriorly. On two occasions the worm suddenly contracted to such an extent that it disappeared into the snake within 1-2 seconds.

Two types of jaw movement were evident. Characteristic unilateral feeding movements were used to slowly pull the worm posteriorly. At other times during the swallowing process, the mouth was slowly opened and closed. During these periods, the worm usually moved slowly into the snake by means of short contractions.

According to Tucker (1977), this phenomenon occurs when the snake begins swallowing a worm from the posterior end. This study indicates that it occurs regardless of which end is initially seized or engulfed; indeed, the process appears to be more rapid when the worm is seized at the anterior end.

Due to the posteriorly curved teeth, the worm is unable to move back out of the snake's mouth once a contraction pulls it deeper into the snake. *Diadophis*, like most xenodontine snakes, have enlarged teeth on the posterior end of the maxilla, which in other snakes of this subfamily are usually associated with a mild venom. It is not clear whether *Diadophis* secretes a venom, though Shaw and Campbell (1974) reported that one observer experienced a burning sensation after being bitten. Regardless of the possible association of the enlarged teeth with venom, these teeth may be of great assistance in swallowing earthworms and other food items.

Literature Cited

Anderson, P.
1965. The reptiles of Missouri. *University of Missouri Press, Columbia, Missouri*, 330 pp.

Blanchard, F. N.
1942. The ring-neck snakes, genus *Diadophis*. *Bull. Chicago Acad. Sci. 7*(1):1-144.

Fitch, H. S.
1975. A demographic study of the ringneck snake (*Diadophis punctatus*) in Kansas. *Univ. Kansas. Misc. Publ. Mus. Nat. Hist.* No. 62:1-53.

Henderson, R. W.
1970. Feeding behavior, digestion and water requirements of *Diadophis punctatus arnyi* Kennicott. *Herpetologica 26*(4):520-526.

Hudson, G. E.
1942. The amphibians and reptiles of Nebraska. *Nebraska Conserv. Bull. 24*:1-146.

Shaw, C. E. and S. Campbell.
1974. Snakes of the American west. *Alfred A. Knopf, New York, N. Y.*, 332 pp.

Smith, H. M.
1965. Snakes as pets. *T.F.H. Publications, Inc., Jersey City, N.J.* 126 pp.

Tucker, J. K.
1977. Notes on the food habits of Kirtland's water snake. *Bull. Md. Herp. Soc. 13*(3):193-195.

—Gary Carl, *Department of Herpetology, Fort Worth Zoological Park, Fort Worth, Texas 76110.*

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OBSERVATIONS ON A CAPTIVE MONA ISLAND BOA, *Epicrates monensis monensis* ZENNECK

On 22 May 1974 an *Epicrates monensis* was collected on Mona Island, Puerto Rico. Inasmuch as this is only the tenth known specimen of this rare snake and the first to be observed for any period in captivity, we feel the following observations are noteworthy.

The specimen (USNM 075006) was collected at 10:15 p.m. while active on a branch of a small tree approximately 1.3 m above ground on the southeast side of Isla Mona, approximately 1 km W of Playa de Pajaros. The habitat was subtropical-dry deciduous short-tree forest (Plateau Forest, Rogers, 1975) with an open canopy. Dominant plants included *Cocoloba microstachya*, *Metopium toxiferum*, *Bursera simaruba*, *Croton discolor*, *Dodonea viscosa* and *Opuntia repens*. The specimen is a male, TL 74.7 cm (tail=14.2 cm) with 243 ventrals, 80 caudals, anal single, and 35-41-23 scale rows. The intersupraoculars series is 4-1-3, infralabials 14/14, supralabials 12/13, loreals 1/1, and the 11 circumorbital scales include 2 preoculars and 6 postoculars. Supralabials 6 and 7 enter the orbit on both sides, a condition considered more typical of *E. m. granti* by Sheplan and Schwartz (1974).

The color pattern conforms closely to the description of *E.m. monensis* in Sheplan and Schwartz (1974). The boa was pale brown in life with a series of 52 darker brown dorsal blotches, each bordered by black. The dorsal blotches are irregular in configuration; many joined at the midline to produce a zig-gag effect for short distances at several points along the body whereas others are fused to produce saddle-shaped markings. The blotches are frequently interrupted laterally into the dorsal blotch proper and a smaller ventrolateral blotch. The tail has a series of 15 dark blotches, several of which cross the venter to form rings. There is an indistinct postocular stripe and a pair of transverse dark bars at the occiput. These do not unite with the ventral portion of the first body blotch to form the U-shaped mark described in Sheplan and Schwartz (1974). The venter is white with scattered brown stippling. This specimen is illustrated in color in Laycock (1975).

During the 14 months the boa was kept in captivity it maintained a strictly nocturnal activity pattern, seldom being seen outside of its retreat before full dark. When active it spent most of the time in the branches in the cage, even drinking from the ground level water bowl while entwined in the branches. It was seen on the floor of the cage only when returning to or emerging from the floor level retreat.

The only food items accepted throughout most of the captive period were lizards of the genus *Anolis* (both *A. carolinensis* and *A. sagrei*). These were taken preferentially to other food items. Hairless pink baby mice, appropriately sized *Sceloporus undulatus* and *S. woodi*, and *Hyla cinerea* were offered periodically throughout the captive period and were refused. These alternate food items were offered in conjunction with *Anolis* on 17 occasions and alone on 39 occasions. On all of the 17 occasions where the snake was offered a choice it selected the *Anolis*, evidence that feeding motivation was high and that *Anolis* was the preferred prey species. On many of the occasions where alternate prey were offered, these were left in the cage with the snake for up to two weeks in the case of the *Sceloporus* or for 2 or 3 days with the others. These foods were ignored throughout the entire period.

During the final months of captivity the boa became accustomed to the events associated with feeding despite efforts to minimize external cues to the feeding procedure. During this period it began to emerge from the retreat whenever the cage was disturbed and would immediately approach any moving object in or immediately outside the cage. On two occasions it approached pink mice and nosed them before returning to the retreat and on three occasions performed the same actions with *Hyla cinerea*. On 28 July 1975 it seized and ate a *Hyla cinerea* immediately after the frog was placed in the cage. Two days later, on 30 July, it disgorged the *Hyla* and died after a period of spasms and convulsions.

The specific preference for *Anolis* exhibited by this captive may be natural for subadults under natural conditions but adults, which reach a maximum overall length of 1010 mm (Meerwarth 1901), might be expected to accept a wider variety of prey such as birds, bats, rats, and other small mammals and possibly subadult *Cyclura* which are partially arboreal (Thomas Wiewandt, pers. comm.).

The arboreal habits of the boa appear to reflect the natural habits of the species on Mona Island. On one occasion a large tree was cut down by fishermen at Playa de Pajaros because it harbored two or more boas. They were reported to live in the tangle of branches surrounding its trunk and to emerge at night to climb into the crown (Thomas Wiewandt, pers. comm.). This habit may be a significant factor favoring the survival of this species in the face of predation by the introduced rats, cats and pigs on Mona Island. If predation and habitat modification by humans and habitat destruction by the introduced goats can be controlled, the Mona Island Boa may face no other serious threat to its survival.

Literature Cited

Laycock, G.
1975. Islands Columbus knew. *Audubon Mag.*, *77*(4):46-59.

Meerwarth, H.
1901. Die westindischen Reptilien und Batrachier des naturhistorischen Museums in Hamburg. *Mitth. Naturh. Mus. Hamburg, 18:* 1-41.

Rogers, L.
1975. The vegetation of Mona Island. *in*: Primer Simposio del Departamento de Recursos Naturales. *Depto Recursos Naturales, San Juan, P.R.*, pp. 41-45.

Sheplan, B. R. and A. Schwartz.
1974. Hispaniolan boas of the genus Epicrates (Serpentes, Boidae) and their antillean relationships. *Ann. Carnegie Mus. 45*: 57-143.

—Howard W. Campbell, *National Fish and Wildlife Laboratory, 412 N.E. 16th Ave., Room 250, Gainesville, Florida* and Frederick G. Thompson, *Florida State Museum, Gainesville, Florida.*

Received 14 March 1978

Accepted 23 April 1978

A NOTE ON THE BEHAVIOR OF THE DIAMONDBACK TERRAPIN, *Malaclemys t. terrapin* (SCHOEPFF) IN MARYLAND

During the summer of 1976 Steve Quick and I spent several days craffing from the U. S. Route 50 Bridge over the Choptank River, Dorchester County, Maryland. The river at this point is ca 1800 m in width and is bordered by salt marsh. Depth ranges from 1 to 10 m and there is considerable tidal flow. We used several types of wire mesh crab traps designed to lie flat on the bottom which when raised to the surface by a string retained any crabs attracted to the bait placed in the center of the trap.

Along with blue crabs (*Callinectes* sp), sixteen adult diamondback terrapins, *Malaclemys t. terrapin*, (16 to 23 cm straight line carapace length) were captured. The turtles were attracted to several baits, including shad, salted eel, other fish parts, chicken parts, soft crab parts and various shellfish species (in approximate order of preference). Turtles were captured during daylight hours as well as after dark. The terrapins were often observed congregated around the bridge abuttments and pilings, perhaps to feed on epibenthic organisms attached there. They may also have been attracted by fish entrails discarded by fishermen cleaning their catch. The turtles observed were generally docile and allowed close approach without submerging.

Carr (1952) reports that diamondback terrapins feed primarily upon crustaceans and molluscs, so it is interesting to note their apparent attraction to both fresh and cured fish.

I would like to thank both Mr. Arnold Norden and Mr. Daniel Carver for their helpful criticisms of this manuscript.

Literature Cited

Carr, A.
1952. Handbook of turtles. *Cornell Univ. Press, Ithaca, N.Y.* p 168.

—John D. Cochran, *Maryland Herpetological Society, 2643 North Charles Street, Baltimore, Maryland 21218.*

Received 5 April 1978

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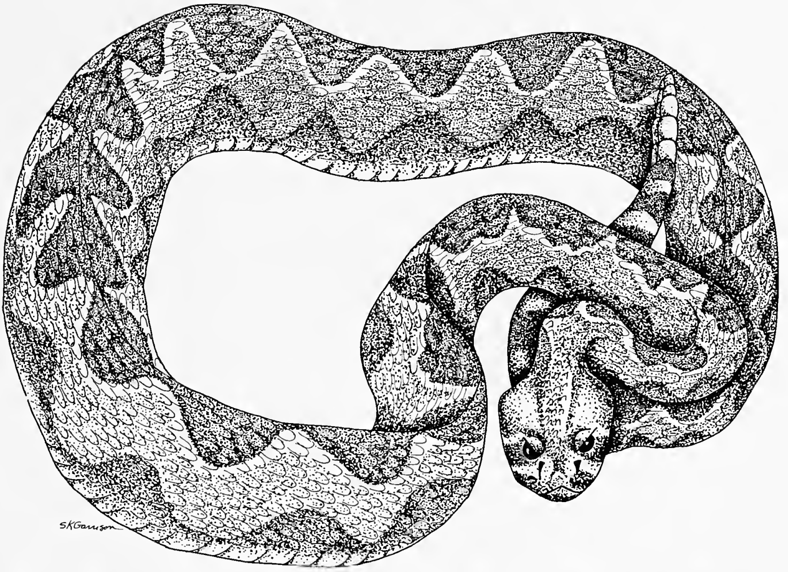

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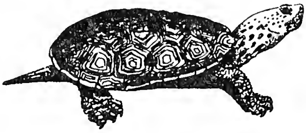
A PRELIMINARY ACCOUNT OF THE RATTLESNAKES WITH THE DESCRIPTIONS OF FOUR NEW SUBSPECIES

HERBERT S. HARRIS, JR. & ROBERT S. SIMMONS



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CONTENTS

Editor's Note: In the paper "A preliminary account of insular rattlesnake populations..." (*Bull. Md. Herp. Soc.* 13(2):92-110), *Crotalus tigris* should be added to the list of species known from Isla Tiburón. Ronald Crombie of the USNM kindly informed me of two specimens (USNM 093591, 093692) collected at Tecomate around Camp Caracol, Isla Tiburón during Sept. - Oct. 1976 by NFWL party including R. Crombie, Norm Scott, Clyde Jones, et. al.

H.S.H.

Editor's Note: The paper presented here was one of many presented 5 November 1976 at the Primer Congreso Mundial de Ofidiologia, Caracas, Venezuela. A "Proceedings" of this meeting was to be published prior to December 31, 1976, but has never materialized. This paper published here, has been withdrawn from publication in that proceedings should it ever be published. H.S.H.

Editor's Note: Reviewers for Volume 14 included:
Donald Broadley, Jerry D. Hardy, Jr., Robert G. Webb, and John Wright.

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NOTICE: The increase in Subscription Rates indicated above is necessary to offset our increased cost due to rising printing and postage rates and to the increasing number of pages per issue of this journal. We sincerely hope you will bear with us........Editor

BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

VOLUME 14 30 SEPTEMBER 1978 NUMBER 3

A PRELIMINARY ACCOUNT OF THE RATTLESNAKES WITH THE DESCRIPTIONS OF FOUR NEW SUBSPECIES

Herbert S. Harris, Jr. and Robert S. Simmons

In the following preliminary account of the rattlesnakes, genera *Crotalus* and *Sistrurus*, we have listed all species and subspecies currently recognized as valid, and in addition, have included an abbreviated description of four new taxa. Formal descriptions will follow at a later date. Although this is not a standard practice, we hope it will be tolerated for the sake of completeness.

In this arrangement, species are listed alphabetically. Subspecies are listed alphabetically under the nominate species. Following the species or subspecies listed, an abbreviated synonymy is given. It contains the earliest listing of the name currently recognized and also a reference to the taxonomic work giving the usage currently accepted as valid. In a few instances, these may be the same name, indicating that other names or combinations may have been accepted for a period of time, before returning to the earlier name. In some instances, additional listings were needed to clarify current usage.

In this list the subspecies *Crotalus triseriatus aquilus* Klauber has been elevated to specific level, and will be recognized as *Crotalus aquilus* Klauber. Klauber's paratypic series contained three forms, *Crotalus pricei, Crotalus triseriatus* and *Crotalus aquilus*. Of the latter two, only *Crotalus aquilus* occurs at the type locality. This snake is intermediate in many characters between *C. triseriatus* and *C. lepidus*, but is as different as they are from each other.

Crotalus triseriatus anahuacus Gloyd has been resurrected as it fully describes the high elevation montane form occurring on all the peaks across the Volcanic Axis of Mexico being dark and having the blotches reduced to spots. However, the type locality restriction is not justified for this subspecies since it is a montane form restricted to higher elevations than Coyoacán, Mexico.

Crotalus atrox elegans Schmidt has been resurrected from synonymy as *Crotalus ruber elegans* for the red diamond rattlesnakes of Ángel de la Guarda, Gulf of California, Baja del Norte, Mexico. These snakes are stunted as compared to *C. r. ruber* of the mainland and differ in some meristic characters. These differences will be treated at length in a future paper.

Two recently described subspecies on which the descriptions are in press are included as they should appear prior to this paper. In addition, two subspecies have been listed in their respective places on which a description will be forthcoming.

We are currently evaluating the taxonomy and distributions of all rattlesnake species using all available taxonomic techniques. At this time, the list reflects our current understanding, however, there are a number of additional forms that may require a new description or restructuring.

Immediately following the synonymy section, are illustrations of the majority of known rattlesnakes and distribution maps indicating the currently known distribution of each species and subspecies. In the case of *C. t. triseriatus* and *C. t. anahuacus* a composite map is used at this time.

Crotalus adamanteus Beauvois

Eastern Diamondback Rattlesnake

Figure 1, Map 1

1799. *Crotalus adamanteus* Beauvois, Trans. Amer. Philos. Soc., vol. 4, no. 42, p. 368. Type locality: U.S.; type specimen: none designated. Type locality: restricted to Charleston, S.C. by Schmidt, 1953, p. 227.

1895. *Crotalus adamanteus*; Stejneger, Rept. U. S. Nat. Mus. for 1893, p. 433.

Crotalus atrox Baird and Girard

Western Diamondback Rattlesnake

Figure 2, Map 2a & 2b

1853. *Crotalus atrox* Baird and Girard, Cat. North Amer. Rept., part 1, p. 5. Type locality: Indianola (Calhoun County), Texas; type specimen: USNM 7761.

1930. *Crotalus atrox*; Klauber, Bull. Zoöl. Soc. San Diego, no. 6, p. 6.

Crotalus aquilus Klauber

Queretaran Blotched Rattlesnake

Figure 3, Map 3

1952. *Crotalus triseriatus aquilus* (Part) Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 24. Type locality: near Alvarez, San Luis Potosí, Mexico; type specimen: MCZ 27843.

Crotalus basiliscus basiliscus (Cope)

Mexican West-Coast Rattlesnake

Figure 4, Map 4

1864. *Caudisona basilisca* Cope, Proc. Acad. Nat. Sci. Phila., vol. 16, no. 3, p. 166. Type locality: near Colima, Colima, Mexico; type specimen: USNM 53586. Type locality subsequently restricted to Colima, Colima, by Smith and Taylor, 1950, Univ. Kansas Sci. Bull., vol. 33, part 2, no. 8, p. 328.
1948. *Crotalus basiliscus basiliscus* Gloyd, Nat. Hist. Misc., no. 17, p. 1.

Crotalus basiliscus oaxacus Gloyd

Oaxacan Rattlesnake

Figure 5, Map 4

1948. *Crotalus basiliscus oaxacus* Gloyd, Nat. Hist. Misc., no. 17, p. 1. Type locality: Oaxaca, Oaxaca, Mexico; type specimen: USNM 46467.

Crotalus catalinensis Cliff

Santa Catalina Island Rattlesnake

Figure 6, Map 5

1954. *Crotalus catalinensis* Cliff, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 5, p. 80. Type locality: Santa Catalina Island, Gulf of California, Mexico; type specimen: Stanford 15631.

Crotalus cerastes cerastes Hallowell

Mojave Desert Sidewinder

Figure 7, Map 6

1854. *Crotalus cerastes* Hallowell, Proc. Acad. Nat. Sci. Phila., vol. 7, p. 95. Type locality: borders of the Mohave River, and in the desert of the Mohave (California); type specimen: designated, no number, disposition unknown.

1944. *Crotalus cerastes cerastes* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 10, no. 8, p. 94.

Crotalus cerastes cercobombus Savage and Cliff

Sonoran Desert Sidewinder

Figure 8, Map 6

1953. *Crotalus cerastes cercobombus* Savage and Cliff, Nat. Hist. Misc. no. 119, p. 2. Type locality: near Gila Bend, Maricopa County, Arizona; type specimen: Stanford 7287.

Crotalus cerastes laterorepens Klauber

Colorado Desert Sidewinder

Figure 9, Map 6

1944. *Crotalus cerastes laterorepens* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 10, no. 8, p. 94. Type locality: The Narrows, San Diego County, California; type specimen: LMK 34074.

Crotalus durissus durissus Linnaeus

Central American Rattlesnake

Figure 10, Map 7

1758. *Crotalus durissus* Linnaeus, Syst. Nat. ed. 10, p. 214. Type locality: America; type specimen: originally in Claudius Grill Surinam collection; the collection later sent to the Zoölogical Museum of the Royal University at Upsala, Sweden, but the type was apparently lost. Type locality subsequently restricted to Jalapa, Veracruz, Mexico, by Smith and Taylor, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 348, 1950.

1952. *Crotalus durissus durissus* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 61.

Crotalus durissus cascavella Wagler

Northeastern Brazilian Rattlesnake

Figure 11, Map 8

1824. *Crotalus cascavella* Wagler, in Spix, Sp. Nov. Serp. Bras. p. 60, pl. 24. Type locality: Bahia, Brazil; restricted through neotype designation to Mina Caraiba, Bahia Brazil, by Hoge, Mem. Inst. Butantan, vol. 32, p. 139, 1965; neotype specimen: IBH 23 400.

1966. *Crotalus durissus cascavella* Hoge, Mem. Inst. Butantan, vol. 32, p. 139, 1965.

Crotalus durissus collilineatus Amaral

Central Brazilian Rattlesnake

Figure 12, Map 8

1926. *Crotalus terrificus* var. *collilineatus* Amaral, Rev. Mus. Paulista, vol. 15, p. 90. Type locality: none specified in original description, restricted through lectotype designation to Estado de Mato Grosso, Brazil by Amaral and Hoge, in Hoge, Mem. Inst. Butantan, vol. 32, p. 139, 1965; lectotype specimen: IBH n? 2180.

1966. *Crotalus durissus collilineatus* Hoge, Mem. Inst. Butantan, vol. 32, p. 139, 1965.

Crotalus durissus culminatus Klauber

Northwestern Neotropical Rattlesnake

Figure 13, Map 7

1952. *Crotalus durissus culminatus* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 65. Type locality: Hacienda El Sabino, near Uruapan, Michoacán, Mexico; type specimen: Taylor 5224.

Crotalus durissus cumanensis Humboldt

Venezuelan Rattlesnake

Figure 14, Map 8

1833. *Crotalus cumanensis* Humboldt in Humboldt and Bonpland, Recueil d'Obs. Zool. Anat. Comp., vol. 2, p. 6. Type locality: Cumaná, Venezuela; type specimen: none designated.
1966. *Crotalus durissus cumanensis* Hoge, Mem. Inst. Butantan, vol. 32, p. 142, 1965.

Crotalus durissus dryinas Linnaeus

Guianian Rattlesnake

Figure 15, Map 8

1758. *Crotalus dryinas* Linnaeus, Systema Naturae, ed. 10, p. 214. Type locality: America; restricted to Paramaribo, Surinam, by Hoge, Mem. Inst. Butantan, vol. 32, p. 143, 1965; type specimen: originally in the Adolph Frideric Museum; later this collection was sent to the Zoölogical Museum of the Royal University at Upsala, Sweden, but the type specimen was lost.
1966. *Crotalus durissus dryinus* Hoge, Mem. Inst. Butantan, vol. 32, p. 142, 1965.[1]

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[1] Hoge changed *dryinas* to *dryinus*; however, *dryinas* is correct.

Crotalus durissus marajoensis Hoge

Marajoan Rattlesnake

Figure 16, Map 8

1966. *Crotalus durissus marajoensis* Hoge, Mem. Inst. Butantan, vol. 32, p. 143, 1965. Type locality: Tuiuiu, Ilha de Marajó, State Pará, Brazil; type specimen: IBH 17 779.

Crotalus durissus neoleonensis Zertuche

Nuevo Leon Neotropical Rattlesnake

Figure 17, Map 7

1978. *Crotalus durissus neoleonensis* Zertuche, In press.

Crotalus durissus ruruima Hoge

Mt. Roraima Rattlesnake

Figure 18, Map 8

1966. *Crotalus durissus ruruima* Hoge, Mem. Inst. Butantan, vol. 32, p. 145, 1965. Type locality: Paulo Camp, Mt. Roraima, Venezuela; type specimen: AMNH 36 056.

Crotalus durissus terrificus (Laurenti)

South American Rattlesnake

Figure 19, Map 8

1768. *Caudisona terrifica* Laurenti, Synopsis Reptilium, p. 93. Type locality: "Habitat in America infragraduum elev. 45", restricted through neotype designation to Julio de Castilho, Munićipil Taquari, Estado Rio Grande do Sul, Brazil, by Hoge, Mem. Inst. Butantan, vol. 32, p. 147, 1965; neotype specimen: IBH 22 997.

1936. *Crotalus durissus terrificus* Klauber, Occ. Papers, San Diego Soc. Nat. Hist., no. 1, p. 4.

Crotalus durissus totonacus Gloyd and Kauffeld

Totonacan Rattlesnake

Figure 20, Map 7

1940. *Crotalus totonacus* Gloyd and Kauffeld, Bull. Chicago Acad. Sci., vol. 6, no. 2, p. 12. Type locality: Panaco Island, about 75 miles south of Tampico, Veracruz, Mexico, 12 miles inland from Cabo Rojo; type specimen: Chi. Acad. 4469.
1945. *Crotalus durissus totonacus* Smith and Taylor, U. S. Nat. Mus., Bull. 187, p. 190.

Crotalus durissus trigonicus Harris and Simmons

Rupununi Savanna Rattlesnake

Figure 21, Map 8

1957. *Crotalus durissus terrificus* (Part) Allen and Neill, Herpet., vol. 13, no. 1, p. 67.
1972. *Crotalus durissus terrificus* (Part) Klauber, Rattlesnakes, vol. 1, p. 35.
1978. *Crotalus durissus trigonicus* Harris and Simmons, Mem. Inst. Butantan (In press).

Crotalus durissus tzabcan Klauber

Yucatán Neotropical Rattlesnake

Figure 22, Map 7

1952. *Crotalus durissus tzabcan* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 71. Type locality: Kantunil, Yucatán, Mexico; type specimen: CNHM 36168.

Crotalus enyo enyo (Cope)

Lower California Rattlesnake

Figure 23, Map 9

1861. *Caudisona enyo* Cope, Proc. Acad. Nat. Sci. Phila., vol. 13, p. 203. Type locality: Cape San Lucas, Baja California Sur, Mexico; type specimen: PANS 7159.

1954. *Crotalus enyo enyo* Lowe and Norris, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 4, p. 52.

Crotalus enyo cerralvensis Cliff

Cerralvo Island Rattlesnake

Figure 24, Map 9

1954. *Crotalus enyo cerralvensis* Cliff, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 5, p. 82. Type locality: Cerralvo Island, Gulf of California, Mexico; type specimen: Stanford 14021.

Crotalus enyo furvus Lowe and Norris

Rosario Rattlesnake

Figure 25, Map 9

1954. *Crotalus enyo furvus* Lowe and Norris, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 4, p. 52. Type locality: 10.9 miles north of El Rosario, Baja California del Norte, Mexico; type specimen MVZ 55388.

Crotalus exsul Garman

Cedros Island Diamond Rattlesnake

Figure 26, Maps 10 & 20

1883. *Crotalus exsul* Garman, Mem. Mus. Comp. Zoöl., vol. 8, no. 3, p. 114. Type locality: Cedros Island, west coast Baja California; cotype specimens: MCZ 652 (2 specimens).

Crotalus horridus horridus Linnaeus

Timber Rattlesnake

Figure 27, Map 11

1758. *Crotalus horridus* Linnaeus, Syst. Nat., ed. 10, p. 214. Type locality: America; type specimen: originally in the King Adolph Frideric collection; later sent to the Royal Zoological State Museum at Stockholm, but now lost. Type locality restricted to vicinity of New York City by Schmidt, 1953, p. 227.

1935. *Crotalus horridus horridus* Gloyd, Copeia, no. 4, p. 176.

1973. *Crotalus horridus*; Pisani, Collins and Edwards, Trans. Kan. Acad. Sci., vol. 75, no. 3, p. 255, 1972.

Crotalus horridus atricaudatus Latreille

Canebrake rattlesnake

Figure 28, Map 11

1802. *Crotalus atricaudatus* Latreille, in Sonnini and Latreille, Hist. Nat. Rept., vol. 3, p. 209. Type locality: Carolina; type specimen: none designated. Type locality restricted to Charleston, S.C., by Schmidt, 1953, p. 228.

1935. *Crotalus horridus atricaudatus* Gloyd, Copeia, no. 4, p. 176.

1973. *Crotalus horridus*; Pisani, Collins and Edwards, Trans. Kan. Acad. Sci., vol. 75, no. 3, p. 255, 1972.

Crotalus intermedius intermedius Troschel

Totalcan Small-Headed Rattlesnake

Figure 29, Map 12

1865. *Crotalus intermedius* Troschel, in Müller, Reisen in den Vereinigten

Staaten, Canada und Mexico, vol. 3, p. 613. Type locality: Mexico; type specimen: in Müller collection; later in the collection of the Zoölogical Institute at Bonn, which was subsequently destroyed in World War II.

1952. *Crotalus intermedius intermedius* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 9.

Crotalus intermedius gloydi Taylor

Oaxacan Small-Headed Rattlesnake

Figure 30, Map 12

1941. *Crotalus triseriatus gloydi* Taylor, Univ. Kans. Sci. Bull. vol. 27, part 1, no. 7, p. 130. Type locality: Cerro San Felipe, elevation 10,000 feet, near (15 km. northeast of) Oaxaca de Juárez, Oaxaca, Mexico; type specimen: EHT-HMS 23645.

1957. *Crotalus intermedius gloydi* Davis and Dixon, Sw. Nat., vol. 2, no. 1, p. 25.

Crotalus intermedius omiltemanus Günther

Omilteman Small-Headed Rattlesnake

Figure 31, Map 12

1895. *Crotalus omiltemanus* Günther, Biol. Cent.-Amer., Rept. Batr., p. 192. Type locality: Omilteme, Guerrero, Mexico; type specimens: BM 93.3.15.11 and 95.3.15.11 (currently BM 1946.1.19.28 and 29).

1952. *Crotalus intermedius omiltemanus* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 14.

Crotalus lannomi Tanner

Autlán Rattlesnake

Figure 32, Map 13

1966. *Crotalus lannomi* Tanner, Herpet., vol. 22, no. 4, p. 298. Type locality: 1.8 mi. west of the pass, Puerto Los Mazos, on Mexican Highway No. 80, Jalisco, Mexico; type specimen: BYU 23800.

Crotalus lepidus lepidus (Kennicott)

Mottled Rock Rattlesnake

Figure 33, Map 14

1861. *Caudisona lepida* Kennicott, Proc. Acad. Nat. Sci. Phila., vol. 13, p. 206. Type localities: Presidio del Norte and Eagle Pass, Texas; type specimens: two heads, now lost.

1936. *Crotalus lepidus lepidus* Gloyd, Occ. Papers Mus. Zoöl. Univ. Mich. no. 337, p. 2.

Crotalus lepidus klauberi Gloyd

Banded Rock Rattlesnake

Figure 34, Map 14

1936. *Crotalus lepidus klauberi* Gloyd, Occ. Papers. Mus. Zoöl. Univ. Mich., no. 337, p. 2. Type locality: Carr Canyon, Huachuca Mountains, Cochise County, Arizona; type specimen: MZUM 79895.

Crotalus lepidus maculosus Tanner, Dixon and Harris

Durango Rock Rattlesnake

Figure 35, Map 14

1972. *Crotalus lepidus maculosus* Tanner, Dixon and Harris, Great Basin Nat., vol. 32, no. 1, p. 16. Type locality: 15 miles (24 km) west of La Ciudad, near Highway 40, Durango, Mexico; type specimen: BYU 33328.

Crotalus lepidus morulus Klauber

Tamaulipan Rock Rattlesnake

Figure 36, Map 14

1952. *Crotalus lepidus morulus* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 52, f.n. Type locality: 10 miles northwest of Gómez Farías on the trail to La Joya de Salas, Tamaulipas, Mexico; type specimen: MZUM 101376.

Crotalus mitchellii mitchellii (Cope)

San Lucan Speckled Rattlesnake

Figure 37, Map 15a & 15b

1861. *Caudisona mitchellii* Cope, Proc. Acad. Nat. Sci. Phila., vol. 13, p. 293. Type locality: Cape St. (= San) Lucas, Baja California, Mexico; type specimen: USNM 529½, now lost.
1895. *Crotalus mitchellii mitchellii* (Part) Stejneger, Rept. U.S. Nat. Mus. for 1893, p. 454.
1936. *Crotalus mitchellii mitchellii* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 19, p. 154.

Crotalus mitchellii angelensis Klauber

Ángel de la Guarda Island Speckled Rattlesnake

Figure 38, Map 15b

1963. *Crotalus mitchelli angelensis* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 13, no. 5, p. 73. Type locality: Puerto Refugio, Ángel de la Guarda Island, Gulf of California, Mexico; type specimen: SDSNH 51994.
1972. *Crotalus mitchellii angelensis* Klauber, Rattlesnakes, vol. 1, p. 42.

Crotalus mitchellii muertensis Klauber

El Muerto Island Speckled Rattlesnake

Figure 39, Map 15b

1949. *Crotalus mitchellii muertensis* Klauber, Trans. San Diego Soc. Nat.

Hist., vol. 11, no. 6, p. 97. Type locality: El Muerto Island, Gulf of California, Mexico; type specimen: LMK 37447.

Crotalus mitchellii pyrrhus (Cope)

Southwestern Speckled Rattlesnake

Figure 40, Maps 15a & 15b

1866. *Caudisona pyrrha* Cope, Proc. Acad. Nat. Sci. Phila., vol. 18, p. 308. Type locality: not stated, but known from the type specimen to be Canyon Prieto, Yavapai County, Arizona; type specimen: USNM 6606.
1895. *Crotalus mitchellii pyrrhus* (Part) Stejneger, Rept. U.S. Nat. Mus. for 1893, p. 456.
1936. *Crotalus mitchellii pyrrhus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 19, p. 157.

Crotalus mitchellii stephensi Klauber

Panamint Rattlesnake

Figure 41, Map 15a

1930. *Crotalus confluentus stephensi* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 3, p. 108. Type locality: 2 miles west of Jackass Springs, Panamint Mountains, elevation 6,200 ft., Inyo County, California; type specimen: MVZ 6699.
1936. *Crotalus mitchellii stephensi* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 19, p. 162.

Crotalus molossus molossus Baird and Girard

Northern Black-Tailed Rattlesnake

Figure 42, Map 16a

1853. *Crotalus molossus* Baird and Girard, Cat. North Amer. Rept., part 1, p. 10. Type locality: Fort Webster, Santa Rita del Cobre (Grant County), New Mexico; type specimen: USNM 485.

1936. *Crotalus molossus molossus* Gloyd, Occ. Papers Mus. Zoöl. Univ. Mich., no. 325, p. 2.

Crotalus molossus estebanensis Klauber

San Esteban Island Rattlesnake

Figure 43, Maps 16a & 16b

1949. *Crotalus molossus estebanensis* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 6, p. 104. Type locality: San Esteban Island, Gulf of California, Mexico; type specimen: LMK 26792.

Crotalus molossus nigrescens Gloyd

Mexican Black-Tailed Rattlesnake

Figure 44, Map 16a

1936. *Crotalus molossus nigrescens* Gloyd, Occ. Papers Mus. Zoöl., Univ. Mich., no. 325, p. 2. Type locality: 4 miles west of La Colorada, Zacatecas, Mexico; type specimen: MZUM 77833.

Crotalus polystictus (Cope)

Mexican Lance-Headed Rattlesnake

Figure 45, Map 17

1865. *Caudisona polysticta* Cope, Proc. Acad. Nat. Sci. Phila., vol. 17, p. 191. Type locality: Tableland, Mexico; type specimen: none designated. Type locality subsequently restricted to Tupátaro, Guanajuato, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 330.

1875. *Crotalus polystictus* Cope, in Yarrow, Surv. W. of 100th Merid. (Wheeler), vol. 5, chap. 4, p. 533.

Crotalus pricei pricei Van Denburgh

Western Twin-Spotted Rattlesnake

Figure 46, Map 18

1895. *Crotalus pricei* Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, vol. 5, p. 856. Type locality: Huachuca Mountains (Cochise County), Arizona; type specimen: Stanford 1702.

1946. *Crotalus pricei pricei* Smith, Univ. Kans. Sci. Bull., vol. 31, part 1, no. 3, p. 79.

Crotalus pricei miquihuanus Gloyd[2], [3]

Eastern Twin-Spotted Rattlesnake

Figure 47, Map 18

1940. *Crotalus triseriatus miquihuanus* Gloyd, Chi. Acad. Sci. spec. pub. no. 4, p. 102. Type locality: Cerro Potosí, near Galeana, Nuevo León, Mexico; type specimen: CNHM 30850.

1946. *Crotalus pricei miquihuanus* Smith, Univ. Kans. Sci. Bull., vol. 31, part 1, no. 3, p. 79.

Crotalus pusillus Klauber

Tancitaran Dusky Rattlesnake

Figure 48, Map 19

1952. *Crotalus pusillus* Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 34. Type locality: Tancítaro, Michoacán, elevation 5,000 feet; type specimen: CNHM 39112.

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[2] A specimen (MZUM 110878) from near Rincón de Romos, Aquascalientes, Mexico was assigned (temporarily) to this subspecies by Klauber in his monumental work "Rattlesnakes" (1952), Vol. 1, p. 45. He points out that "Additional specimens, if like this individual...will justify the description of a new subspecies (of *C. pricei*), or maybe even a new species". This specimen is intermediate between *Crotalus pricei* and *Crotalus intermedius* both in meristic characters, pattern and geographic distribution. Additional specimens should indeed prove interesting in evaluating the evolution of both *C. pricei* and *C. intermedius*.

[3] A single specimen of *C. pricei* is available from Alvarez, San Luis Potosí, Mexico. This specimen SDSNH 19050 (LMK 3500) was included by Klauber as a paratype of *C. aquilus* (*C. t. aquilus* per Klauber). It is a male having 160 ventrals, Ca. 26 subcaudals, scale row formula of 21-21-17, 59 body blotches, 6 tail blotches, anterior subocular contacting 3rd and 4th supralabials, both the prenasal and postnasal in broad contact with the 1st supralabial, 11 rattle fringe scales, 6 scales in the prefrontal area (2 canthals, 4 intercanthals), and a pattern of cross-confluent bands. This specimen appears intermediate between *C. t. pricei* and *C. t. miquihuanus*; its meristic characters favoring the former and its pattern the latter.

Crotalus ruber ruber Cope

Red Diamond Rattlesnake

Figure 49, Map 20

1892. *Crotalus adamanteus ruber* Cope, Proc. U. S. Nat. Mus., vol. 14, p. 690. Type locality: not designated, but type specimen recorded as being from Southern California; type specimen: USNM 9209. Type locality subsequently restricted to Dulzura, San Diego County, California, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 356.
1949. *Crotalus ruber ruber* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 5, p. 59.

Crotalus ruber elegans Schmidt

Ángel de la Guarda Red Diamond Rattlesnake

Figure 50, Map 20

1922. *Crotalus atrox elegans* Schmidt, Bull. Amer. Mus. Nat. Hist., vol. 46, art. 11, p. 699. Type locality: Ángel de la Guarda Island, Gulf of California, Mexico; type specimen: USNM 64452, Paratypes: AMNH 5231, 5586.

Crotalus ruber lorenzoensis Radcliffe and Maslin

San Lorenzo Red Diamond Rattlesnake

Figure 51, Map 20

1975. *Crotalus ruber lorenzoensis* Radcliffe and Maslin, Copeia 1975, no. 3, p. 490. Type locality: San Lorenzo Sur Island in the Gulf of California, Baja California Norte, Mexico; type specimen: SDSNH 46009.

Crotalus ruber lucasensis Van Denburgh

San Lucan Diamond Rattlesnake

Figure 52, Map 20

1920. *Crotalus lucasensis* Van Denburgh, Proc. Calif. Acad. Sci., ser. 4, vol. 10, no. 2, p. 29. Type locality: Agua Caliente, Cape region of Baja California; type specimen: CAS 45888.
1949. *Crotalus ruber lucasensis* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 5, p. 59.

Crotalus ruber monserratensis subsp. nov.

Monserrate Red Diamond Rattlesnake

Figure 53, Map 20

1930. *Crotalus ruber* Klauber, Bull. Zoöl. Soc. San Diego, no. 6, p. 3.
1936. *Crotalus ruber* Klauber, Trans. San Diego Soc. Nat. Hist., vol. VIII, no. 20, p. 240.
1940. *Crotalus ruber* Gloyd, Chi. Acad. Sci. spec. pub. 4, p. 207.
1954. *Crotalus ruber ruber* (Part) Cliff, Trans. San Diego Soc. Nat. Hist., vol. XII, no. 5, p. 87.
1956. *Crotalus ruber ruber* (Part) Klauber, Rattlesnakes, vol. 1, p. 41.
1966. *Crotalus ruber ruber* (Part) Soulé and Sloan, Trans. San Diego Soc. Nat. Hist., vol. 14, no. 11, p. 143.
1972. *Crotalus ruber ruber* (Part) Klauber, Rattlesnakes, vol. 1, p. 46.

Diagnois. — A moderately drawfed island subspecies of *Crotalus ruber*. From mainland *C. r. ruber* it can be separated by its very vivid and distinctive pattern and in having 27 scale rows at midbody. It has a smaller head than either *C. r. ruber* or *C. r. lucasensis*. *C. r. monserratensis* has a higher number of body blotches than *C. r. lucasensis* and a lower number than *C. r. ruber*. It also has a lower number of subcaudals than either *C. r. ruber* or *C. r. lucasensis*. *C. r. monserratensis* can be separated further from *C. r. lucasensis* by the width of the light preocular stripe; generally two scale rows wide in *C. r. monserratensis*, whereas, in *C. r. lucasensis* it is generally 3 or more scale rows wide. It can be separated from *C. r. elegans* by its very contrasting and distinctive pattern and from *C. r. lorenzoensis* by having 27 scale rows at midbody instead of usually 25.

Type Specimens. — Holotype: RS 1217 HSH/RSS (NHSM), an adult male collected on Isla Monserrate, Gulf of California, Baja Sur, Mexico in July 1976 by James Nyhan. Paratypes: RS 1198, 1199, 1210-1226 HSH/RSS (NHSM).

Description of the Type Specimens.— Holotype: 930 mm total length, 61.5 mm tail length, 27 scale rows at midbody, 188 ventrals, 23 subcaudals, 16/16 supralabials, 18/17 infralabials, 29 body blotches (diamonds), 4 bands on the tail, maximum width of preocular stripe is 2 scales, first infralabials divided, prenasal contacts first supralabial, minimum number scales between supraoculars 6, 2 preoculars, prefoveals 9/8, loreals 2/2 (not counting a postloreal on each side), no intergenials or submentals, and 12 rattle fringe scales.

The following summary of the type specimens includes the holotype: Size, max. 1045 mm, min. 377 mm. Scale rows 27 at midbody; ventrals, males 188-201 (mean 195.6), females 194-203 (mean 197.6); subcaudals, males 21-25 (mean 23.1), females 18-22 (mean 19.4); supralabials, males 14-18 (mean 15.8), females 15-18 (mean 16.3); infralabials, males 16-18 (mean 17.1), females 15-19 (mean 17.6); body blotches (diamonds), males 29-36 (mean 32.6), females 30-34 (mean 32.8); tail length as percent of total length, males 6.46, females 5.26; maximum width of preocular stripe 1-2 scale rows (mean 1.8); first infralabials are divided; prenasal contacts the first supralabial in 65% of the specimens; min. number of scales between supraoculars 3-8 (mean 5.6); total length divided by head length, males 24.6, females 23.7; preoculars 2; prefoveals 6-12 (mean 8.5); loreals 1-3; rattle fringe scales 10-13 (mean 11.8). General ground color varies from light brown to rust brown with very distinctive dark diamonds outlined with white-tipped scales. The white-tipped scales bordering the diamonds are most obvious towards the center of the body, the neck and posterior portions being less distinctive. The diamonds consist of dark contrasting scales one scale row wide with centers that are darker than the ground color, but not nearly as dark as the one scale row wide diamond outline.

Range: — Known only from the type locality.

Crotalus scutulatus scutulatus (Kennicott)

Mojave Rattlesnake

Figure 54, Map 21

1861. *Caudisona scutulata* Kennicott, Proc. Acad. Nat. Sci. Phila., vol. 13, p. 207. Type locality: none designated; type specimen: none designated. Type locality subsequently restricted to Wickenburg, Maricopa County, Arizona, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 353.

1940. *Crotalus scutulatus scutulatus* Gloyd, Chi. Acad. Sci., spec. pub. 4, p. 200.

Crotalus scutulatus salvini Günther

Huamantlan Rattlesnake

Figure 55, Map. 21

1895. *Crotalus salvini* Günther, Biol. Cent.-Amer., Rept. Batr., p. 193. Type locality: Huamantla (Tlaxcala), Mexico, elevation 8,000 feet; type specimen: BM 73.1.13.1 (currently BM 1946.1.19.35).

1940. *Crotalus scutulatus salvini* Gloyd, Chi. Acad. Sci., spec. pub. 4, p. 201.

Crotalus stejnegeri Dunn

Long-Tailed Rattlesnake

Figure 56, Map 22

1919. *Crotalus stejnegeri* Dunn, Proc. Biol. Soc. Wash., vol. 32, p. 214. Type locality: Plumosas (= Plomosas), Sinaloa, Mexico; type specimen: USNM 46586.

Crotalus tigris Kennicott

Tiger Rattlesnake

Figure 57, Map 23

1859. *Crotalus tigris* Kennicott, in Baird, Repts. of Boundary, U. S. Mex. Boundary, Surv., vol. 2, p. 14. Type locality: Sierra Verde and Pozo Verde, Sonora, Mexico; type specimen: USNM 471.

Crotalus tortugensis Van Denburgh and Slevin

Tortuga Island Diamond Rattlesnake

Figure 58, Maps 2b & 24

1921. *Crotalus tortugensis* Van Denburgh and Slevin, Proc. Calif. Acad.

Sci., ser. 4, vol. 11, no. 17, p. 398. Type locality: Tortuga Island, Gulf of California, Mexico; type specimen: CAS 50515.

Crotalus transversus Taylor

Cross-Banded Mountain Rattlesnake

Figure 59, Map 25

1944. *Crotalus transversus* Taylor, Univ. Kans. Sci. Bull., vol. 30, part 1, no. 4, p. 47. Type locality: near Tres Marias (= Tres Cumbres), about 55 km. southwest of Mexico, D.F. in Morelos, Mexico, elevation about 10,000 ft.; type specimen: EHT-HMS 30001.

Crotalus triseriatus triseriatus (Wagler)

Central-Plateau Dusky Rattlesnake

Figure 60, Map 26

1830. *Uropsophus triseriatus* Wagler, Nat. Syst. Amph., p. 176. Type locality: Mexico; type specimen: originally in the König. Univers. zu Berlin collection. Type locality subsequently restricted to Alvarez, San Luis Potosí, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 342.[4]
1931. *Crotalus triseriatus triseriatus* (Part) Klauber, in Githens and George, Bull. Antivenin Inst. Amer., vol. 5, no. 2, p. 33.
1940. *Crotalus triseriatus triseriatus* (Part) Gloyd, Chi. Acad. Sci. spec. pub. 4, p. 84.
1952. *Crotalus triseriatus triseriatus* (Part) Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 19.

Crotalus triseriatus anahuacus Gloyd

Montane Dusky Rattlesnake

Figure 61, Map 26

1940. *Crotalus triseriatus anahuacus* (Part) Gloyd, Chi. Acad. Sci. spec.

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[4] This restriction not valid, since *C. t. triseriatus*, as now defined and as Klauber (1956) pointed out, does not range into San Luis Potosí.

pub. 4, p. 91. Type locality: Valley of Mexico; type specimen: MCZ 33681. Type locality subsequently restricted to Coyoacán, Distrito Federal, Mexico, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 329.[5]

Crotalus triseriatus ssp.

Western Dusky Rattlesnake

Figure 62

(Description forthcoming)

Crotalus triseriatus quadrangularis[6] subsp. nov.

Hidalgan Dusky Rattlesnake

Figure 63, Map 26

1952. *Crotalus triseriatus aquilus* (Part) Klauber, Bull. Zoöl. Soc. San Diego, no. 26, p. 24.
1956. *Crotalus triseriatus aquilus* (Part) Klauber, Rattlesnakes, vol. 1, p. 44.
1972. *Crotalus triseriatus aquilus* (Part) Klauber, Rattlesnakes, vol. 1, p. 49.

Diagnois.—A small rattlesnake very similar in appearance to the larger *C. aquilus* but differing in head shape, body proportions and in having a higher number of rectangular dorsal body blotches, with a one scale space between them. *C. aquilus* generally has fewer body blotches with 2 or more scales between each blotch. It can also be separated from *C. aquilus* in having a prominent and distinctive dark ocular stripe contrasting above as in *C. triseriatus*, whereas, in *C. aquilus* the dark ocular stripe is usually similar to that found in *C. lepidus*.

The character states used to separate *C. t. quadrangularis* from *C. aquilus* in their order of importance are: more than 36 body blotches; generally only 1 scale between blotches instead of 2 or more; supraocular arched, not flat; generally 3 or more prefoveals instead of 2 or less; prenasal curves under postnasal preventing contact of postnasal and first supralabial, instead of postnasal having broad contact with first supralabial; head scales bordering supraoculars dorsally total 17 or more,

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[5] This restriction is not justified since this form is a montane species restricted to higher elevations. It will be discussed in a forthcoming paper.

[6] *Quadrangularis*, Latin: referring to the rectangular dorsal blotches in this species.

instead of 16 or less (this is not counting upper preocular or upper postocular); first infralabials generally curve down between the genials instead of just meeting them; strong contrast between upper edge of postocular stripe and rest of head [color sexual dimorphism is apparent[7] in a number of populations of *C. aquilus* (a *C. lepidus* characteristic), the males being green and the females gray. In these males, there usually is strong contrast above the postocular stripe]. *C. t. quadrangularis* also differs from *C. aquilus* in not having the occassional mal-colored scale in the throat region (a *C. lepidus* characteristic) and in obtaining a smaller adult size.

C. t. quadrangularis can be separated from *C. t. triseriatus* in having a larger rattle size as was indicated by Klauber for *C. aquilus*. Klauber's type series contained both *C. t. quadrangularis* and *C. aquilus* which in preserative are almost impossible to separate.

Type Specimens. — Holotype: RS 1233 HSH/RSS (NHSM), an adult male collected September 1973, 3mi SW Jacala, Hidalgo, Mexico at an elevation of 6700' by Barry Armstrong. Paratypes: RS 1088, 1229, 1230, 1231, 1232, 1234 HSH/RSS (NHSM); PAS 11683, 11684, 14769; SDSNH 46795; USNM 140070.

Description of the Type Specimens. — Holotype: 457 mm total length, 41.5 mm tail length, 23 scale rows at midbody, 156 ventrals, 27 subcaudals, 12 supralabials, 11 infralabials, a total of 19 dorsal head scales surrounding supralabials (not counting upper preoculars or upper postoculars), anterior subocular contacts 4th and 5th supralabial, 40 body blotches, 6 tail bands, upper preocular single, prefoveals 3/4, 1 loreal, 6 scales in the internasal prefrontal area, min. number of scales between the supraoculars 2, 2 preoculars, 10 rattle fringe scales.

The following summary of the type specimens includes the holotype: Size, max. 508 mm, min. 194 mm. Scale rows 23 at midbody; ventrals, males 148-158 (mean 154.6), females 152-158 (mean 155.7); subcaudals, males 27-29 (mean 28.0), females 20-25 (mean 22.0); supralabials, males 11-12 (mean 11.6), females 11-13 (mean 12.1); infralabials, males 10-12 (mean 11.1), females 11-12 (mean 11.4); dorsal head scales around supraoculars (counting both sides as total) 14-20 (mean 17.1); anterior subocular generally contacts 4 and 5 supralabials; body blotches, males 35-41 (mean 38.2), females 37-48 (mean 40.4); tail blotches, males 5-7 (mean 5.8), females 3-7 (mean 5.1); tail length as percent of total length, males 9.08-10.06 (mean 9.45), females 6.70-7.92 (mean 7.45); upper preoculars single; prefoveals 2-5 (mean 3.2); loreals 1; rattle fringe scales 8-10 (mode 10). General ground color in life, varies from light grey through greyish-green to brown. The dorsal blotches, usually rectangular, are seldom indented longintudinal but may be indented on the sides. The blotches are generally out-lined with black, however, two specimens are without melanin. Tail color is usually lighter than ground color at least ventrally. The rattle matrix is brown and dotted with dark brown to black.

Range. — Known only at present from Minas Viejas, 3 mi, 18 mi, SW Jacala, Jacala, Zacualtipan all in the State of Hidalgo, Mexico. *C. t. quadrangularis* does not appear to be smypatric with *C. aquilus*.

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[7] *Crotalus lepidus* and *Crotalus triseriatus* are closely related as has been pointed out by both Smith (1946, Univ. Kan. Sci. Bull., vol. 31, pt. 1, no. 3, p. 87) and Gloyd (1940, Chi. Acad. Sci. spec. pub. 4, p. 81). With the segragation of *C. t. quadrangularis* and the elevation of *C. aquilus* to specific status, we may be opening a "can of worms". *C. aquilus* could very easily be placed as a subspecies of *C. lepidus*, however, so could *C. t. triseriatus*, *C. t. anahuacus*, and *C. t. quadrangularis* and we see no useful purpose in lumping them at this time. It is however, to be noted that *C. aquilus* is closer to *C. lepidus* than is *C. triseriatus*.

Crotalus unicolor van Lidth de Jeude

Aruba Island Rattlesnake

Figure 64, Map 8

1887. *Crotalus horridus* var. *unicolor* van Lidth de Jeude, Notes Leyden Mus., vol. 9, no. 8, p. 133. Type locality: Aruba Island, Netherlands West Indies; type specimen: Leyden Mus. 613 and 1579.
1972. *Crotalus unicolor* Harris and Simmons, Bull. Md. Herp. Soc., vol. 8, no. 1, p. 27.

Crotalus vegrandis Klauber

Uracoan Rattlesnake

Figure 65, Map 8

1941. *Crotalus vegrandis* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 9, no. 30, p. 334. Type locality: Maturín Savannah, near Uracoa, Sotillo District, state of Monagas, Venezuela; type specimen: CM 17384.
1956. *Crotalus durissus vegrandis* Klauber, Rattlesnakes, vol. 1, p. 34.
1966. *Crotalus vegrandis*; Hoge, Mem. Inst. Butantan, vol. 32, p. 145, 1965.

Crotalus viridis viridis (Rafinesque)

Prairie Rattlesnake

Figure 66, Map 27

1818. *Crotalinus viridis* Rafinesque, Amer. Month. Mag. & Crit. Rev., vol. 4, no. 1, p. 41. Type locality: The Upper Missouri (Valley); type specimen: none designated. Type locality subsequently restricted to Gross, Boyd County, Nebraska, by Smith and Taylor, 1950. Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 358.
1936. *Crotalus viridis viridis* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 2, p. 191.

Crotalus viridis abyssus Klauber

Grand Canyon Rattlesnake

Figure 67, Map 27

1930. *Crotalus confluentus abyssus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 3, p. 114. Type locality: Tanner Trail, 300 ft. below the south rim of the Grand Canyon, Coconino County, Arizona; type specimen: LMK 2216.
1936. *Crotalus viridis abyssus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

Crotalus viridis caliginis Klauber

Coronado Island Rattlesnake

Figure 68, Map 27

1949. *Crotalus viridis caliginis* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 6, p. 90. Type locality: South Coronado Island, northwest coast of Baja California, Mexico; type specimen: LMK 2800.

Crotalus viridis cerberus (Coues)

Arizona Black Rattlesnake

Figure 69, Map 27

1875. *Caudisona lucifer* var. *cerberus* Coues, Surv. W. of 100th Merid. (Wheeler), vol. 5, chap. 5, p. 606. Type locality: San Francisco Mountains, Coconino County, Arizona; type specimens: field numbers 509 (= PANS 7085?) and 511 (= PANS 7088).
1949. *Crotalus viridis cerberus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 6, p. 83.

Crotalus viridis concolor Woodbury

Midget Faded Rattlesnake

Figure 70, Map 27

1929. *Crotalus concolor* Woodbury, Bull. Univ. Utah, vol. 20, no. 6, p. (2). Type locality: King's Ranch, at the base of the Henry Mountains, Garfield County, Utah; type specimen: Utah 306.
1936. *Crotalus viridis concolor* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.
1940. *Crotalus viridis decolor* Gloyd, Chi. Acad. Sci. spec. pub. 4, p. 216.
1972. *Crotalus viridis concolor* Klauber, Rattlesnakes, vol. 1, p. 51.[8]

Crotalus viridis helleri Meek

Southern Pacific Rattlesnake

Figure 71, Map 27

1905. *Crotalus helleri* Meek, Field Col. Mus., Zoöl. Ser., vol. 7, no. 1, pub. 104, p. 7. Type locality: San José, Baja California, Mexico; type specimen: CNHM 1272.
1949. *Crotalus viridis helleri* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 6, p. 77.

Crotalus viridis lutosus Klauber

Great Basin Rattlesnake

Figure 72, Map 27

1930. *Crotalus confluentus lutosus* Klauber, Trans. San Diego Soc., Nat. Hist., vol. 6, no. 3, p. 100. Type locality: 10 miles northwest of Abraham on the road to Joy, Millard County, Utah; type specimen: LMK 1814.
1936. *Crotalus viridis lutosus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

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[8] Klauber, Rattlesnakes, 1972, vol. 1, p. 51 inadvertently listed himself as author in error.

Crotalus viridis nuntius Klauber

Hopi Rattlesnake

Figure 73, Map 27

1935. *Crotalus confluentus nuntius* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 13, p. 78. Type locality: Canyon Diablo, Coconino County, Arizona; type specimen: LMK 3105.
1936. *Crotalus viridis nuntius* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

Crotalus viridis oreganus Holbrook

Northern Pacific Rattlesnake

Figure 74, Map 27

1840. *Crotalus oreganus* Holbrook, North Amer. Herp., ed. 1, vol. 4, p. 115. Type locality: banks of the Oregon or Columbia River; type specimen: PANS 7158. Type locality subsequently restricted to The Dalles, Wasco County, Oregon, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 360.
1949. *Crotalus viridis oreganus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 6, p. 67.

Crotalus willardi willardi Meek

Arizona Ridge-Nosed Rattlesnake

Figure 75, Map 28

1905. *Crotalus willardi* Meek, Field Columbian Mus., pub. 104, Zoöl. Ser., vol. 7, no. 1, p. 18. Type locality: above Hamburg, Middle branch of Ramsey Canyon, Huachuca Mountains, Cochise County, Arizona; type specimen: CNHM 902.
1949. *Crotalus willardi willardi* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 8, p. 125.

Crotalus willardi amabilis Anderson

Del Nido Ridge-Nosed Rattlesnake

Figure 76, Map 28

1962. *Crotalus willardi amabilis* Anderson, Copeia, no. 1, p. 160. Type locality: Arroyo Mesteño, Sierra del Nido, Chihuahua, Mexico, elevation 8,500 ft.; type specimen MVZ 68896.

Crotalis willardi meridionalis Klauber

Southern Ridge-Nosed Rattlesnake

Figure 77, Map 28

1949. *Crotalus willardi meridionalis* Klauber, Trans. San Diego, Soc. Nat. Hist., vol. 11, no. 8, p. 131. Type locality: Coyotes, Durango, Mexico, elevation 8,000 ft.; type specimen: LMK 6569.

Crotalus willardi obscurus Harris

New Mexican Ridge-Nosed Rattlesnake

Figure 78, Map 28

1974. *Crotalus willardi obscurus* Harris, Natl. Parks and Conserv. Mag., vol. 48, no. 3, p. 23.

1976. *Crotalus willardi obscurus* Harris and Simmons[9], Bull. Md. Herp. Soc., vol. 12, no. 1, p. 5. Type locality: Upper end Indian Creek Canyon, Animas Mountains, Hidalgo County, New Mexico; type specimen: USNM 195546 (Formal description).

Crotalus willardi silus Klauber

West Chihuahua Ridge-Nosed Rattlesnake

Figure 79, Map 28

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[9] In the original paper (Natl. Parks and Conserv. Mag., vol. 48, no. 3, p. 23) Simmons was inadvertently left off as an author by the editor(s).

1949. *Crotalus willardi silus* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 11, no. 8, p. 128. Type locality: Rio Gavilán, 7 miles southwest Pacheco, Chihuahua, Mexico, elevation 6,200 ft.; type specimen: MVZ 46694.

1976. *Crotalus willardi silus*; Harris and Simmons, Bull. Md. Herp. Soc., vol. 12, no. 1, p. 3.

Sistrurus catenatus catenatus (Rafinesque)

Eastern Massasauga

Figure 80, Map 29

1818. *Crotalinus catenatus* Rafinesque, Amer. Month. Mag. & Crit. Rev., vol. 4, no. 1, p. 41. Type locality: prairies of the Upper Missouri; type specimen: none designated. Type locality restricted to Kansas City, Missouri, by Schmidt, 1953, p. 226.

1900. *Sistrurus catenatus catenatus* Cope, Rept. U.S. Nat. Mus. for 1898, p. 1146.

Sistrurus catenatus edwardsii (Baird and Girard)

Desert Massasauga

Figure 81, Map 29

1853. *Crotalophorus edwardsii* Baird and Girard, Cat. N. Amer. Rept., part 1, p. 15. Type locality: Tamaulipas, Mexico; type specimen: USNM 507.

1955. *Sistrurus catenatus edwardsi* Gloyd, Bull. Chi. Acad. Sci., vol. 10, p. 84.

Sistrurus catenatus tergeminus (Say)

Western Massasauga

Figure 82, Map 29

1823. *Crotalus tergeminus* Say, in Long's Exped. from Pittsburgh to Rocky Mts., edited by Edwin James, vol. 1, p. 499, footnote. Type locality: between the Mississippi River and the Rocky Mountains; type specimen: none designated. Type locality subsequently restricted to Winfield, Cowley County, Kansas by Smith and Taylor, 1950, Univ. Kans. Sci. Bull, vol. 33, part 2, no. 8, p. 358.

1936. *Sistrurus catenatus tergeminus* Klauber, Occ. Papers San Diego Soc. Nat. Hist., no. 1, p. 6

Sistrurus miliarius miliarius (Linnaeus)

Carolina Pigmy Rattlesnake

Figure 83, Map 30

1766. *Crotalus miliarius* Linnaeus, Syst. Nat., ed. 12, p. 372. Type locality: Carolina; type specimen: received by Linnaeus from Alexander Garden, disposition unknown.

1935. *Sistrurus miliarius miliarius* Gloyd, Occ. Papers Mus. Zoöl., Univ. Mich., no. 322, p. 4.

Sistrurus miliarius barbouri Gloyd

Dusky Pigmy Rattlesnake

Figure 84, Map 30

1935. *Sistrurus miliarius barbouri* Gloyd, Occ. Papers Mus. Zoöl. Univ. Mich., no. 322, p. 2. Type locality: Royal Palm Hammock, 12 miles west of Homestead, Dade County, Florida; type specimen: MCZ 12512.

Sistrurus miliarius streckeri Gloyd

Western Pigmy Rattlesnake

Figure 85, Map 30

1935. *Sistrurus miliarius streckeri* Gloyd, Occ. Papers Mus. Zoöl. Univ. Mich., no. 322, p. 4. Type locality: near Imboden, Lawrence County, Arkansas; type specimen: MZUM 76751.

Sistrurus ravus ravus (Cope)

Mexican Pigmy Rattlesnake

Figure 86, Map 31

1865. *Crotalus ravus* Cope, Proc. Acad. Nat. Sci. Phila., vol. 17, no. 4, p. 191. Type locality: tableland of Mexico; type specimens: USNM 25050-1. Type locality subsequently restricted to Totalco, Veracruz, by Smith and Taylor, 1950, Univ. Kans. Sci. Bull., vol. 33, part 2, no. 8, p. 351.

1896. *Sistrurus ravus* Boulenger, Cat. Snakes Brit. Mus., vol. 3, p. 571.

Sistrurus ravus brunneus[10] subsp. nov.

Oaxacan Pigmy Rattlesnake

Figure 87, Map 31

1972. *Sistrurus ravus* (Part) Klauber, Rattlesnakes, vol. 1, p. 57.

Diagnois. — A moderately sized rattlesnake differing from both *S. r. ravus* and *S. r. lutescens* in being a reddish brown color dorsally and in generally having ten rattle fringe scales (at least in males). Both *S. r. ravus* and *S. r. lutescens* generally have eight rattle fringe scales.

This subspecies is geographically separated from both *S. r. ravus* and *S. r. lutescens* thus its separation seems logical.

Type Specimens. — Holotype: AMNH 102916, an adult male collected 1.7 mi. E Ixtlán de Juárez (Vivero Rancho Teja), Oaxaca, Mexico in Pine-oak woodland, at an elevation of 7400 ft. by Boone Hallberg in June 1968. Paratypes: AMNH 65174-5, 89636-7, 93226-7, 100841-2, 102915, 104404, USNM 46555 and 46609.

Description of the Type Specimens. — Holotype: 640 mm total length, 65 mm tail length, 25 scale rows at midbody, 148 ventrals, 30 subcaudals, 12/12 supralabials, 11/12 infralabials, anterior subocular contacts 4th and 5th supralabials, 4 scales in the internasal prefrontal area, 38 body blotches, 7 tail bands and 10 rattle fringe scales.

The following summary of the type specimens includes the holotype: Size, max. 640 mm, min. 187 mm. Scale rows 21-25 (mode 23) at midbody, 3 specimens have 21, 1 has 22, 8 have 23 and 1 has 25; ventrals, males 137-155 (mean 147.6); subcaudals, males 24-33 (mean 29.3), female 21; supralabials, males 11-12 (mean 11.6), female 10; infralabials, males 10-13 (mean 11.6), female 11; body blotches, males 33-42 (mean 36.1),

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[10] *Brunneus*, Latin: deep brown.

female 30; tail length as percent of total length, males 10.1, female 9.6; rattle fringe scales 10 (males), the only female available to us had 8.

Range. — Known only from the State of Oaxaca, Mexico.

Sistrurus ravus lutescens[11] subsp. nov.

Montane Pigmy Rattlesnake

Figure 88, Map 31

1972. *Sistrurus ravus* (Part) Klauber, Rattlesnakes, vol. 1, p. 57.

Diagnois. —A large *Sistrurus ravus* having a brown to golden-brown dorsal coloration with darker brown blotches and a fairly uniform tan to golden-yellow venter. This ventral color extends up onto the labials. The labials are unpigmented with dark pigment, in contrast to *S. r. ravus* which generally has dark stippling on the labials particularily at the sutures. It can further be separated from *S. r. ravus* in having the brown color dorsally instead of grey. The blotches of *S. r. lutescens* in general are less squarish than in *S. r. ravus*. From *S. r. brunneus*, it can be separated by generally having fewer rattle fringe scales, 8 instead of 10.

Type Specimens. —Holotype: UCM 9124, an adult male collected at Huitzilac, Morelos, Mexico by T. Paul Maslin on 16 July 1956. Paratypes: UCM 9125, RS 831, 844, 853, 994, 1227, 1228 HSH/RSS (NHSM).

Description of the Type Specimens. — Holotype: 664 mm total length, 63 mm tail length, 21 scale rows at midbody, 146 ventrals, 31 subcaudals, 11/12 supralabials, 12/12 infralabials, anterior subocular contacts 4th and 5th supralabials, 4 scales in the internasal prefrontal area, 32 body blotches, 5 tail bands, and 8 rattle fringe scales.

The following summary of the type specimens includes the holotype: Size, max. 759 mm, min. 286 mm. Scale rows generally 21 at midbody, 5 specimens have 21 rows, 3 specimens have 23 rows; ventrals, males 141-146 (mean 143.3), females 141-148 (mean 144.3); subcaudals, males 27-31 (mean 29.0), females 21-28 (mean 25.0); supralabials 11-13 (mean 11.7); infralabials 9-12 (mean 11.1); body blotches 31-34 (mean 32.4); tail length as percent of total length, males 9.35, females 8.58; rattle fringe scales 8-9 (mode 8). The general dorsal coloration is brown to golden-brown with darker brown blotches dorsally; there are smaller secondary blotches laterally which are centered off the primary blotches. The supralabials and venter are tan to golden-yellow; the supralabials lacking all darker stippling.

Range. — Known only from the vicinity of Huitzilac, Morelos, Mexico at an elevation from about 2800-3000 meters.

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[11] *Lutescens*, Latin: yellow tinged.

Sistrurus ravus ssp.

Guerreran Pigmy Rattlesnake

Map 31

(Description forthcoming by others)

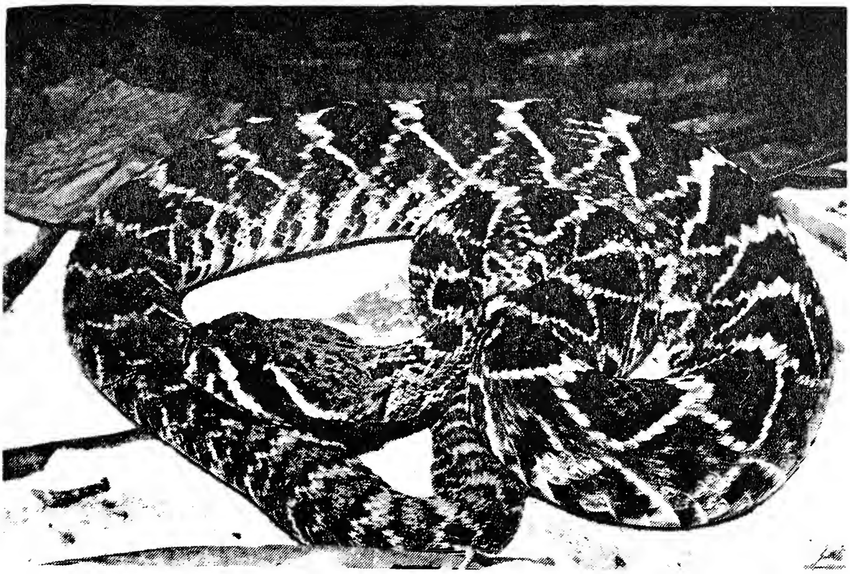


Figure 1. *Crotalus adamanteus*, specimen from near Lakeland, Polk Co., Florida.

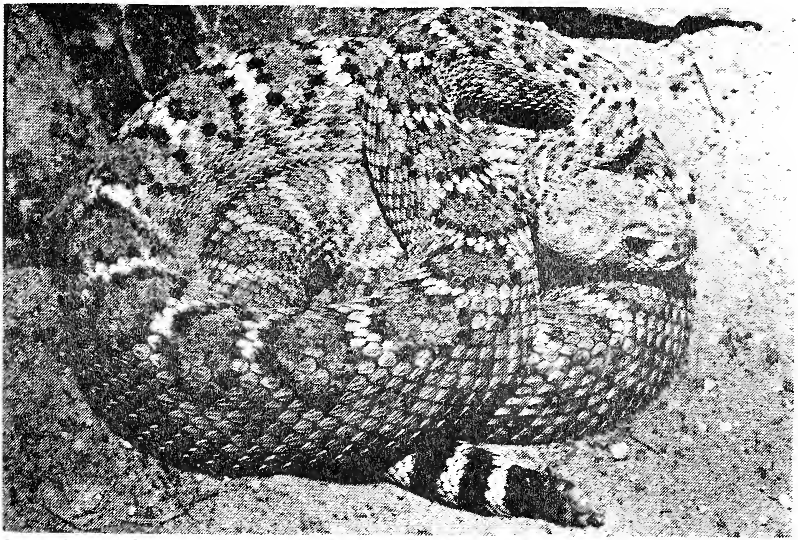


Figure 2. *Crotalus atrox*, specimen from Cochise Co., Arizona (72-7 HSH/ RSS).

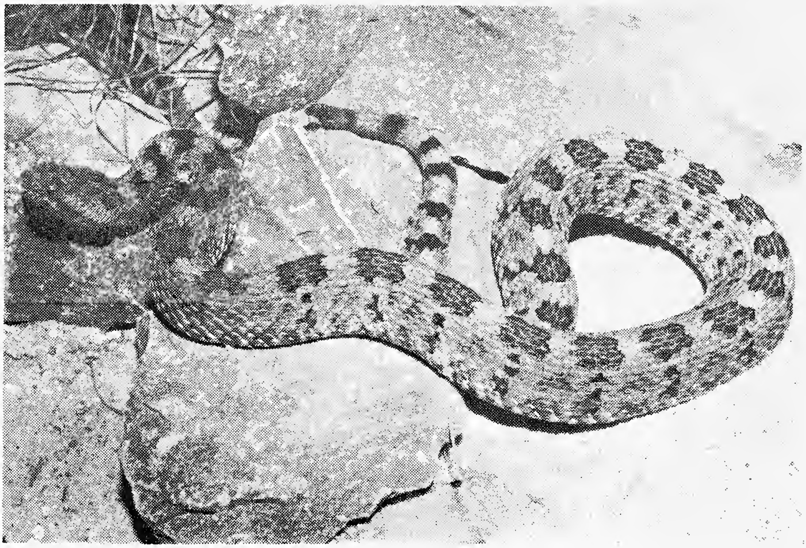


Figure 3. *Crotalus aquilus*, specimen from Ixtapalapa, D.F., Mexico (71-26 HSH/RSS).

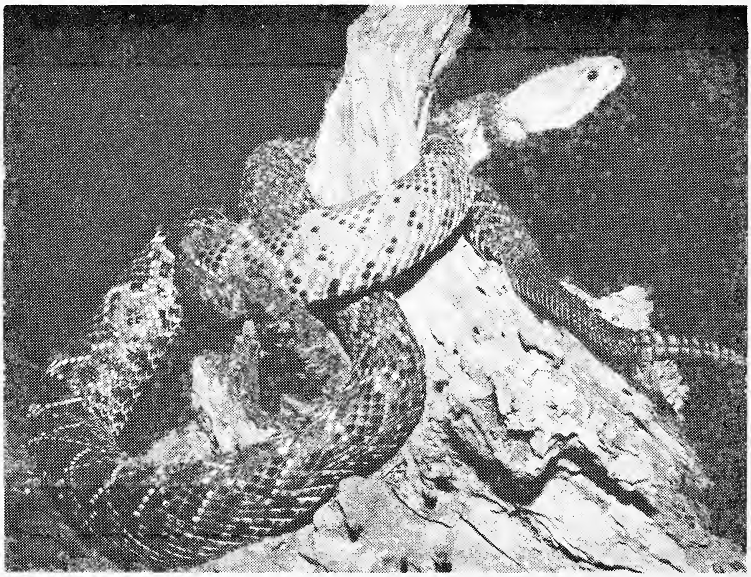


Figure 4. *Crotalus basiliscus basiliscus*, specimen from nr. San Blas, Nayarit, Mexico (RS 802 HSH/RSS).

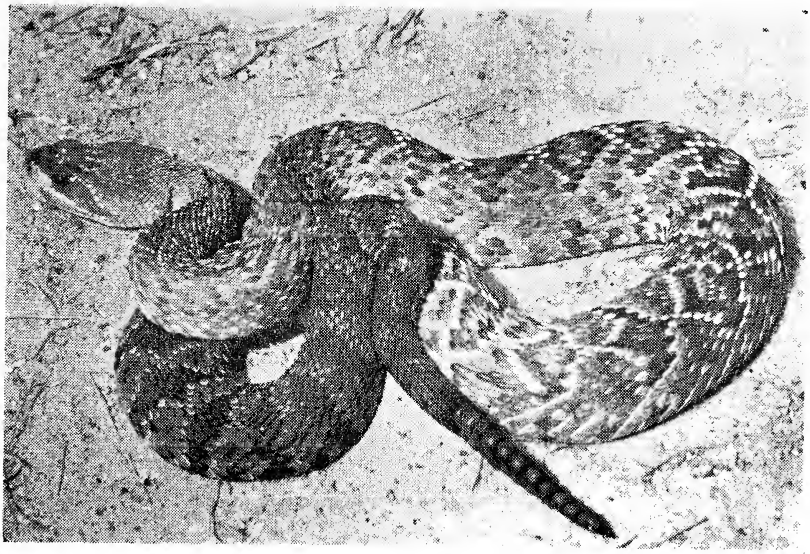


Figure 5. *Crotalus basiliscus oaxacus*, specimen from 25 mi NW Oaxaca, Oaxaca, Mexico (76-22 HSH/RSS).

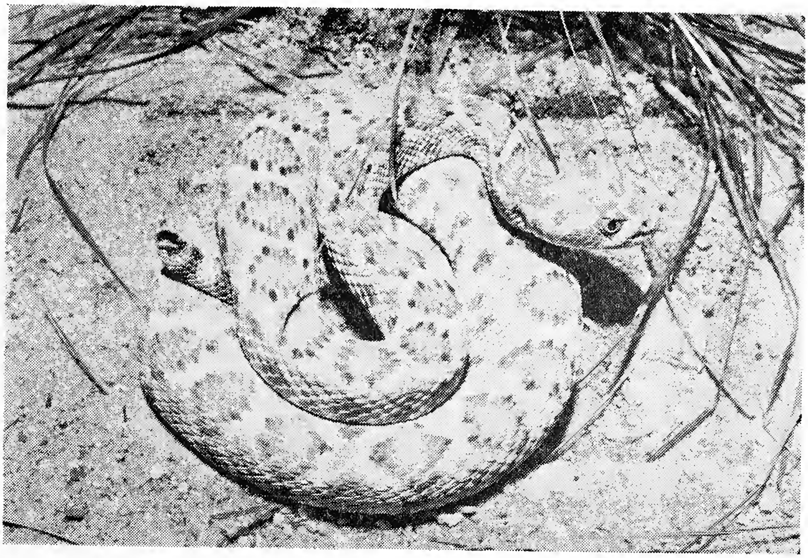


Figure 6. *Crotalus catalinensis*, specimen from Isla Santa Catalina, Gulf of California, Baja Sur, Mexico (71-181 HSH/RSS).

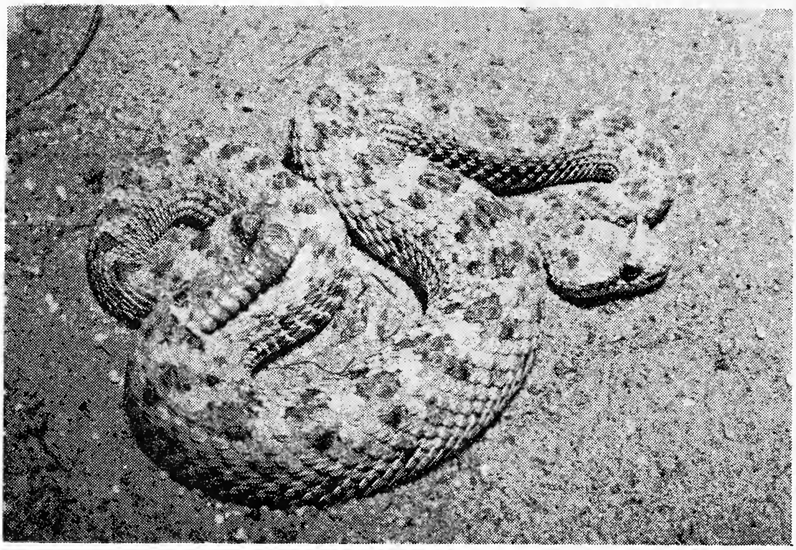


Figure 7. *Crotalus cerastes cerastes*, specimen from Mojave, Kern Co., California (RS 892 HSH/RSS).

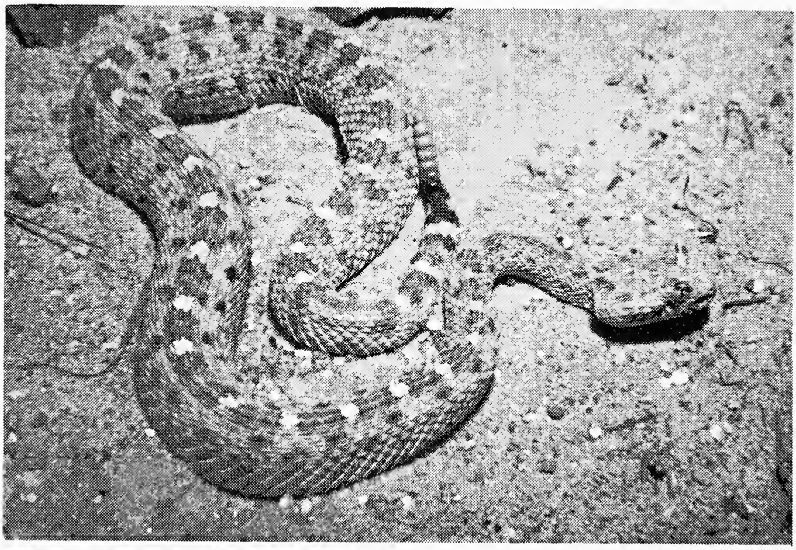


Figure 8. *Crotalus cerastes cercobombus*, specimen from Avra Valley, Pima Co., Arizona (RS 924 HSH/RSS).

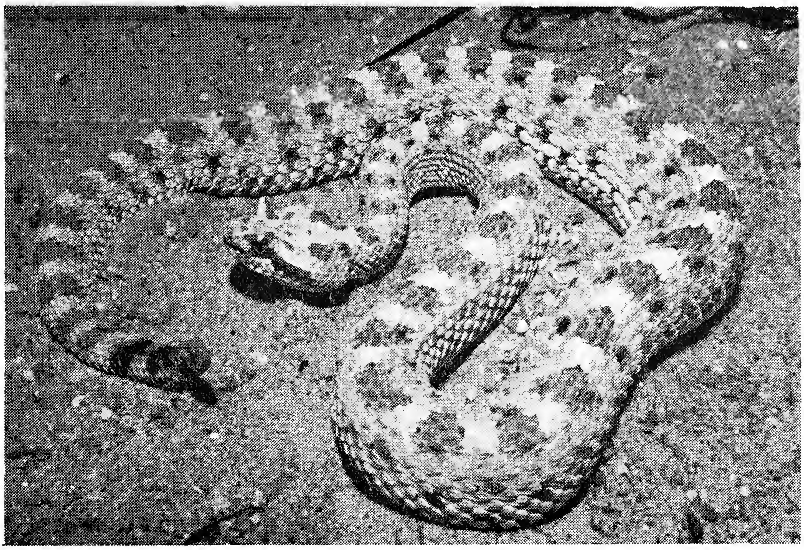


Figure 9. *Crotalus cerastes laterorepens*, specimen from south of Twentynine Palms, San Bernardino Co., California (71-9 HSH/RSS).

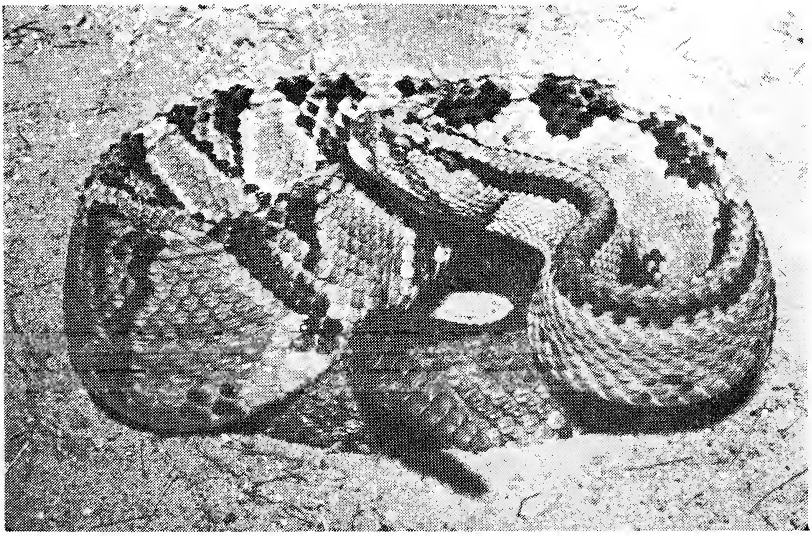


Figure 10. *Crotalus durissus durissus*, specimen from Guatemala (RS 1106 HSH/RSS).

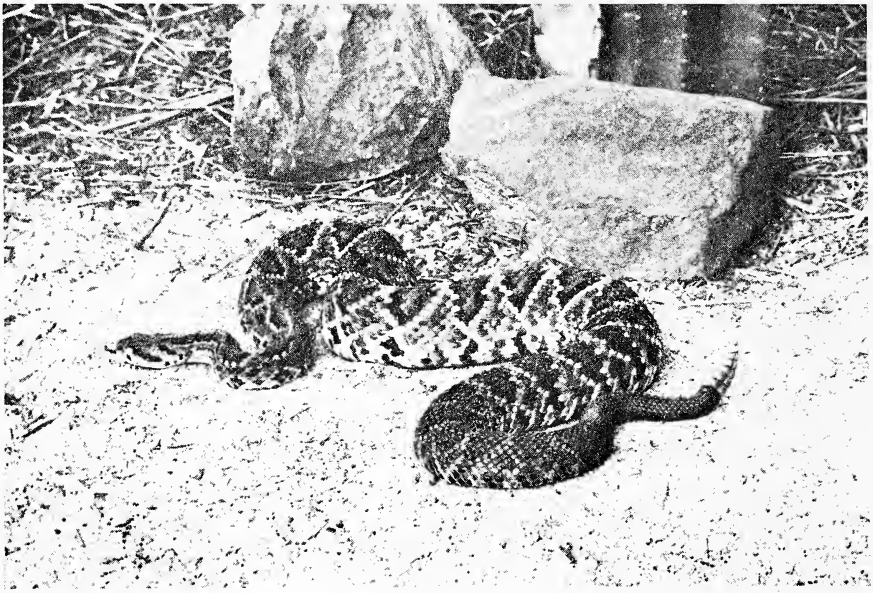


Figure 11a. *Crotalus durissus cascavella*, photograph courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1972 *36*:196).

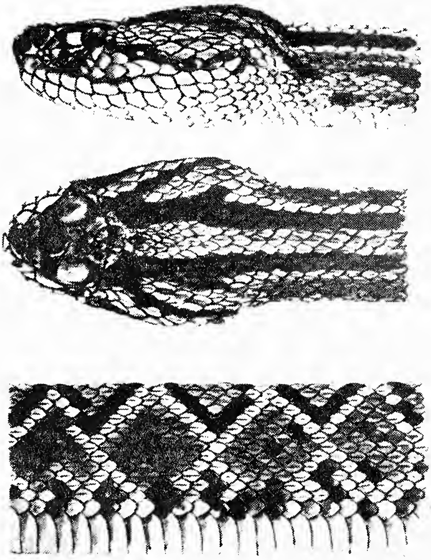


Figure 11b. *Crotalus durissus cascavella*, drawings courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1966 (1965), *32*:176). Specimen from Mina Caraiba, Bahia, Brasil (Neotype: IBH 23 400).

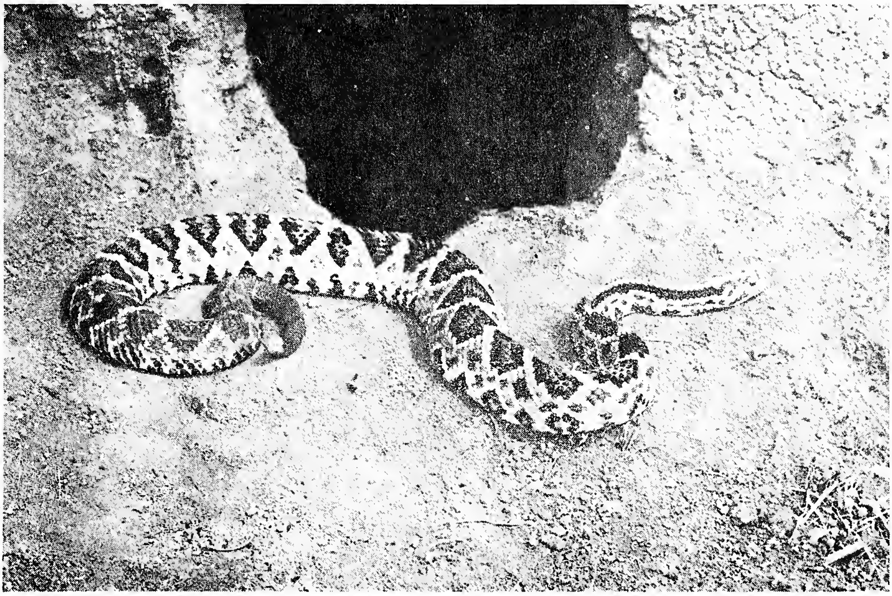


Figure 12a. *Crotalus durissus collilineatus*, photograph courtesy Dr. A. R. Hoge and Instituto Butantan (from Men. Inst. Butantan, 1972, *36*:198).

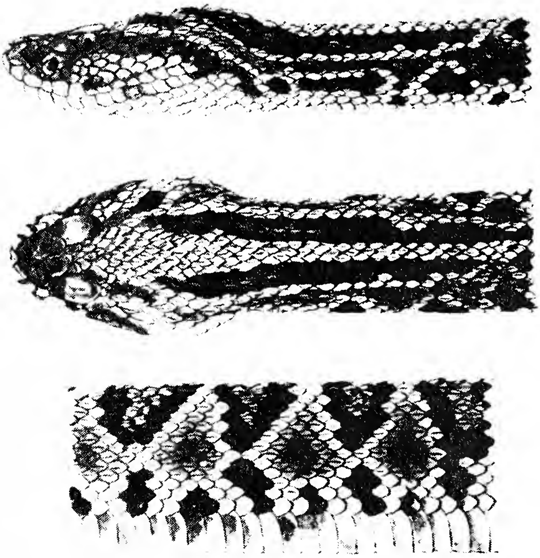


Figure 12b. *Crotalus durissus collilineatus*, drawings courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1966 (1965), *32*:177. Specimen from Brasília, Ter. Federal, Brasil (IBH 23 005).

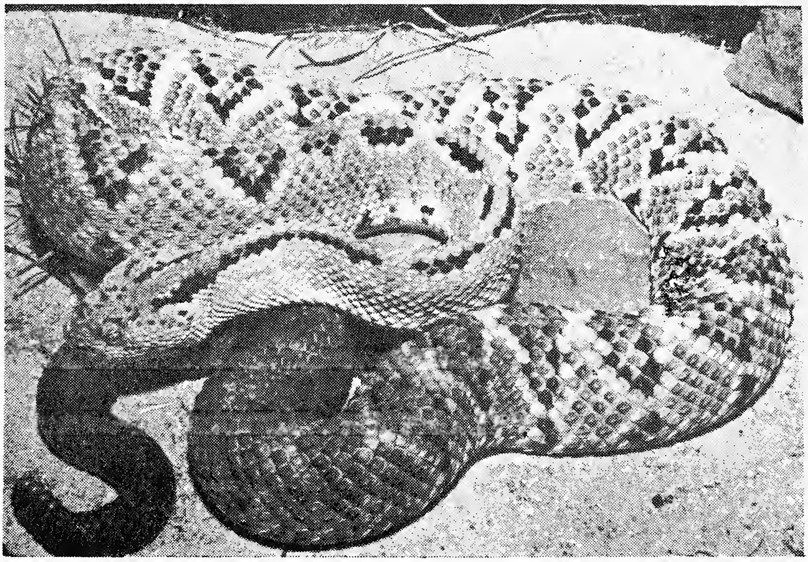


Figure 13. *Crotalus durissus culminatus*, specimen from Aquila, Michoacán, Mexico (RS 896 HSH/RSS).

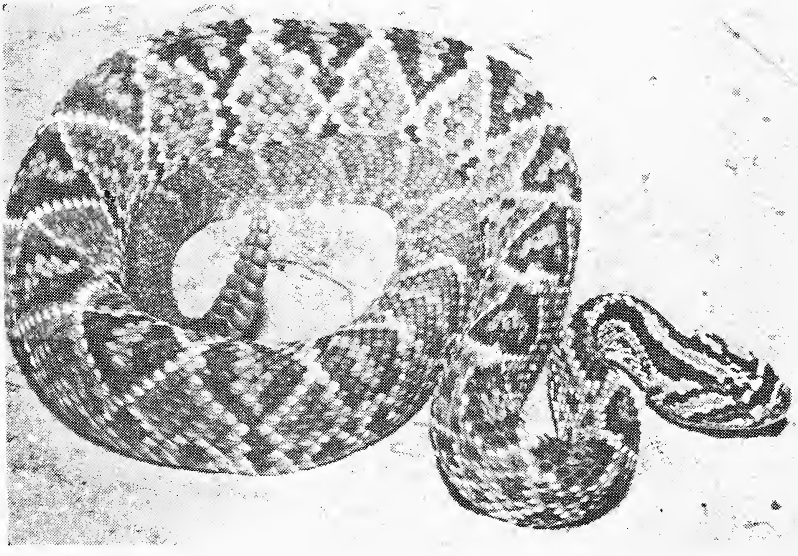


Figure 14. *Crotalus durissus cumanensis*, specimen from near Baranquilla, Colombia (RS 823 HSH/RSS).

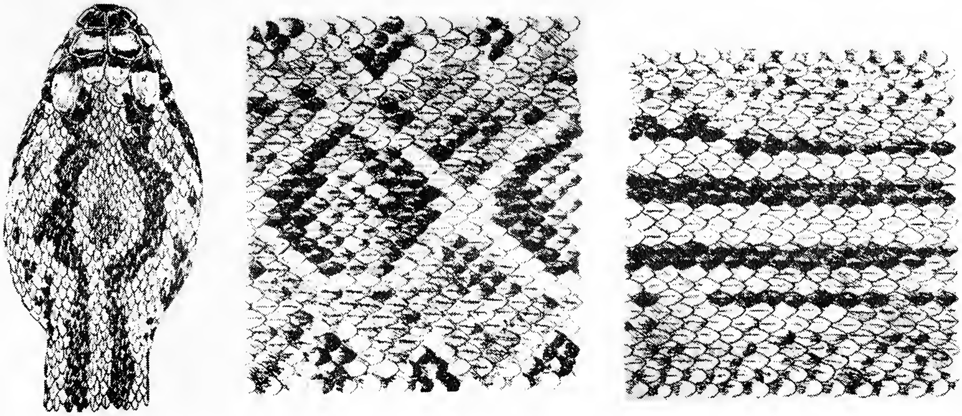


Figure 15. *Crotalus durissus dryinas*, drawings courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1966 (1965), *32*:178). Specimen from the Guianas.

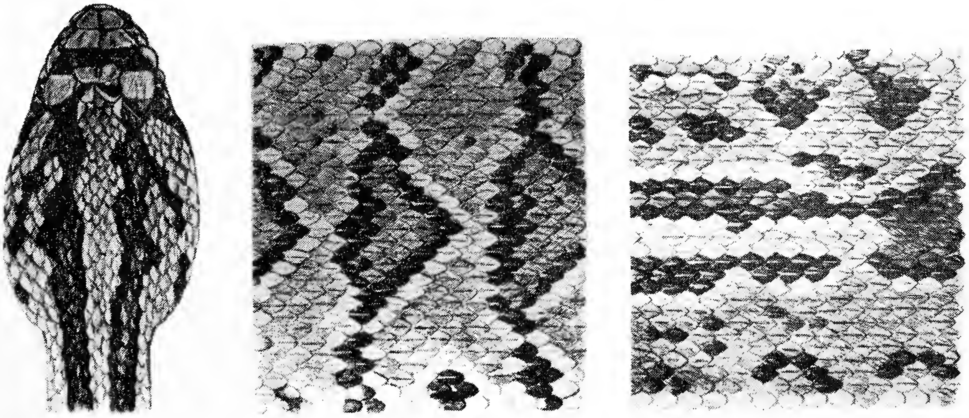


Figure 16. *Crotalus durissus marajoensis*, drawings courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1966 (1965), *32*:179). Specimen from Ilha de Marajó, State Pará, Brasil.

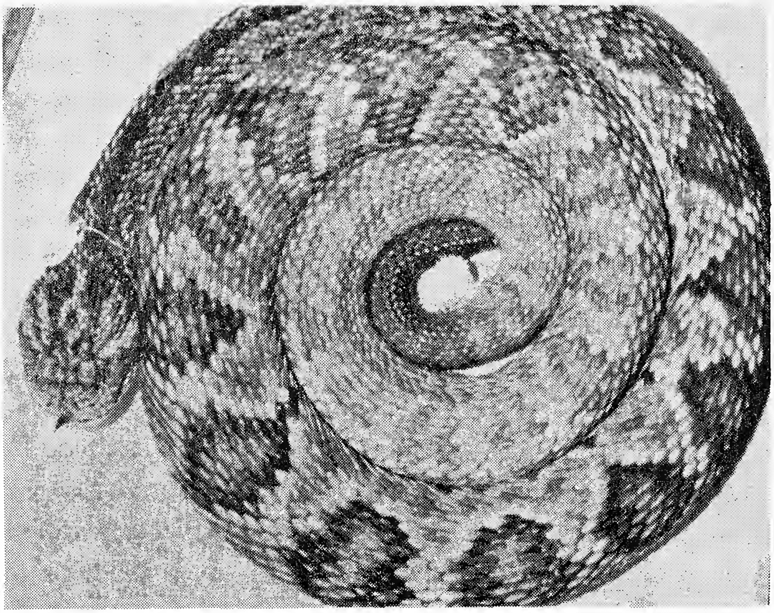


Figure 17. *Crotalus durissus neoleonensis*, specimen from Las Adjuntas, Santiago, Nuevo León, Mexico. [Type Specimen UANL 463 (Univ. Nuevo León)]. Photograph by Carlos H. Trevino, courtesy Ernest A. Liner.

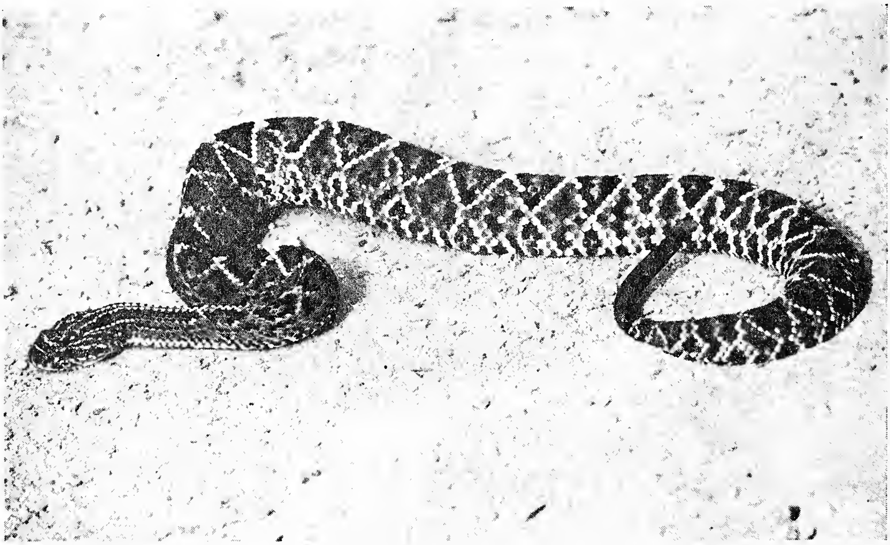


Figure 18a. *Crotalus durissus ruruima*, photograph courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1972, 36: 200).

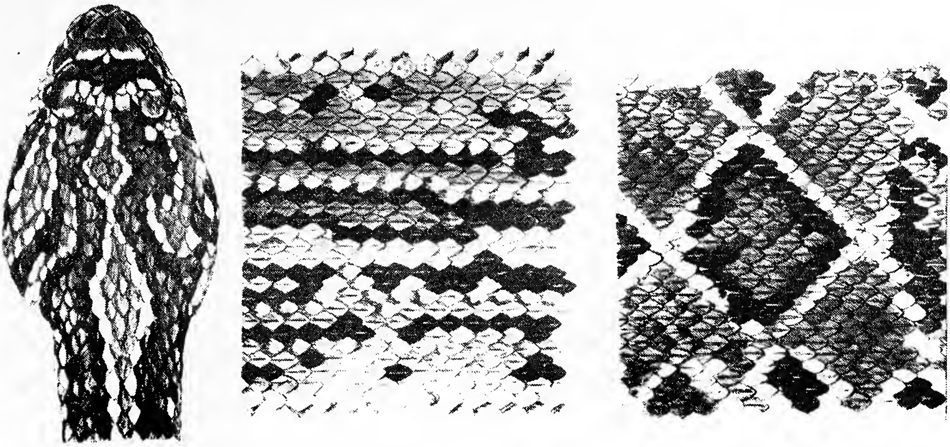


Figure 18b. *Crotalus durissus ruruima*, drawings courtesy Dr. A. R. Hoge and Instituto Butantan (from Mem. Inst. Butantan, 1966(1965), *32*:180). Specimen from Paulo Camp. Mt. Roraima, Venezuela (Holotype: AMNH 36 056).

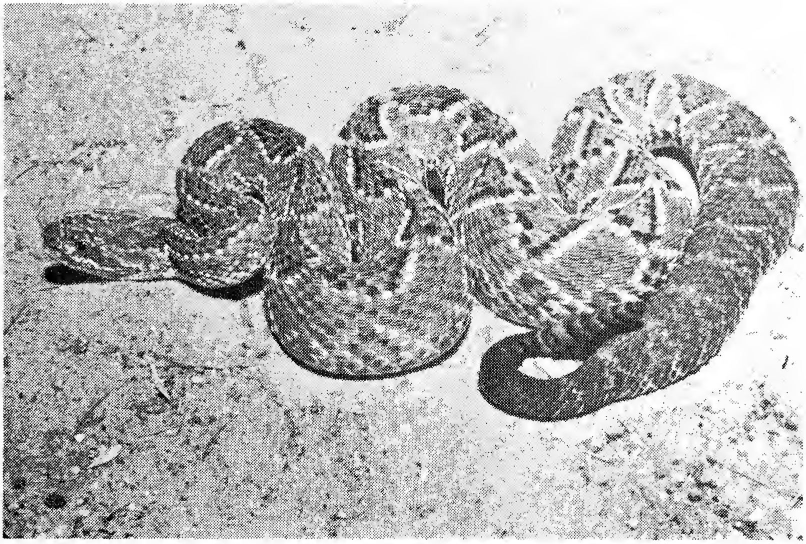


Figure 19. *Crotalus durissus terrificus*, specimen from Paraguay (73-19 HSH/RSS).

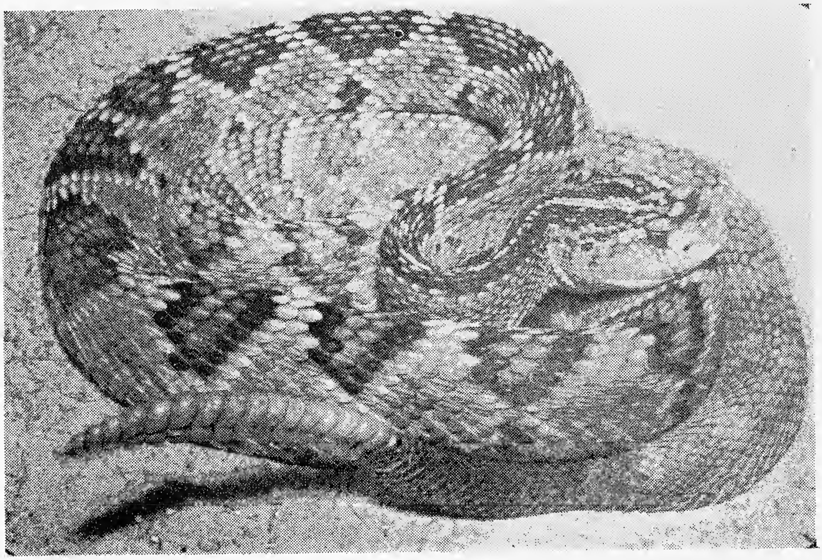


Figure 20. *Crotalus durissus totonacus*, specimen from Nr. Gonzalez, Tamaulipas, Mexico (RS 1129 HSH/RSS).

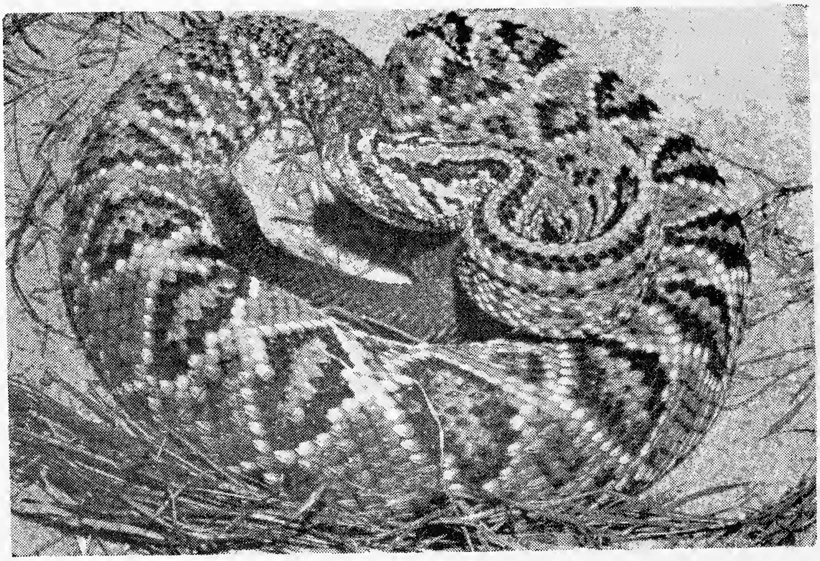


Figure 21. *Crotalus durissus trigonicus*, specimen from the Rupununi Savannahs, Guyana (Holotype: RS 907 HSH/RSS).

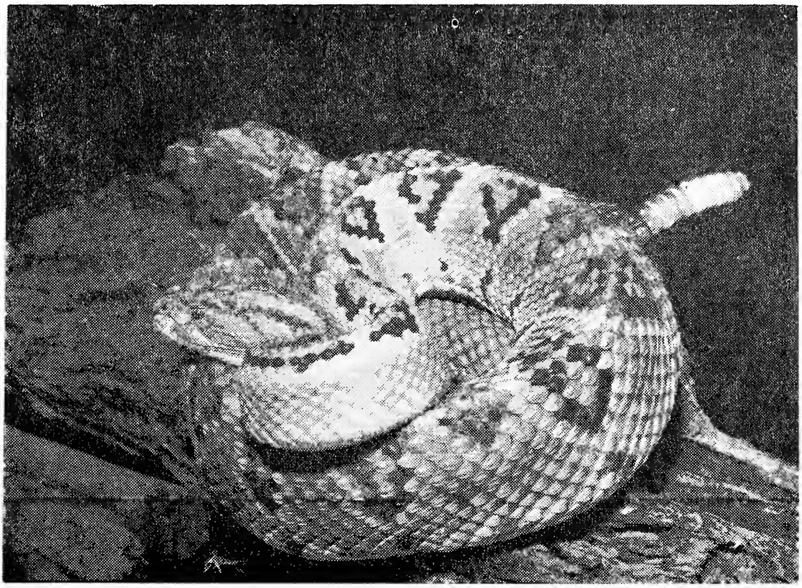


Figure 22. *Crotalus durissus tzabcan*, specimen from near Marida, Yucatán, Mexico (RS 946 HSH/RSS).

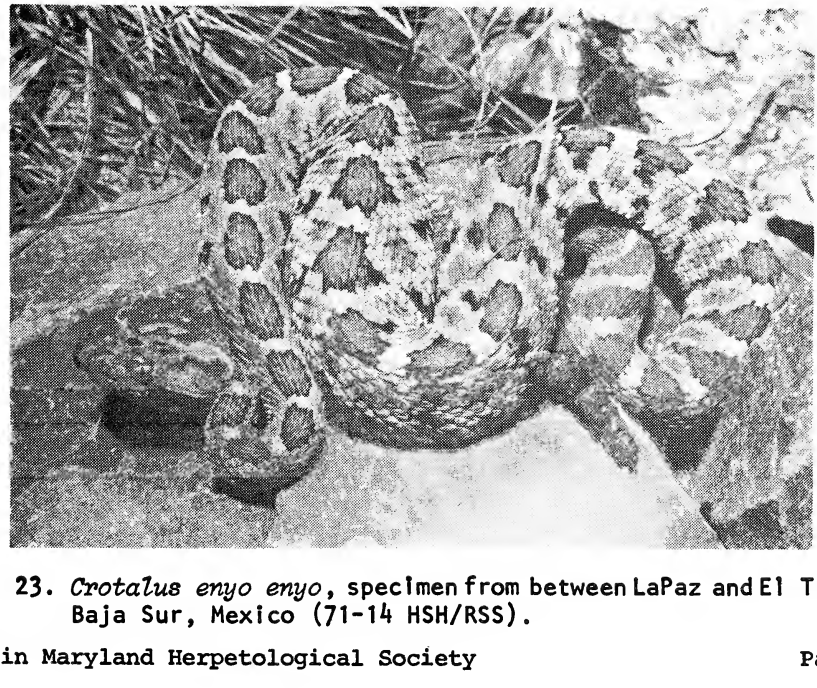


Figure 23. *Crotalus enyo enyo*, specimen from between LaPaz and El Trufino, Baja Sur, Mexico (71-14 HSH/RSS).

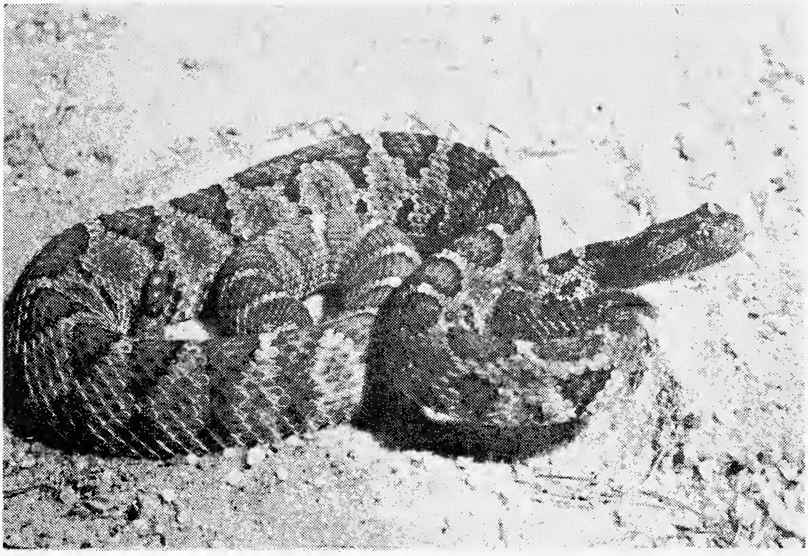


Figure 24. *Crotalus enyo cerralvensis*, specimen from Isla Cerralvo, Gulf of California, Baja Sur, Mexico (75-38 HSH/RSS).

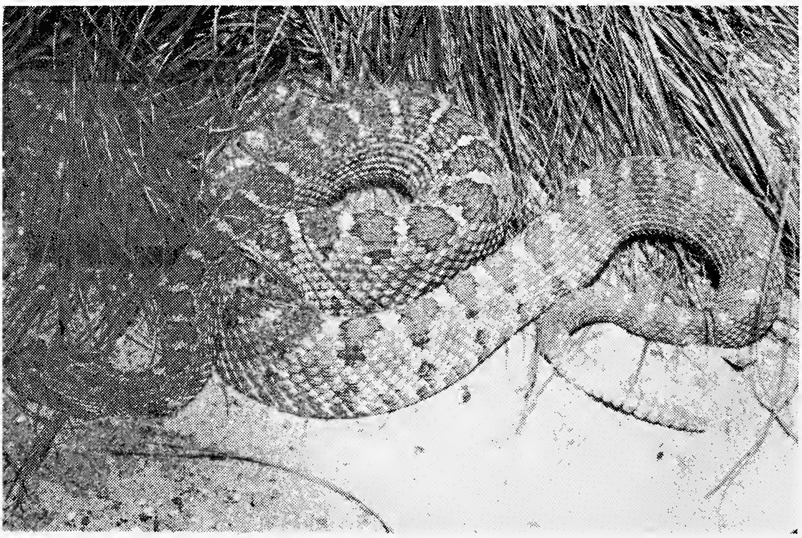


Figure 25. *Crotalus enyo furvus*, specimen from near Rosario, Baja del Norte, Mexico (RS 926 HSH/RSS).

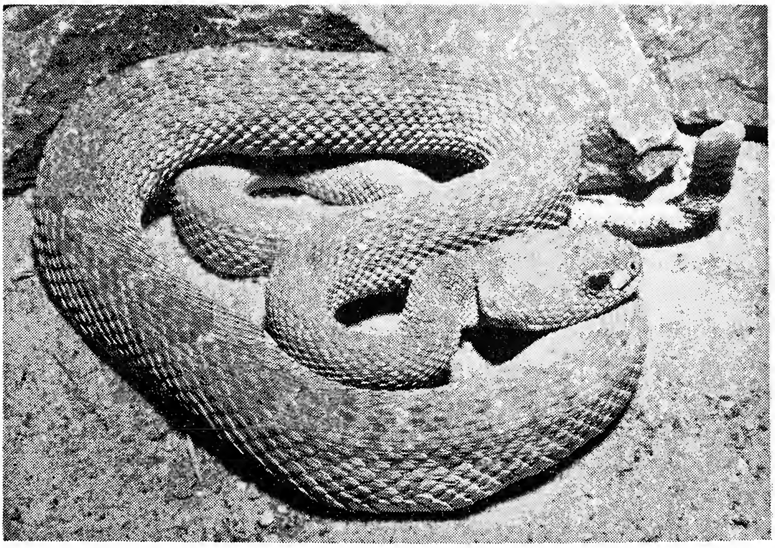


Figure 26. *Crotalus exsul*, specimen from Isla Cedros, off the Pacific Coast of Baja California, Mexico (RS 1040 HSH/RSS).

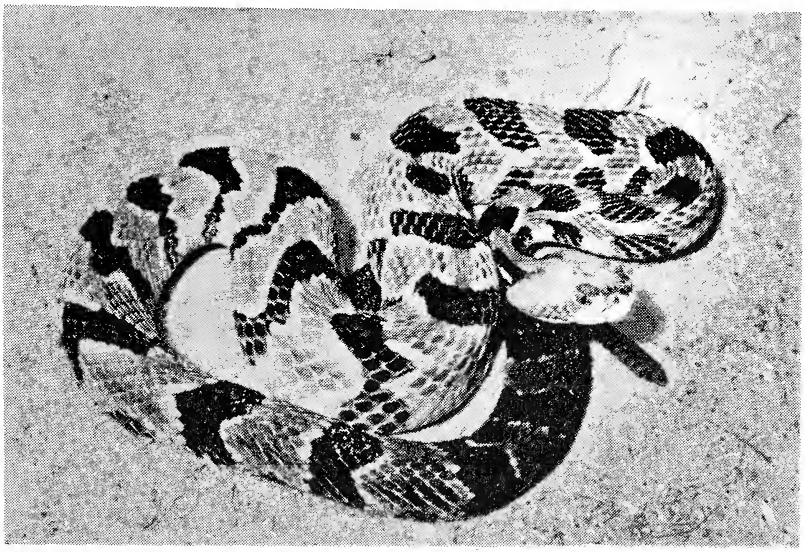


Figure 27. *Crotalus horridus horridus*, specimen from near Thurmont, Frederick Co., Maryland (74-1 HSH/RSS).

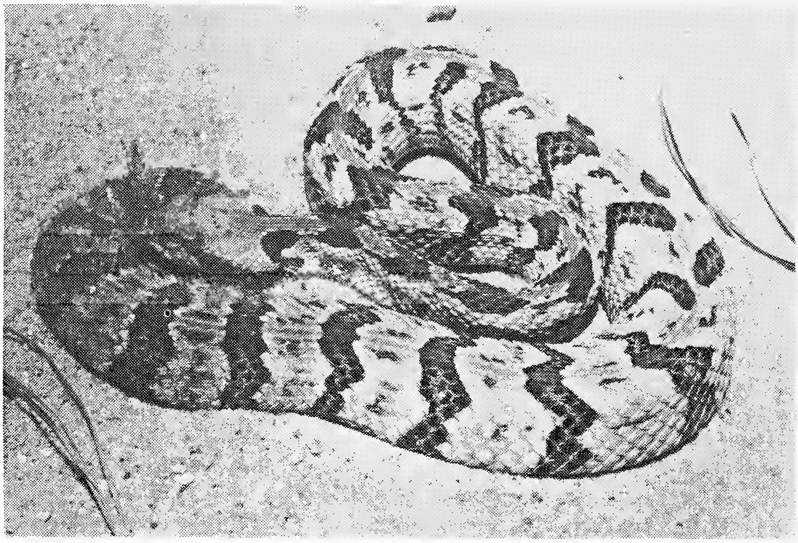


Figure 28. *Crotalus horridus atricaudatus*, specimen from NE of Hardeeville, Jasper Co., South Carolina (76-5 HSH/RSS).

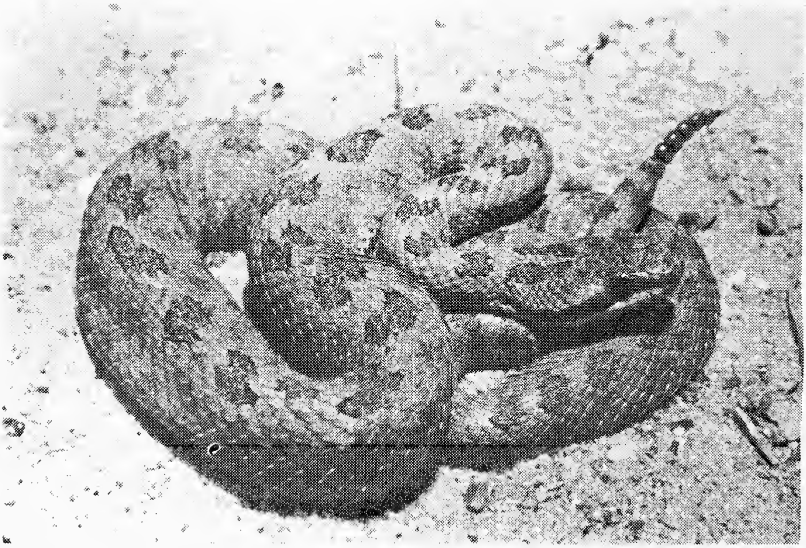


Figure 29. *Crotalus intermedius intermedius*, specimen from Cofré de Perote, Veracruz, Mexico (RS 977 HSH/RSS).

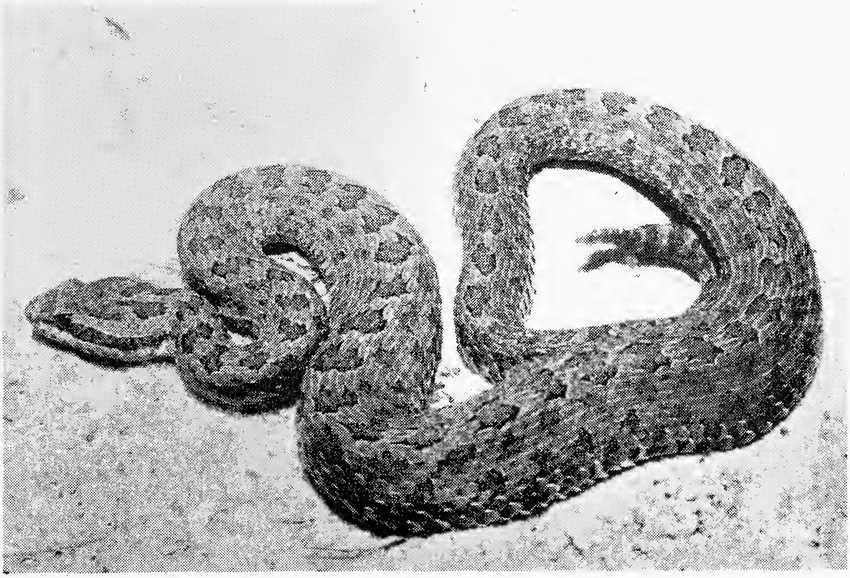


Figure 30 *Crotalus intermedius gloydi*, specimen from Suchixtepec, Oaxaca, Mexico (RS 1163 HSH/RSS).

Figure 31. *Crotalus intermedius omiltemanus*, specimen from Nr. Omilteme, Guerrero, Mexico (RS 1005 HSH/RSS).

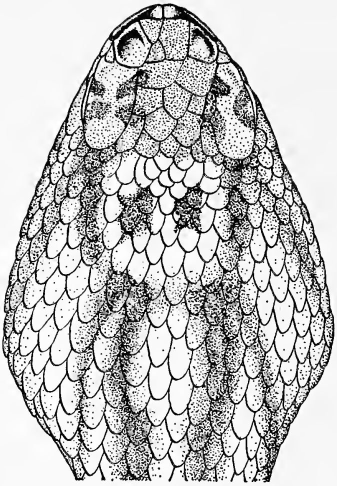


Figure 32. A dorsal view of the head of *Crotalus lannomi* (Holotype, BYU No. 23800) collected 1.8 mi W of the pass, Puerto Los Mazos on Mexican Highway No. 80, Jalisco, Mexico. Illustration courtesy of Wilmer W. Tanner and the Herpetologists' League. (Taken from Herpetologica *22*(4):299).

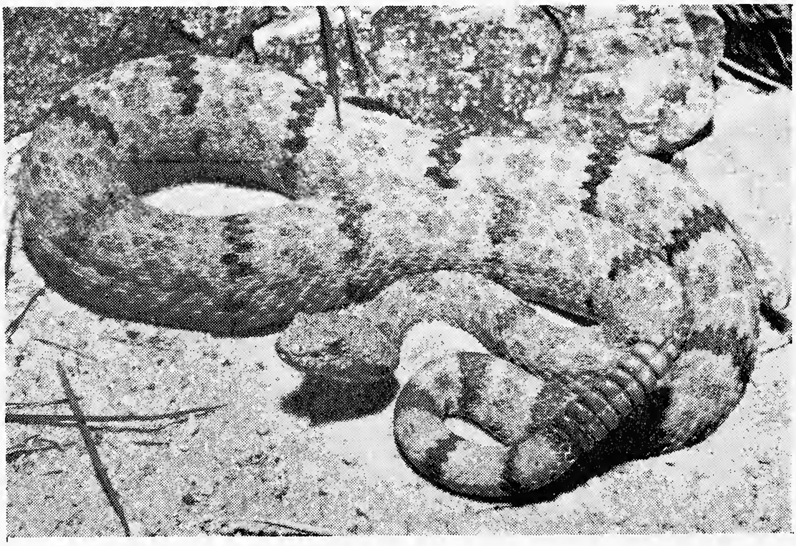


Figure 33. *Crotalus lepidus lepidus*, specimen from Fort Davis, Jeff Davis Co., Texas (RS 928 HSH/RSS).

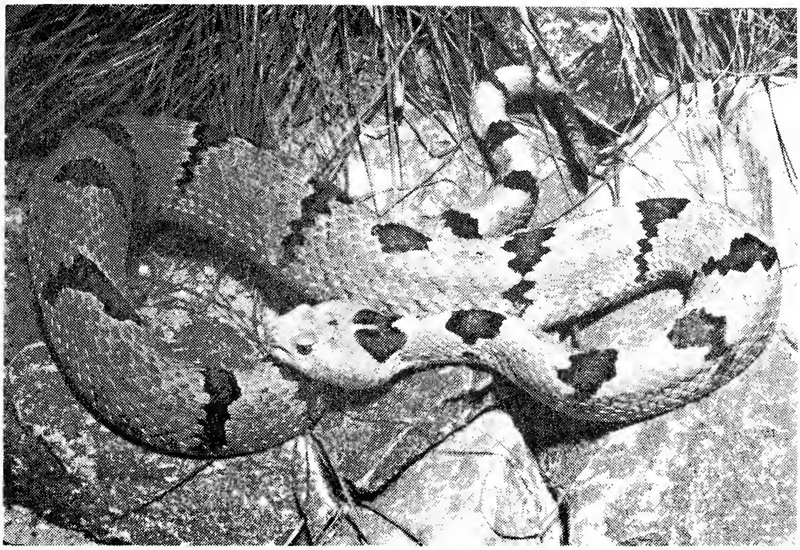


Figure 34. *Crotalus lepidus klauberi*, specimen from southern Zacatecas, Mexico (71-25 HSH/RSS).

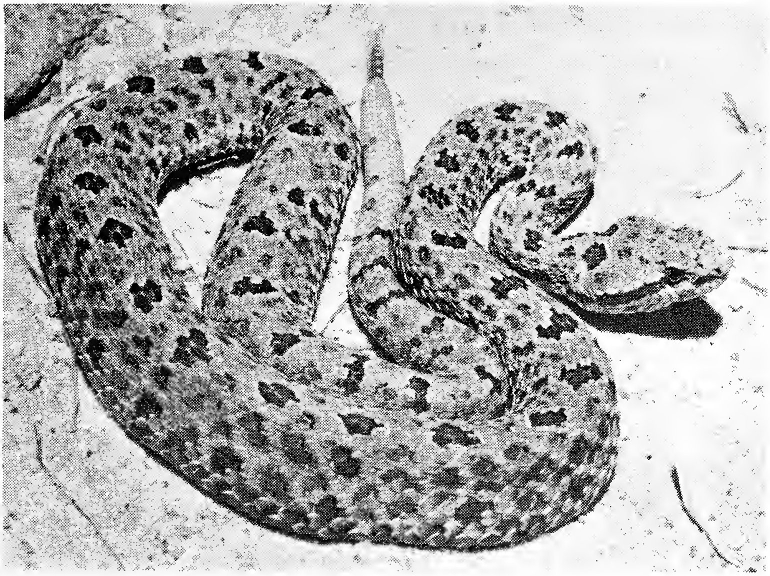


Figure 35. *Crotalus lepidus maculosus*, specimen from 16 mi W Durango - Sinaloa State Line, Sinaloa, Mexico (Paratype: RS 951 HSH/RSS).

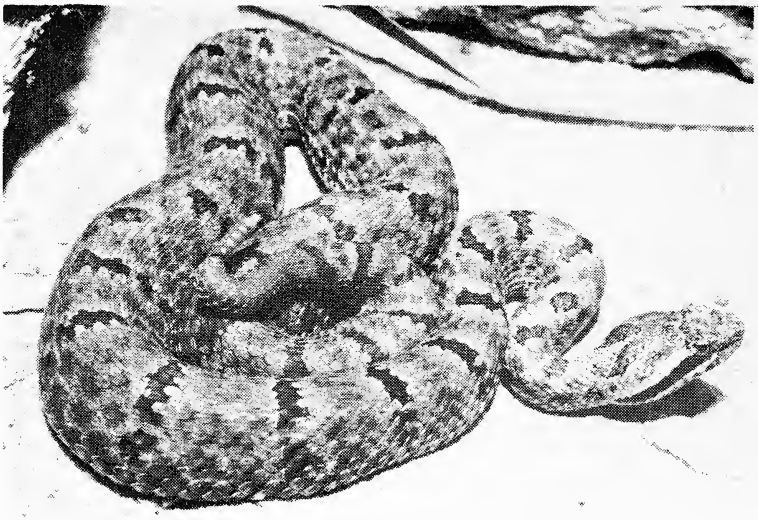


Figure 36. *Crotalus lepidus morulus*, specimen from mountains SE San Francisco, Tamaulipas, Mexico. (72-68 HSH/RSS).

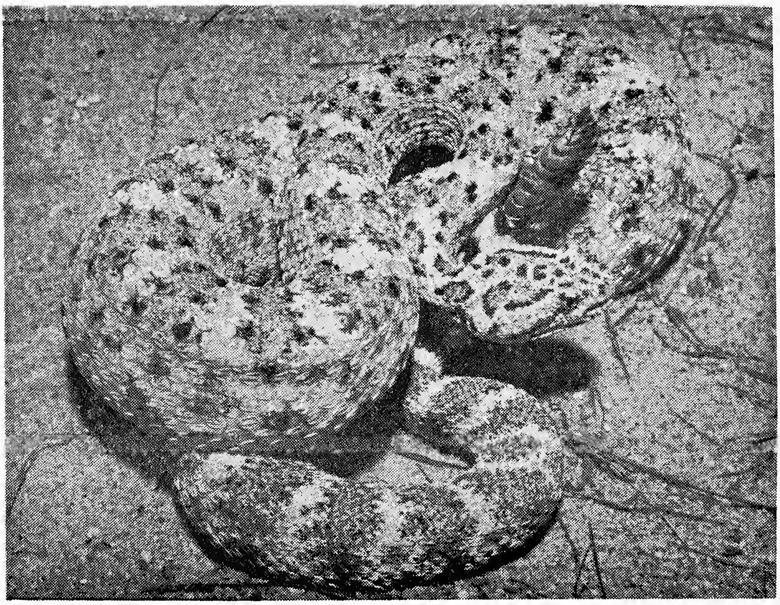


Figure 37. *Crotalus mitchellii mitchellii*, specimen from Nr. Buena Vista, Baja Sur, Mexico (RS 845 HSH/RSS).

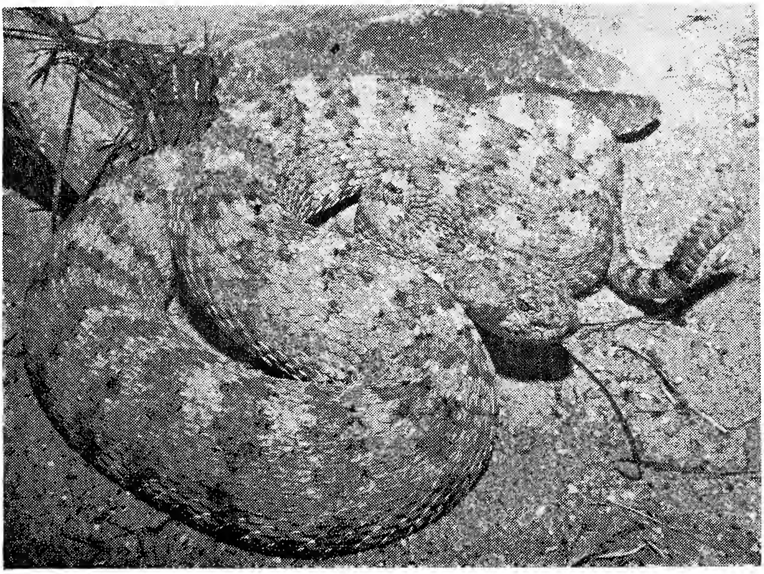


Figure 38. *Crotalus mitchellii angelensis*, specimen from Isla Ángel de la Guarda, Gulf of California, Baja del Norte, Mexico (RS 979 HSH/RSS).

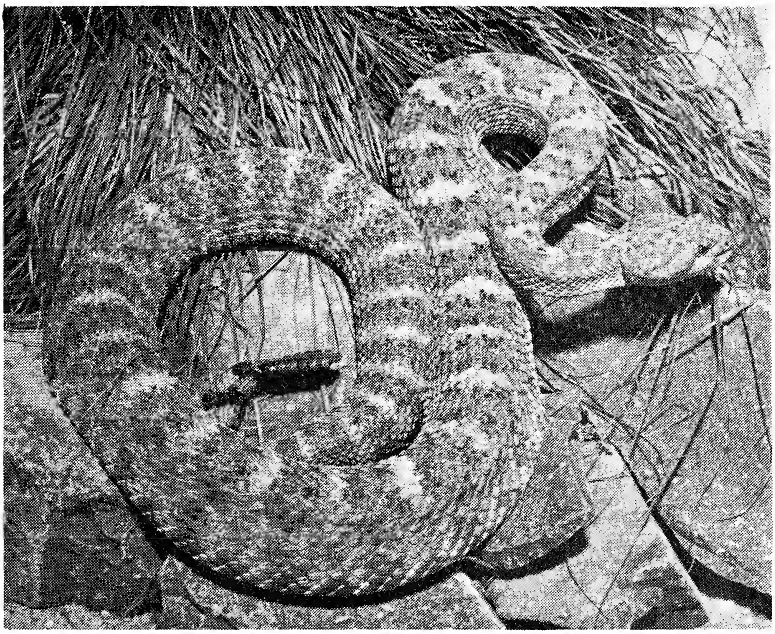


Figure 39. *Crotalus mitchellii muertensis*, specimen from Isla El Muerto, Gulf of California, Baja del Norte, Mexico (RS 850 HSH/RSS).

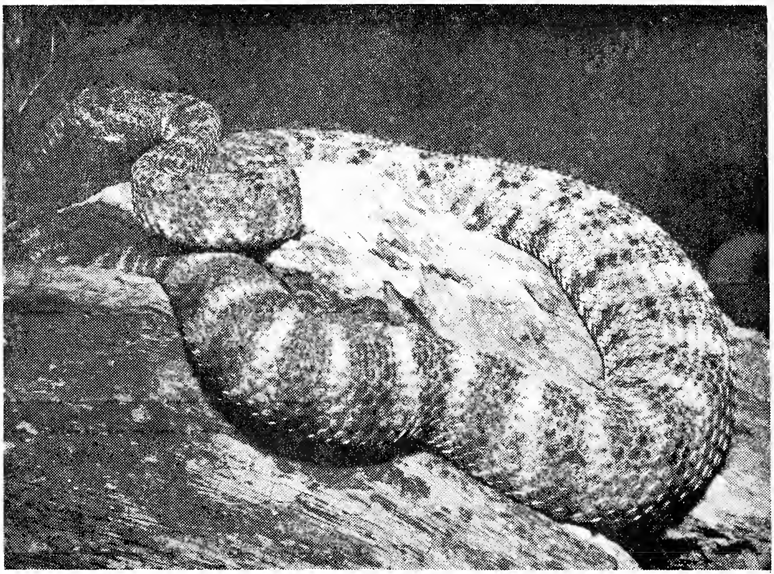


Figure 40. *Crotalus mitchellii pyrrhus*, specimen from Pinacate Peak, Sonora, Mexico.

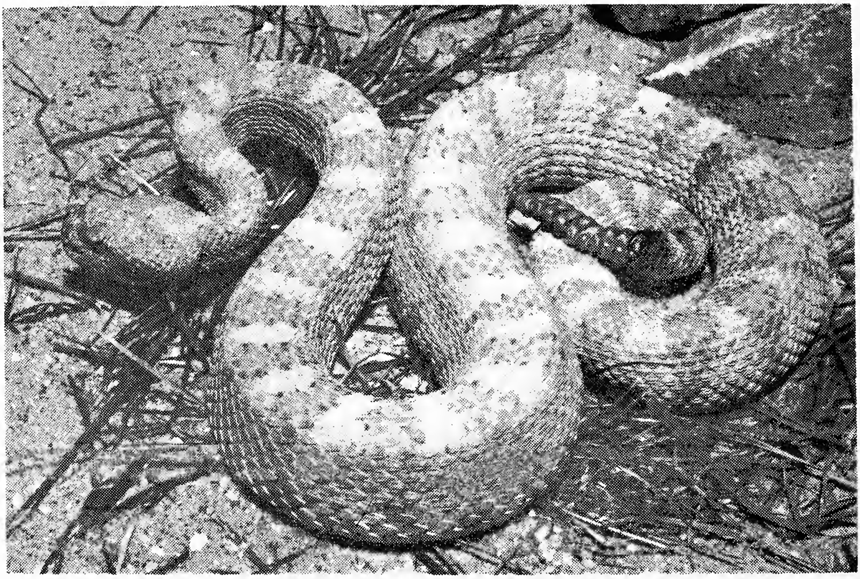


Figure 41. *Crotalus mitchellii stephensi*, specimen from Kyle Cyn, Clark Co., Nevada (71-30 HSH/RSS).

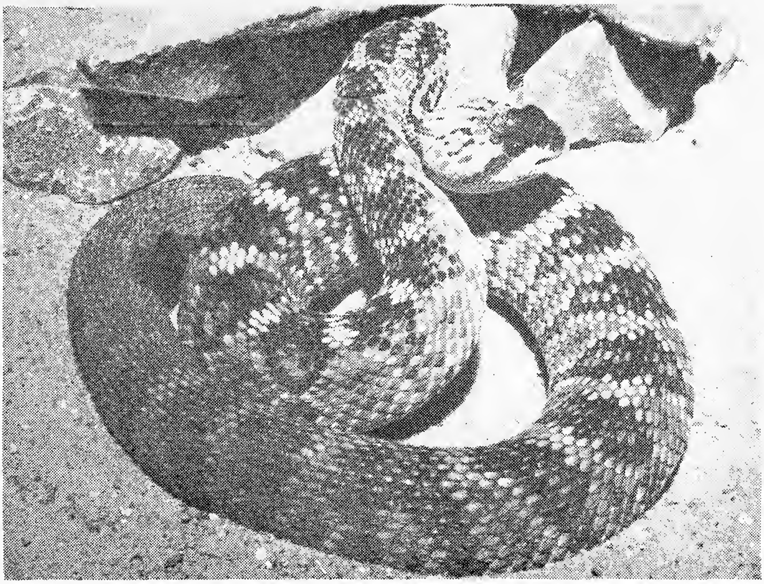


Figure 42. *Crotalus molossus molossus*, specimen from Cave Creek Canon, Chiricahua Mts., Cochise Co., Arizona (71-31 HSH/RSS).

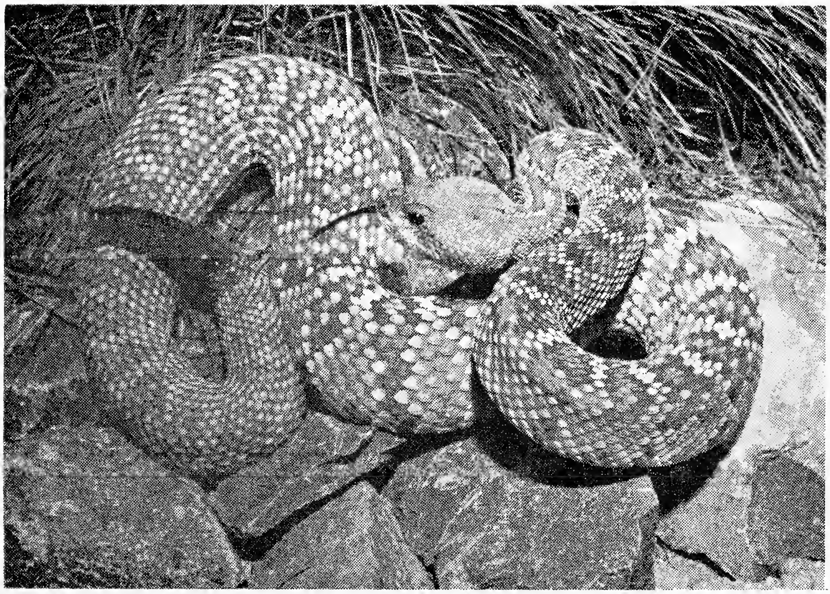


Figure 43. *Crotalus molossus estebanensis*, specimen from Isla San Esteban, Gulf of California, Mexico (71-33 HSH/RSS).

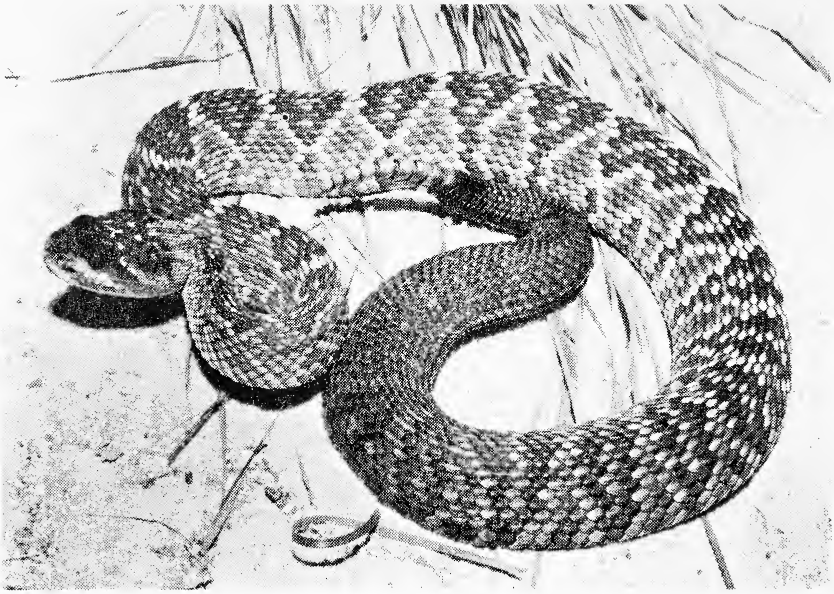


Figure 44. *Crotalus molossus nigrescens*, specimen from near Perote, Veracruz, Mexico (72-30 HSH/RSS).

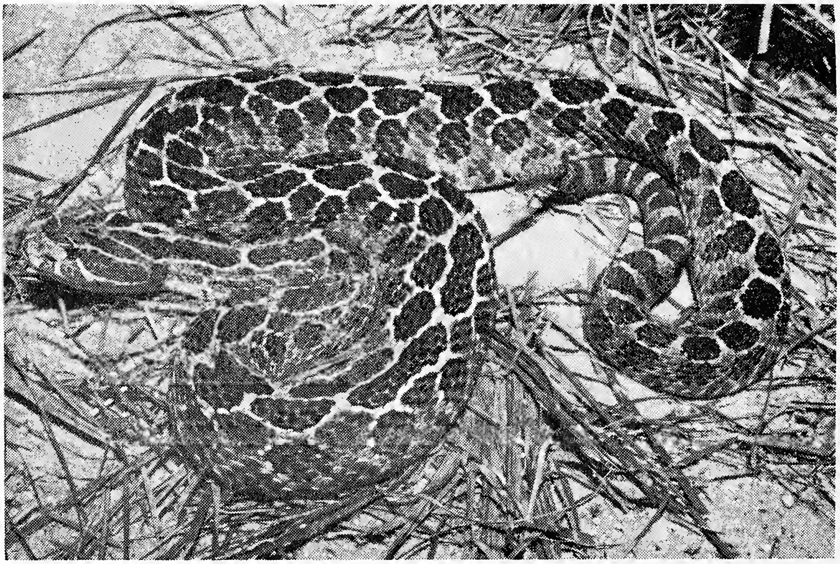


Figure 45. *Crotalus polystictus*, specimen from North of Tapalpa, Jalisco, Mexico (R 678 HSH/RSS).

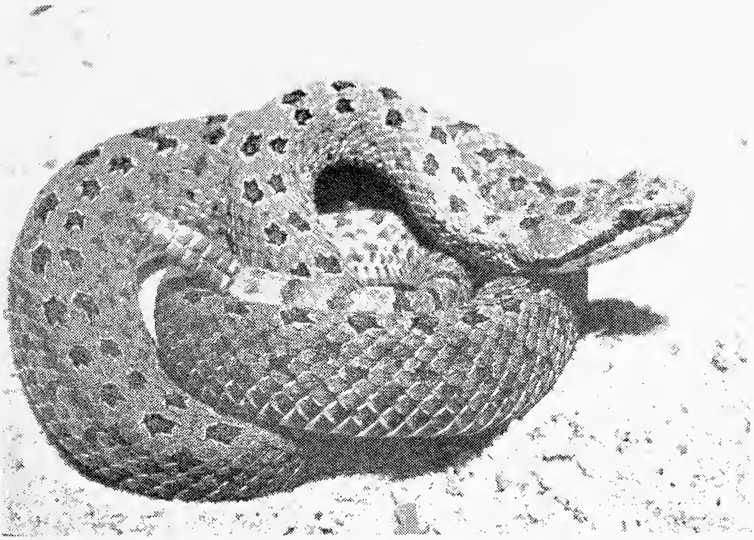


Figure 46. *Crotalus pricei pricei*, specimen from Seirra de Los Ajos, Sonora, Mexico, (RS 983 HSH/RSS).

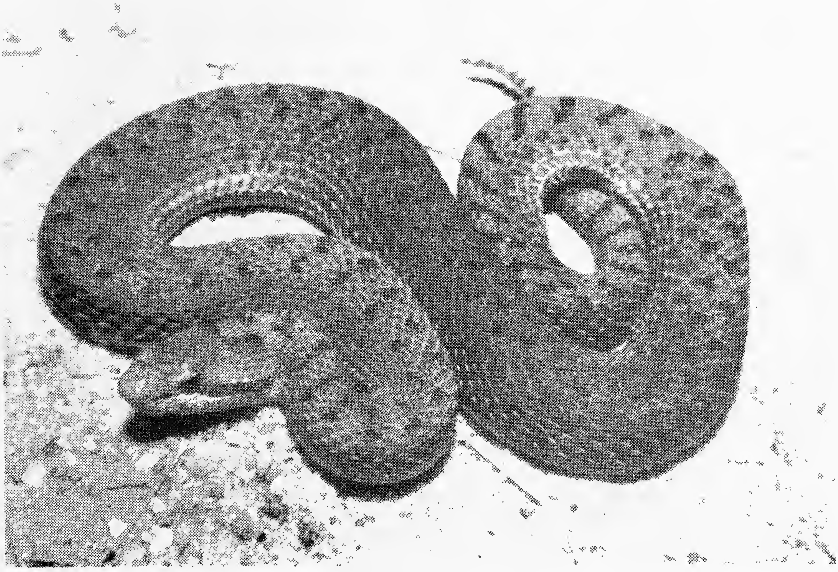


Figure 47. *Crotalus pricei miquihuanus*, specimen from Cerro Potosí, Nuevo León, Mexico (74-14 HSH/RSS).

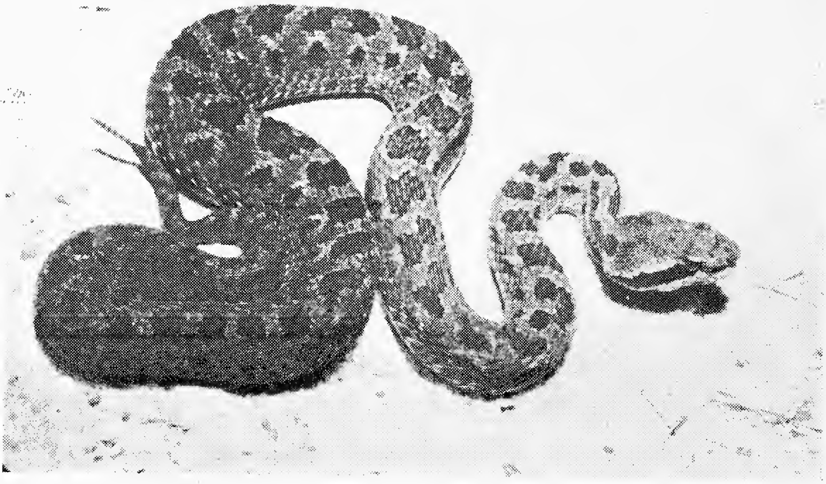


Figure 48. *Crotalus pusillus*, specimen from between Uruapan and Tancítaro, Michoacán, Mexico (73-48 HSH/RSS).

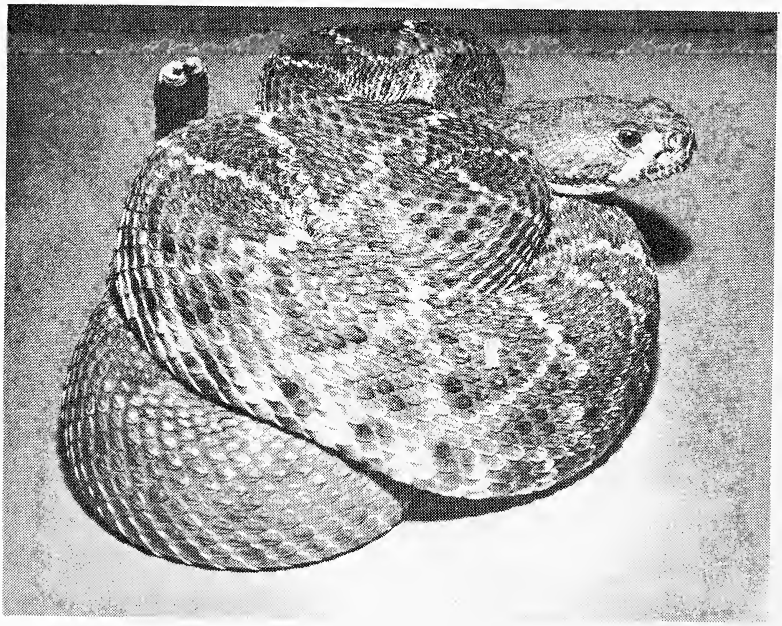


Figure 49. *Crotalus ruber ruber*, specimen from nr. Los Angeles, California.

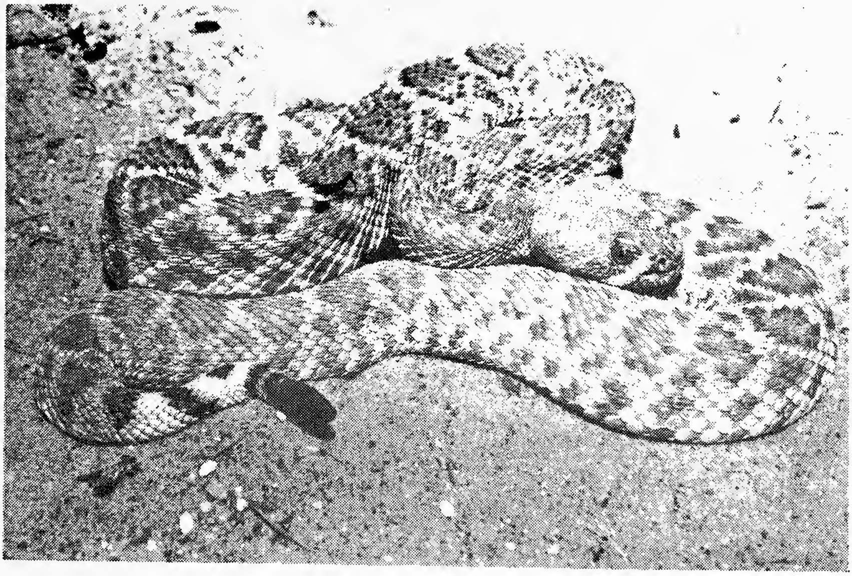


Figure 50. *Crotalus ruber elegans*, specimen from Isla Angel de la Guarda, Gulf of California, Baja del Norte, Mexico (74-40 HSH/RSS).

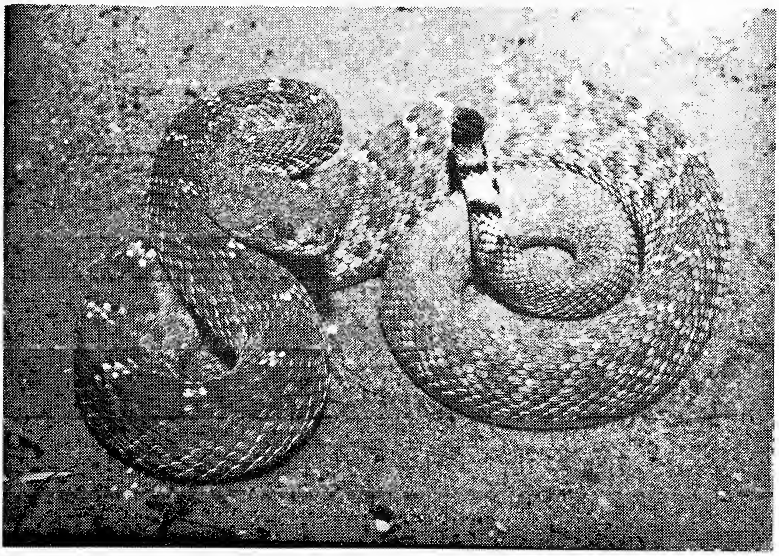


Figure 51. *Crotalus ruber lorenzoensis*, specimen from San Lorenzo Sur, Gulf of California, Baja del Norte, Mexico (77-47 HSH/RSS).

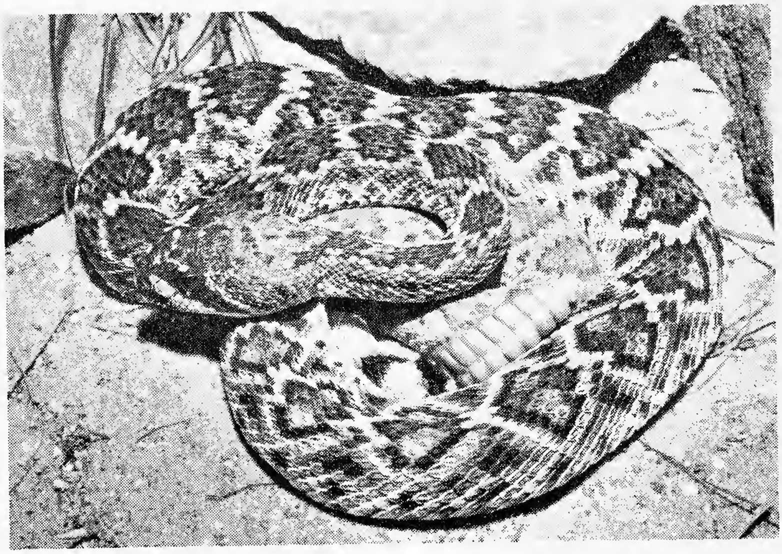


Figure 52. *Crotalus ruber lucasensis*, specimen from LaPaz, Baja Sur, Mexico (RS 947 HSH/RSS).

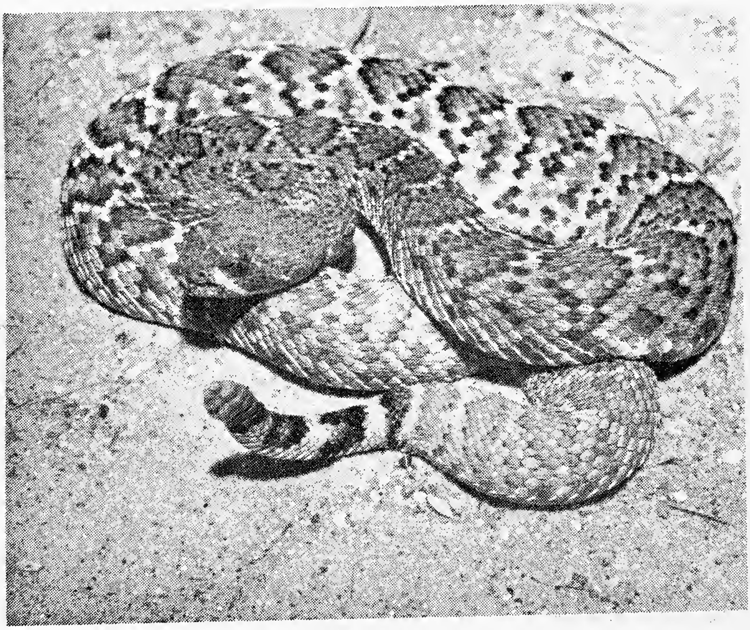


Figure 53. *Crotalus ruber monserratensis* ssp. nov., specimen from Isla Monserrate, Gulf of California, Baja Sur, Mexico (Paratype: RS 1226 HSH/RSS).

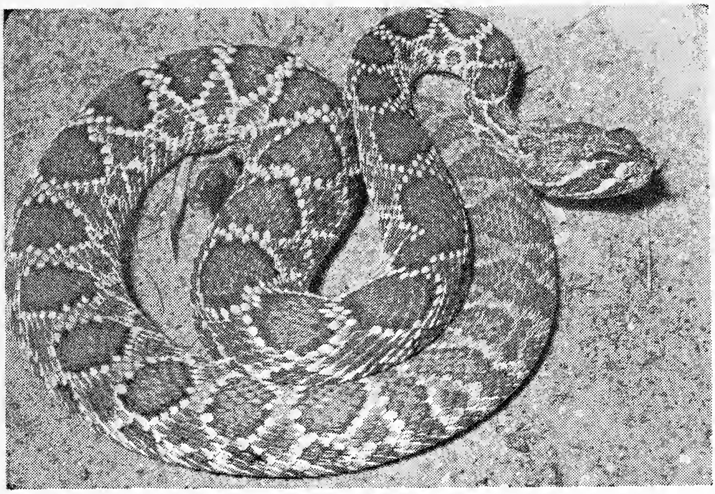


Figure 54. *Crotalus scutulatus scutulatus*, specimen from Nevada (75-27 HSH/RSS).

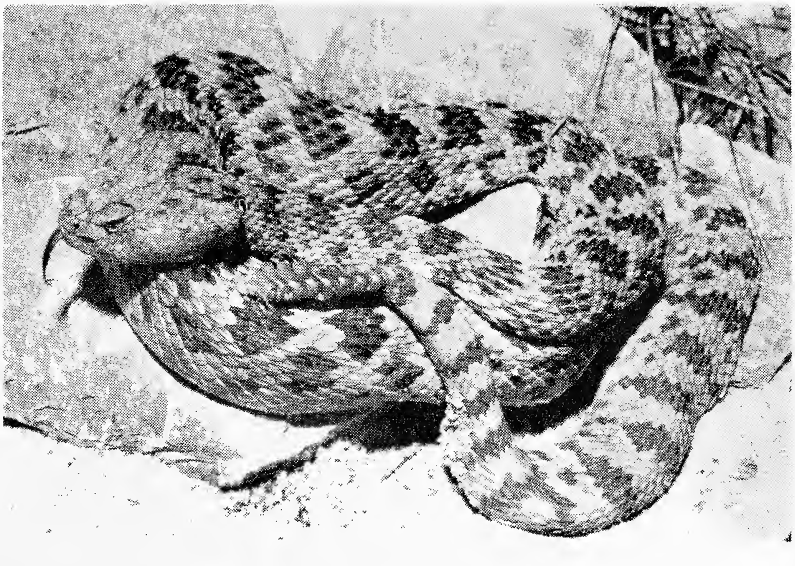


Figure 55. *Crotalus scutulatus salvini*, specimen from near Perote, Veracruz, Mexico (RS 787 HSH/RSS).

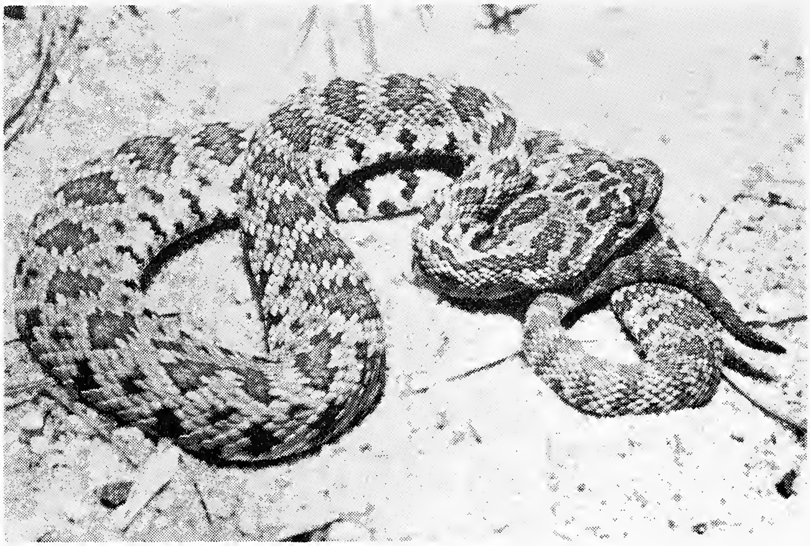


Figure 56. *Crotalus stejnegeri*, specimen from East of Concordia, Sinaloa, Mexico (RS 901 HSH/RSS).

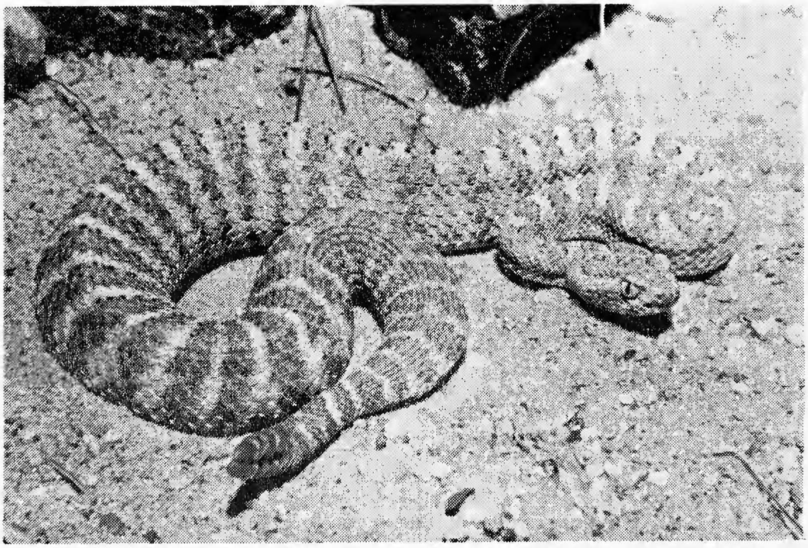


Figure 57. *Crotalus tigris*, specimen from Canyon Lake, Maricopa Co., Arizona (71-41 HSH/RSS).

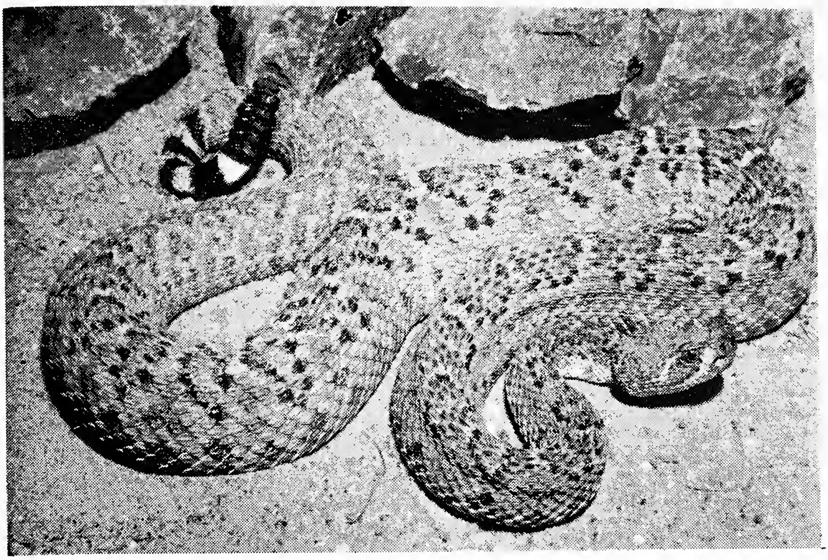


Figure 58. *Crotalus tortugensis*, specimen from Isla Tortuga, Gulf of California, Mexico (RS 828 HSH/RSS).

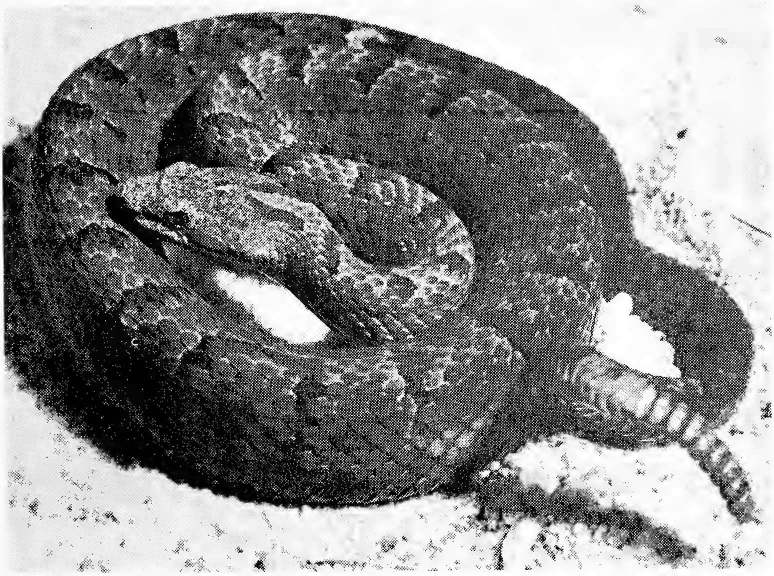


Figure 59. *Crotalus transversus*, specimen from Nr. Laguna Zempoala, México, Mexico (RS 1087 HSH/RSS).

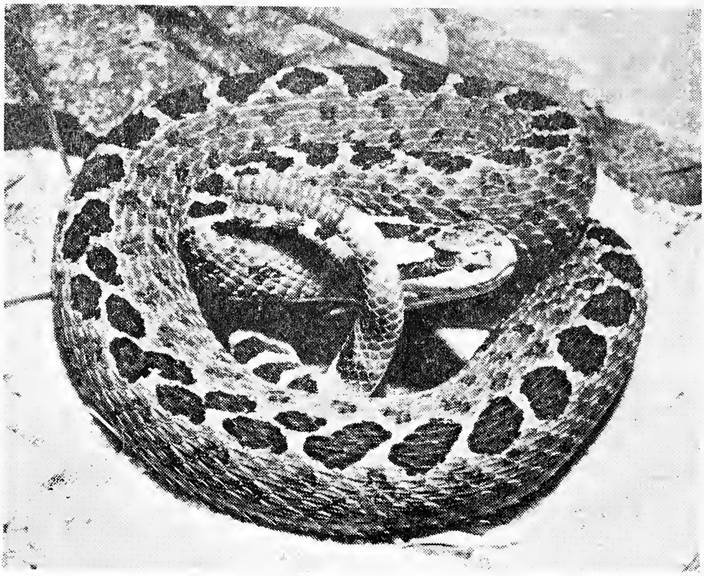


Figure 60. *Crotalus triseriatus triseriatus*, specimen from District Federal, México, Mexico (RS 1058 HSH/RSS).

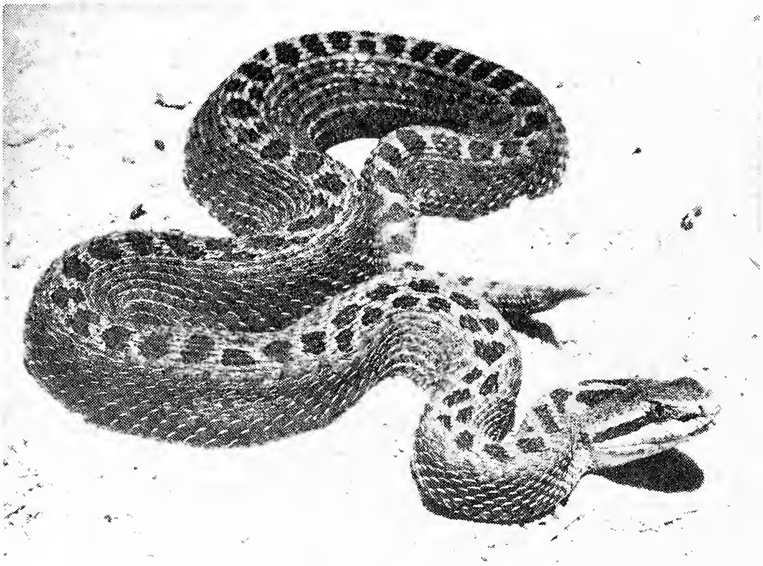


Figure 61. *Crotalus triseriatus anahuacus*, specimen from Laguna Zempoala, México, Mexico (72-96 HSH/RSS).

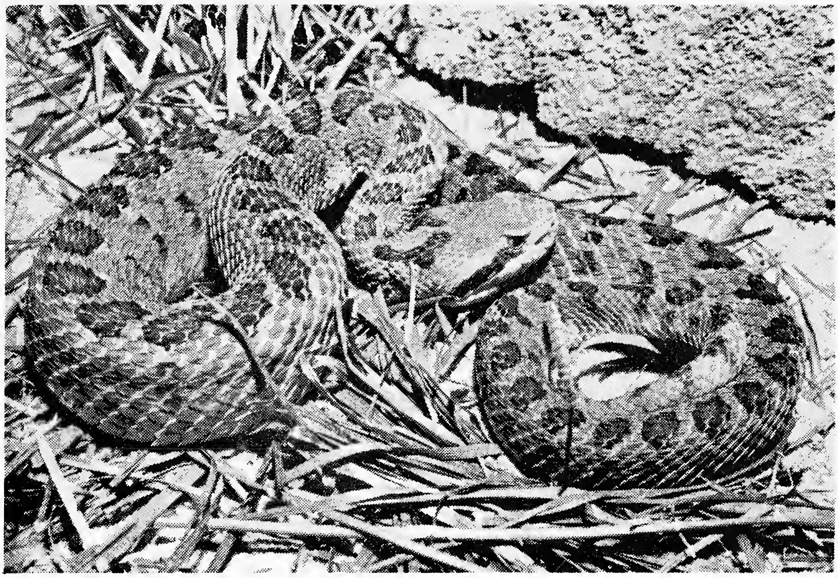


Figure 62. *Crotalus triseriatus* ssp., specimen from Tapalpa, Jalisco, Mexico (RS 999 HSH/RSS).

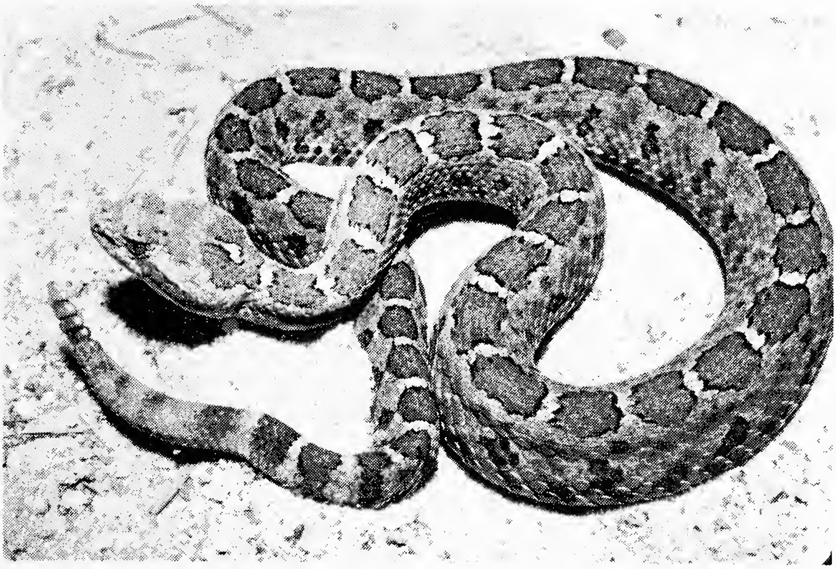


Figure 63. *Crotalus triseriatus quadrangularis* ssp. nov., specimen from near Jacala, Hidalgo, Mexico (Paratype: RS 1232 HSH/RSS).

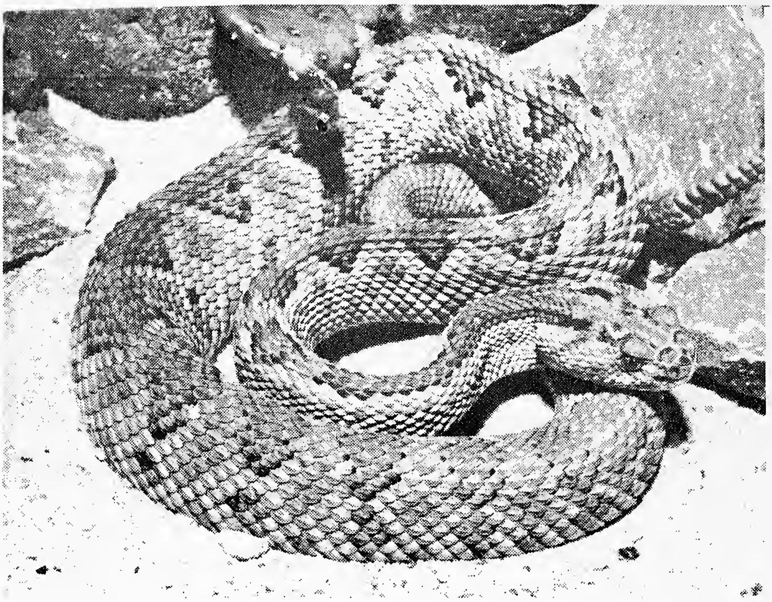


Figure 64. *Crotalus unicolor*, specimen from Santa Cruz, Aruba, off the coast of Venezuela (RS 776 HSH/RSS).

Figure 65. *Crotalus vegrandis*, specimen from near Tremblador, Monagas, Venezuela (72-58 HSH/RSS).

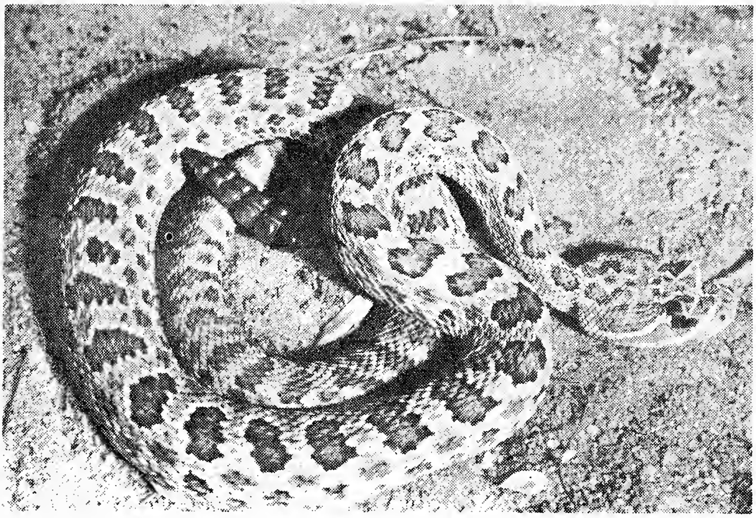


Figure 66. *Crotalus viridis viridis*, specimen from an unknown locality (75-40 HSH/RSS).

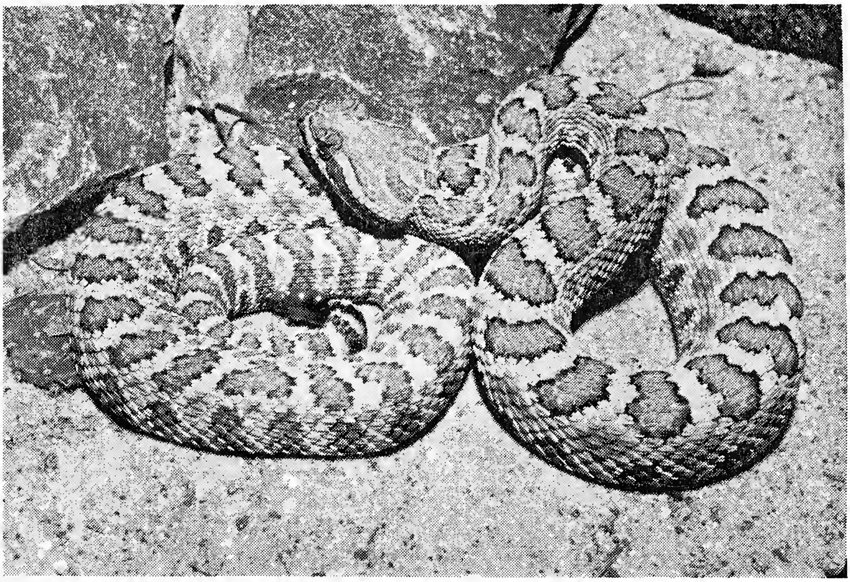


Figure 67. *Crotalus viridis abyssus*, specimen from Havasupi Canon, Coconino Co., Arizona (71-128 HSH/RSS).

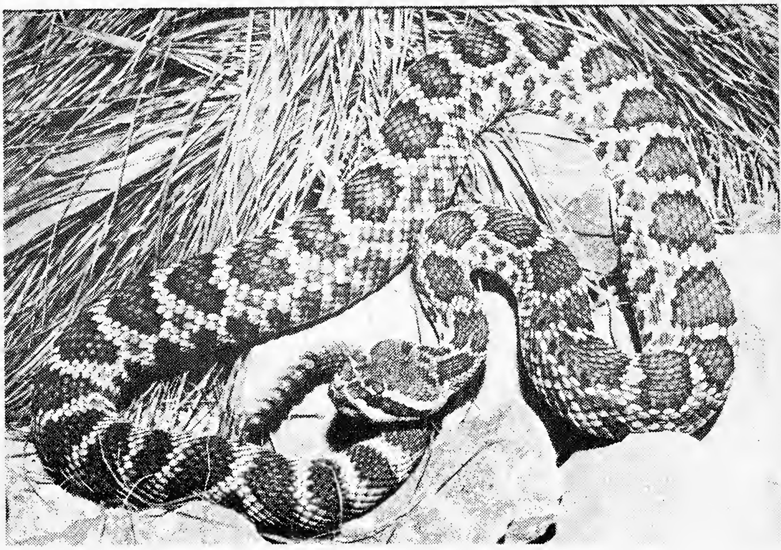


Figure 68. *Crotalus viridis caliginis*, specimen from Isla Coronado Sur, off the Pacific coast of Baja del Norte, Mexico (RS 974 HSH/RSS).

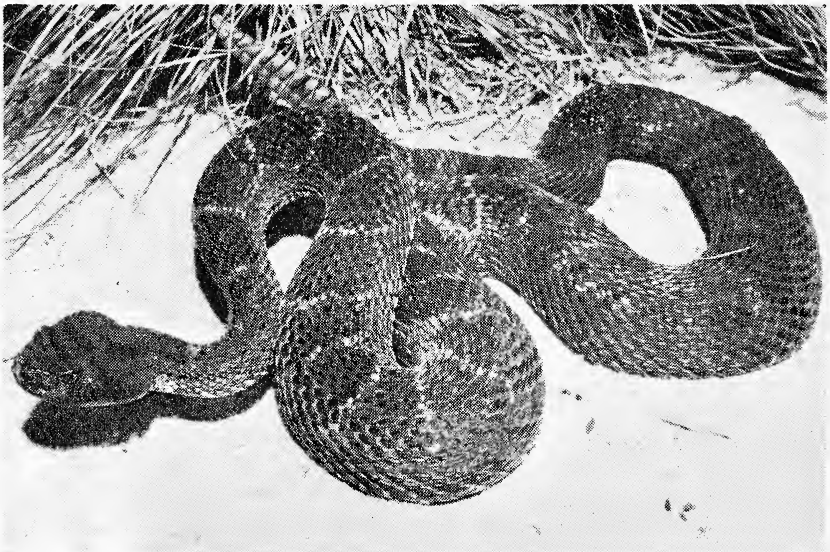


Figure 69. *Crotalus viridis cerberus*, specimen from Molina Basin, Pima Co., Arizona (RS 781 HSH/RSS).

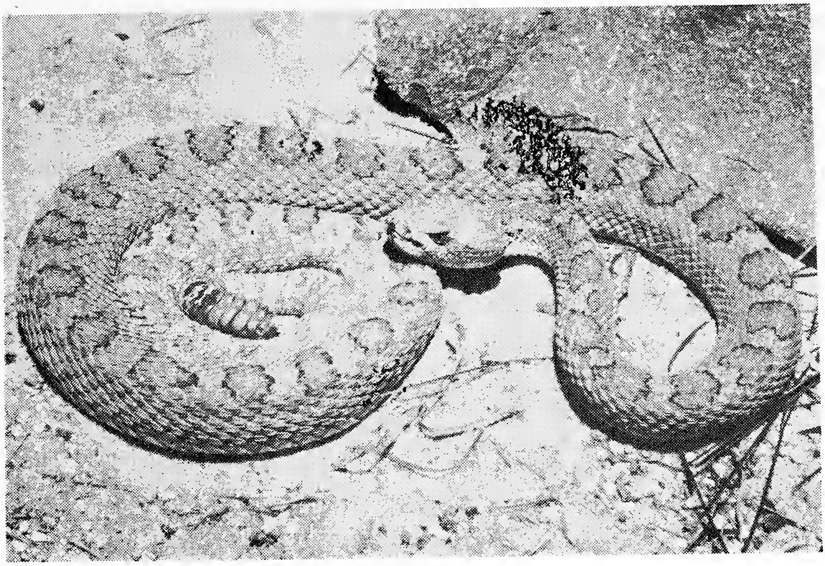


Figure 70. *Crotalus viridis concolor*, specimen from North of Moab, Utah (73-11 HSH/RSS).

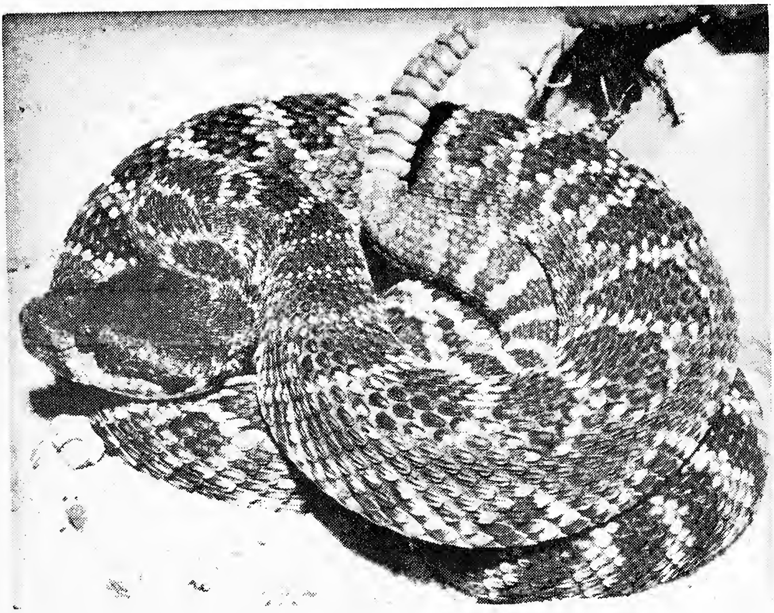


Figure 71. *Crotalus viridis helleri*, specimen from between Los Angeles and San Diego on Coast, California (71-51 HSH/RSS).

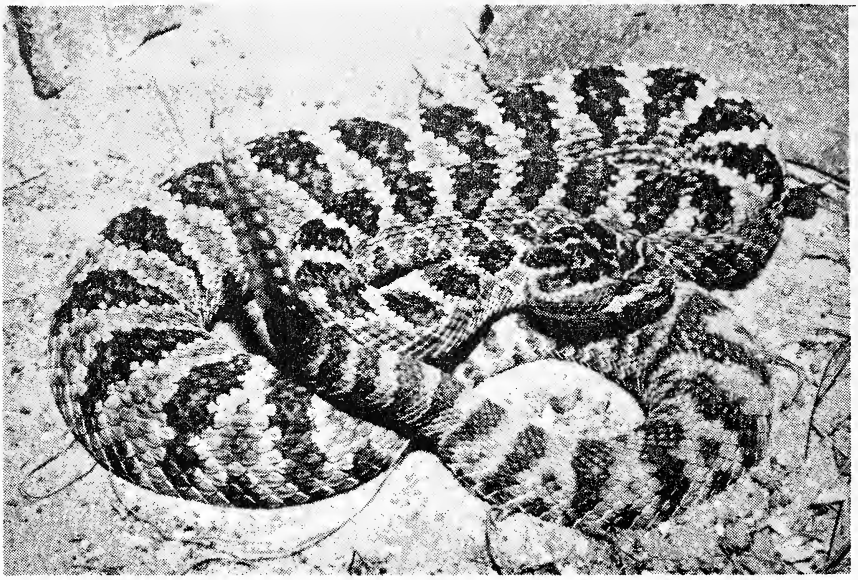


Figure 72. *Crotalus viridis lutosus*, specimen from North of Grand Canyon, Cononico Co., Arizona (71-53 HSH/RSS).

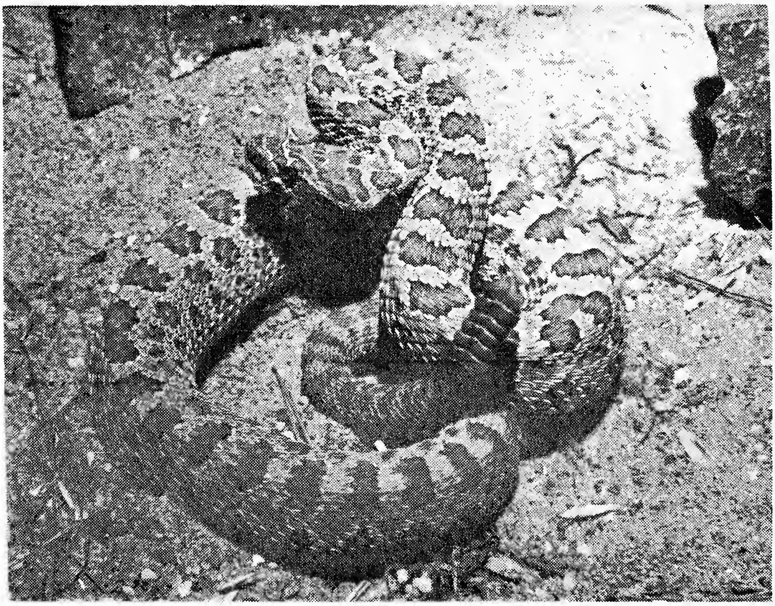


Figure 73. *Crotalus viridis nuntius*, specimen from North of Winslow, Aavago Co., Arizona (RS 1092 HSH/RSS).

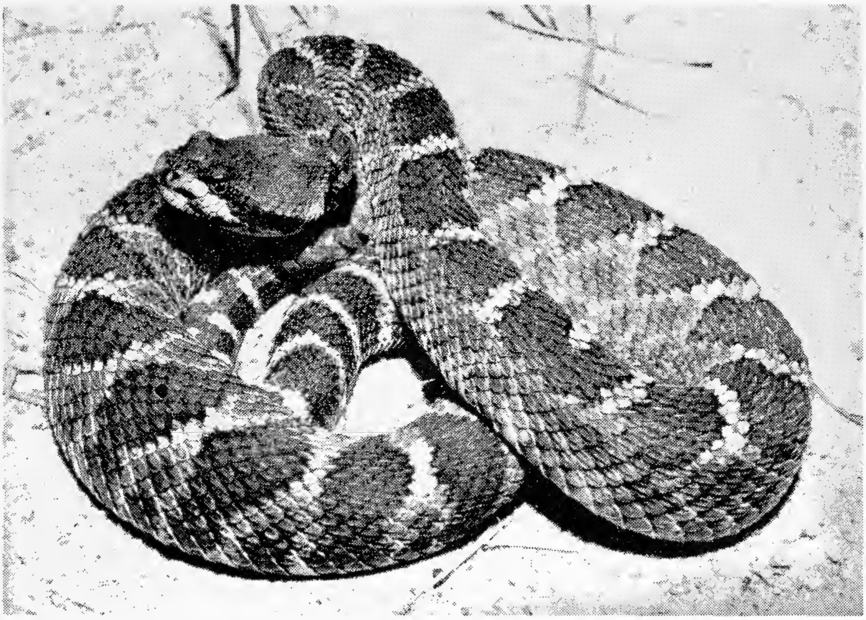


Figure 74. *Crotalus viridis oreganus*, specimen from California (72-59 HSH/RSS).

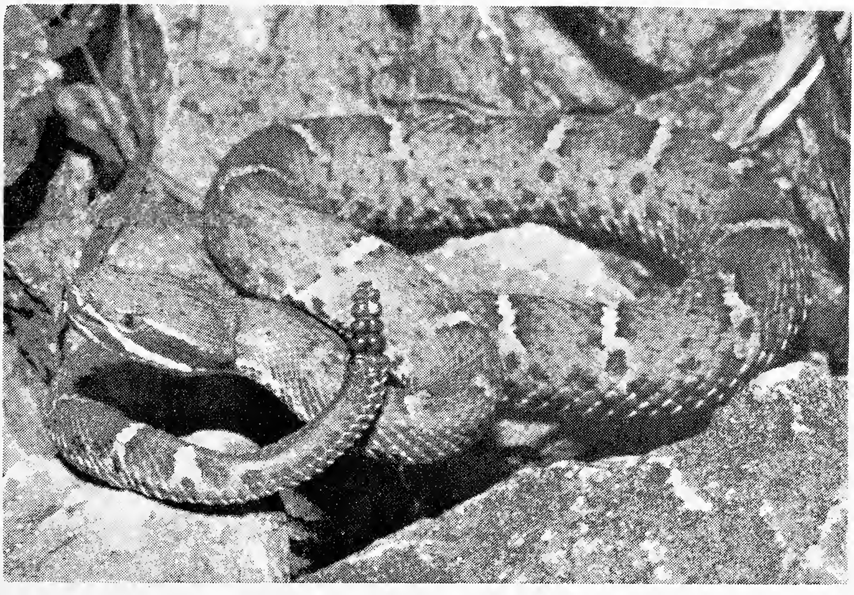


Figure 75. *Crotalus willardi willardi*, specimen from Ramsey Canon, Huachuca Mts., Arizona (RS 840 HSH/RSS).

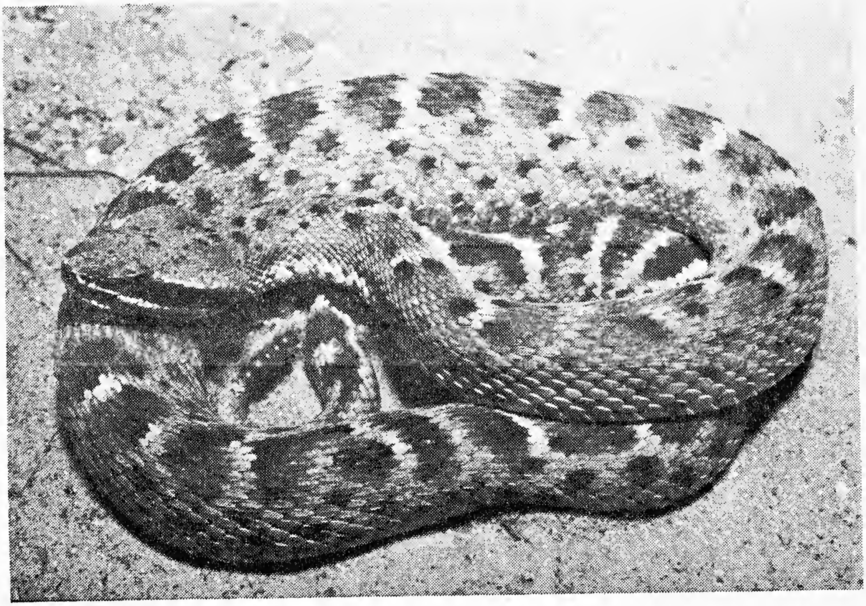


Figure 76. *Crotalus willardi amabilis*, specimen from the Sierra del Nido, Chihuahua, Mexico (RS 1186 HSH/RSS).

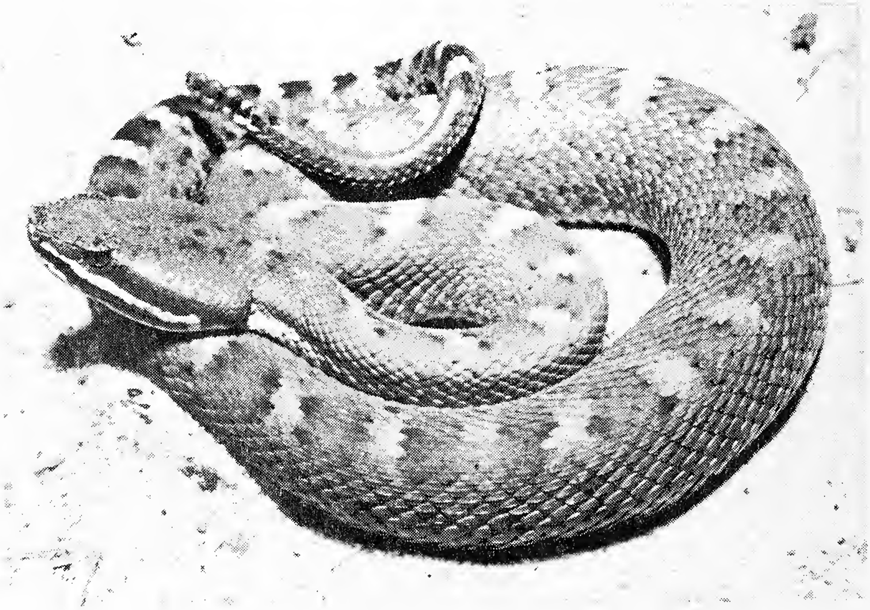


Figure 77. *Crotalus willardi meridionalis*, specimen from near Llano Grande, Durango, Mexico (73-78 HSH/RSS). Specimen courtesy of R.Webb.

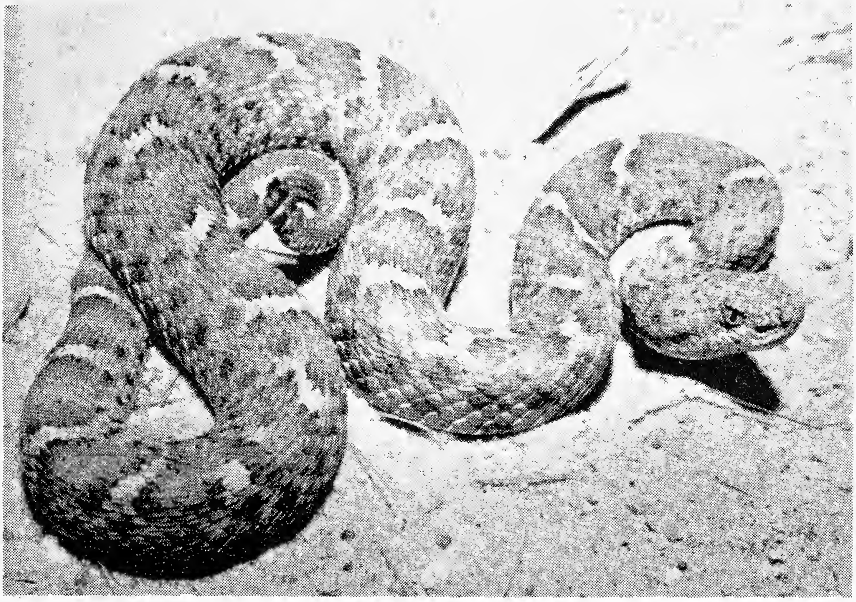


Figure 78. *Crotalus willardi obscurus*, specimen from Indian Creek Canon, Animas Mts., Hidalgo Co., New Mexico (Paratype: RS 955 HSH/RSS).

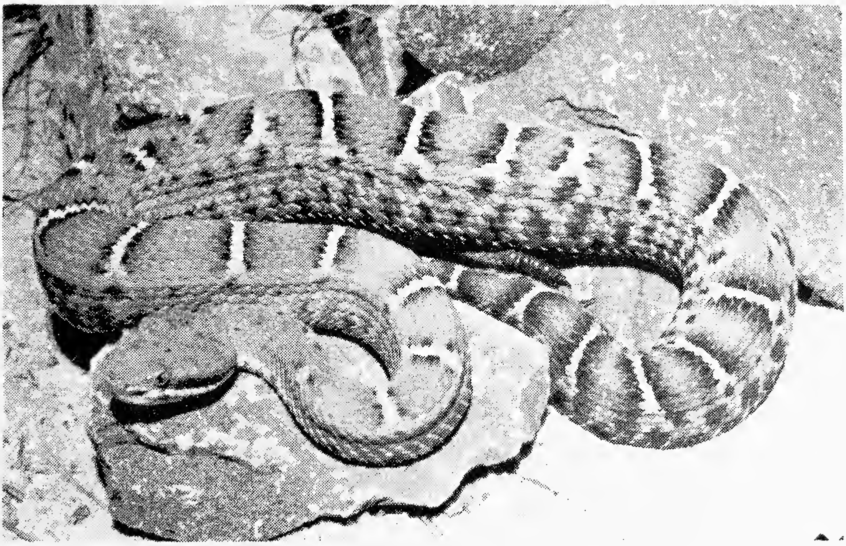


Figure 79. *Crotalus willardi silus*, specimen from Sierra Nacozari, Sonora, Mexico (RS 843 HSH/RSS).

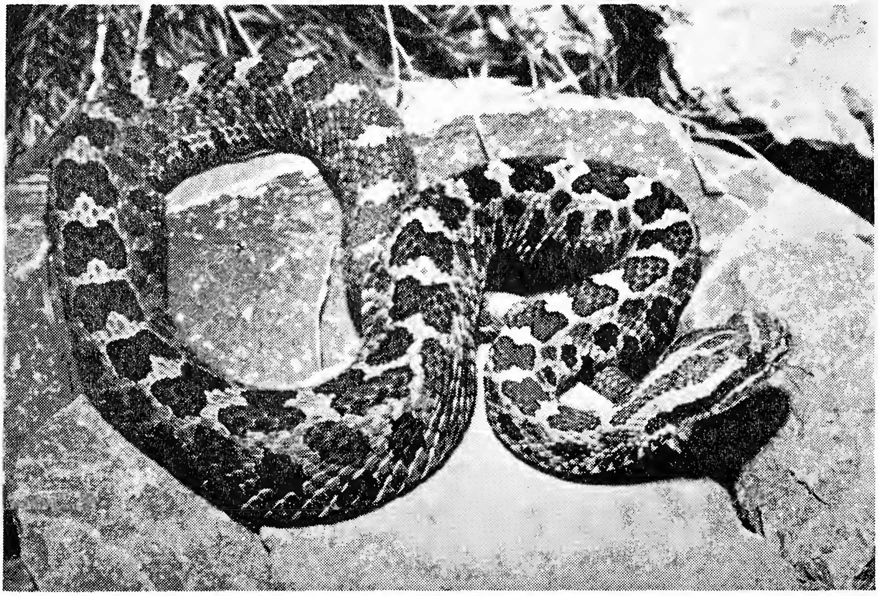


Figure 80. *Sistrurus catenatus catenatus*, specimen from near La Grange, La Grange Co., Indiana (71-59 HSH/RSS).

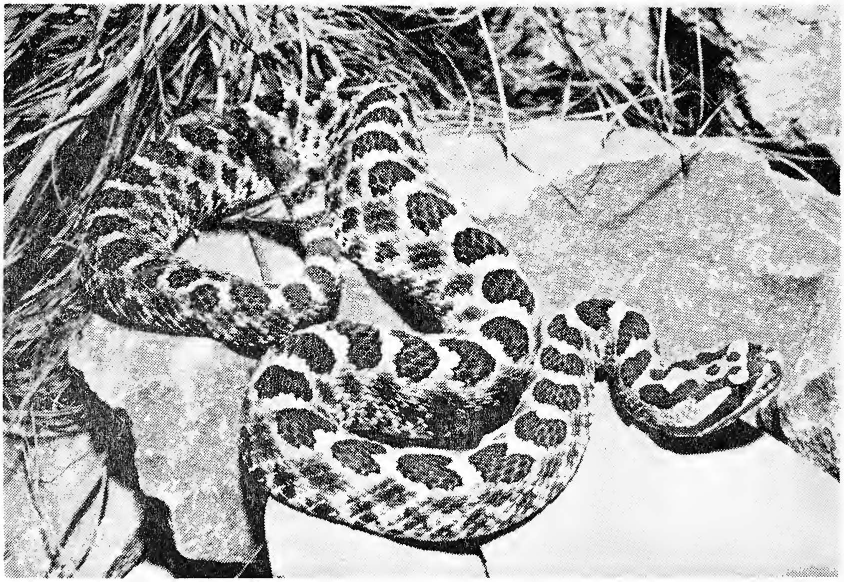


Figure 81. *Sistrurus catenatus edwardsii*, specimen from near Uvalde, Uvalde Co., Texas (RS 960 HSH/RSS).

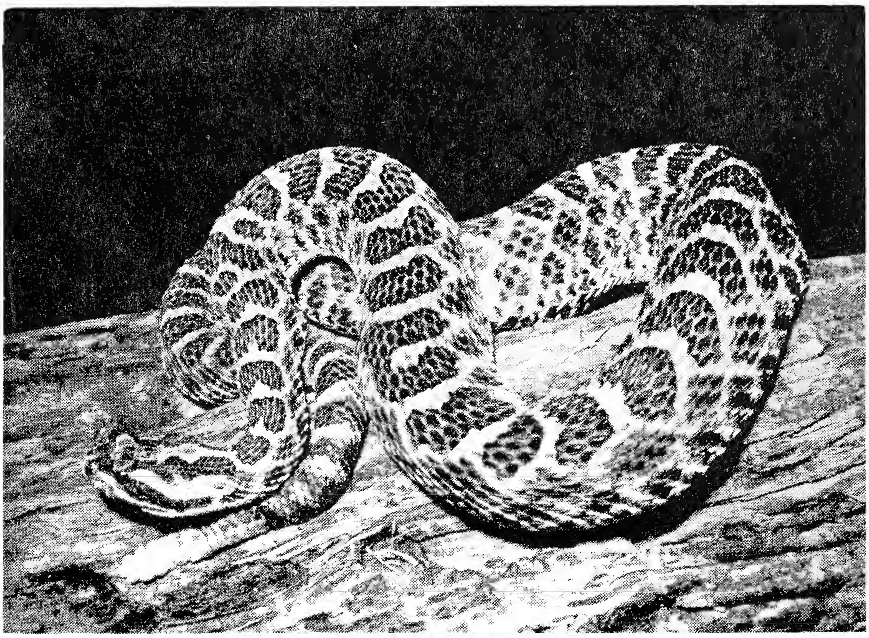


Figure 82. *Sistrurus catenatus tergeminus*, specimen from near Brownwood, Brown Co., Texas.

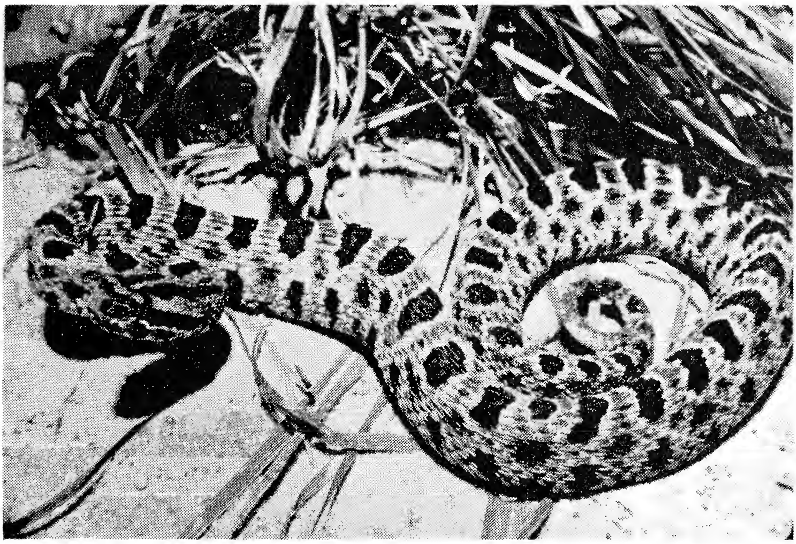


Figure 83. *Sistrurus miliarius miliarius*, specimen from near Wilmington, New Handover Co., North Carolina (RS 788 HSH/RSS).

Figure 84. *Sistrurus miliarius barbouri*, specimen from near Fort Myers, Lee Co., Florida (77-14 HSH/RSS).

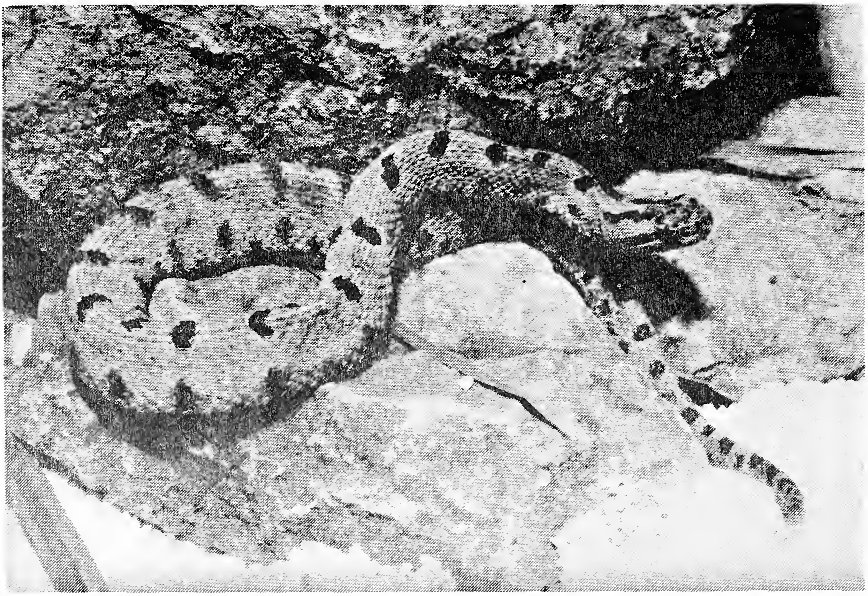


Figure 85. *Sistrurus miliarius streckeri*, specimen from near Houston, Harris Co., Texas (RS 1140 HSH/RSS).

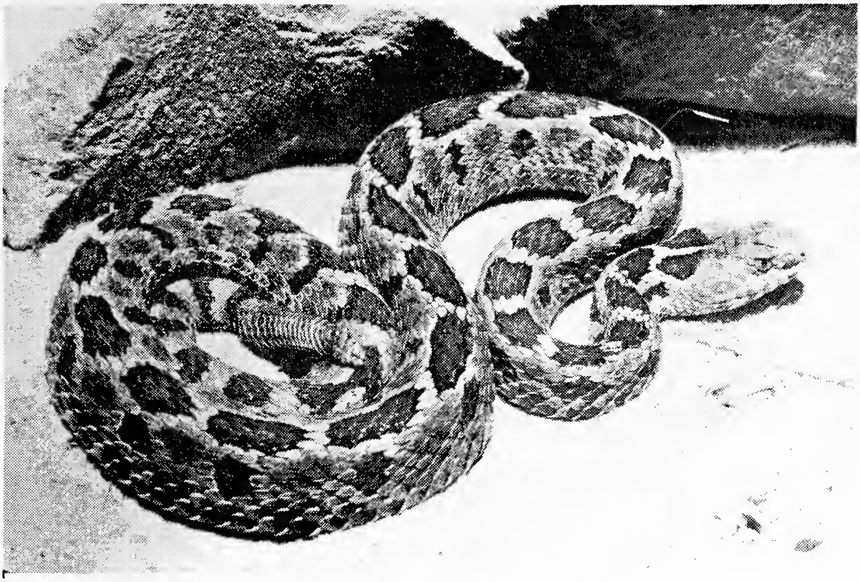


Figure 86. *Sistrurus ravus ravus*, specimen from near Puebla, Puebla, Mexico (RS 956 HSH/RSS).

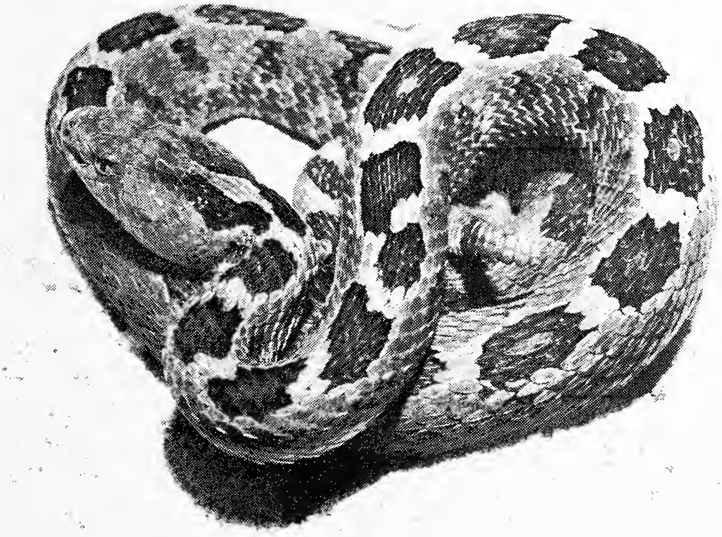


Figure 87. *Sistrurus ravus brunneus* ssp. nov., specimen from near Huajuapan, Oaxaca, Mexico (RS 73-60 HSH/RSS).

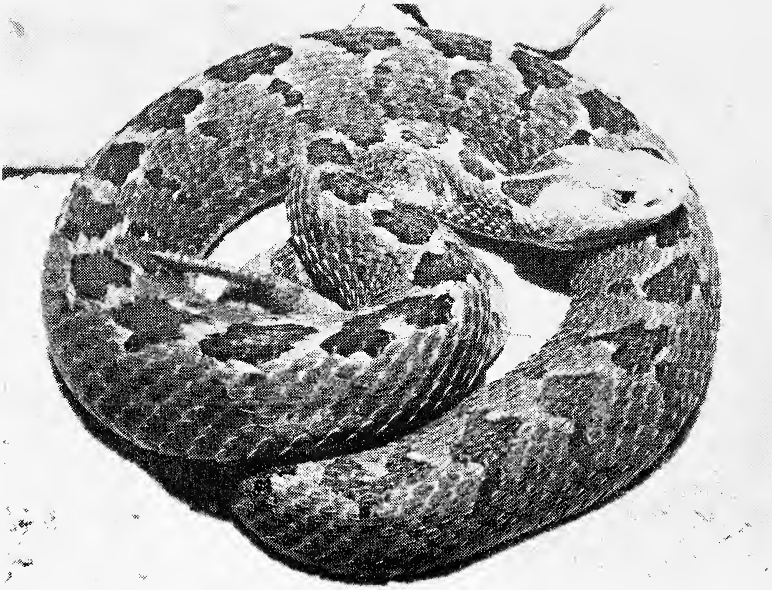
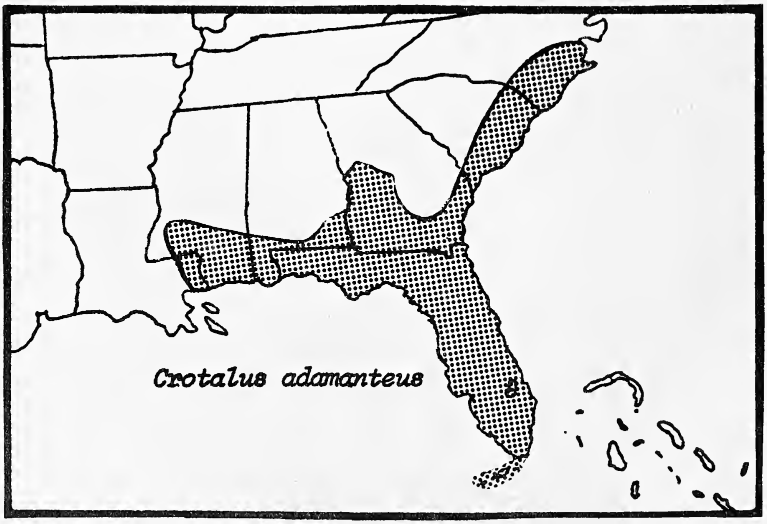
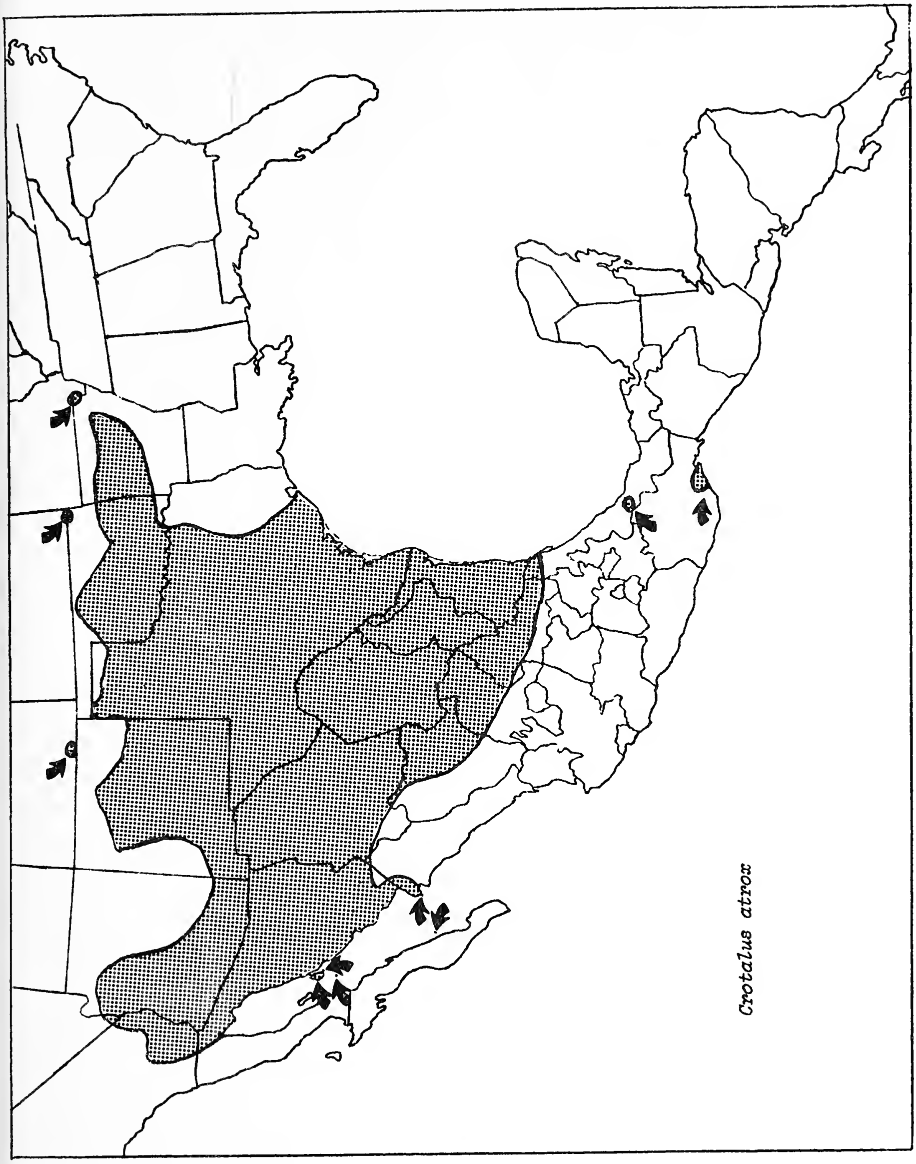


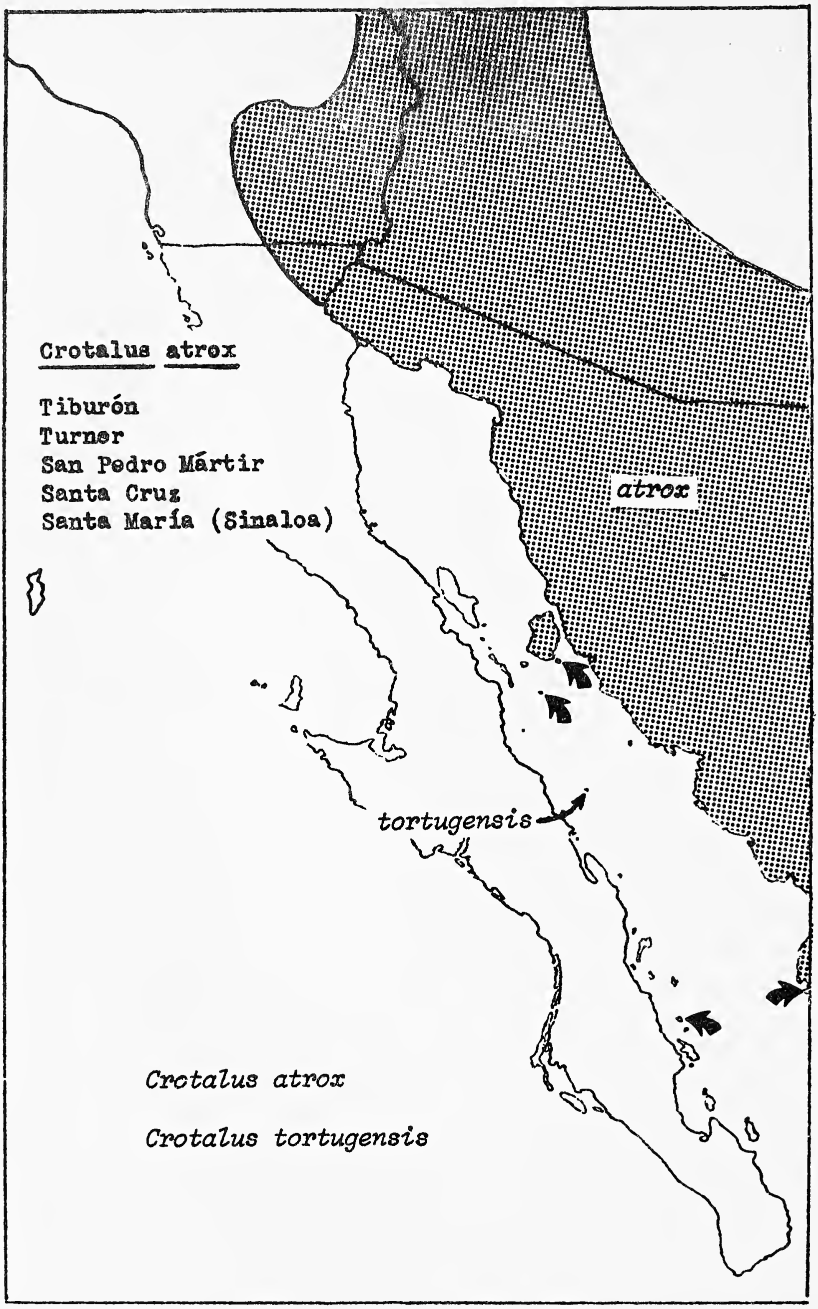
Figure 88. *Sistrurus ravus lutescens* ssp. nov., specimen from near Huitzilac, Morelos, Mexico (Paratype: RS 831 HSH/RSS).



Map 1. The distribution of *Crotalus adamanteus*.

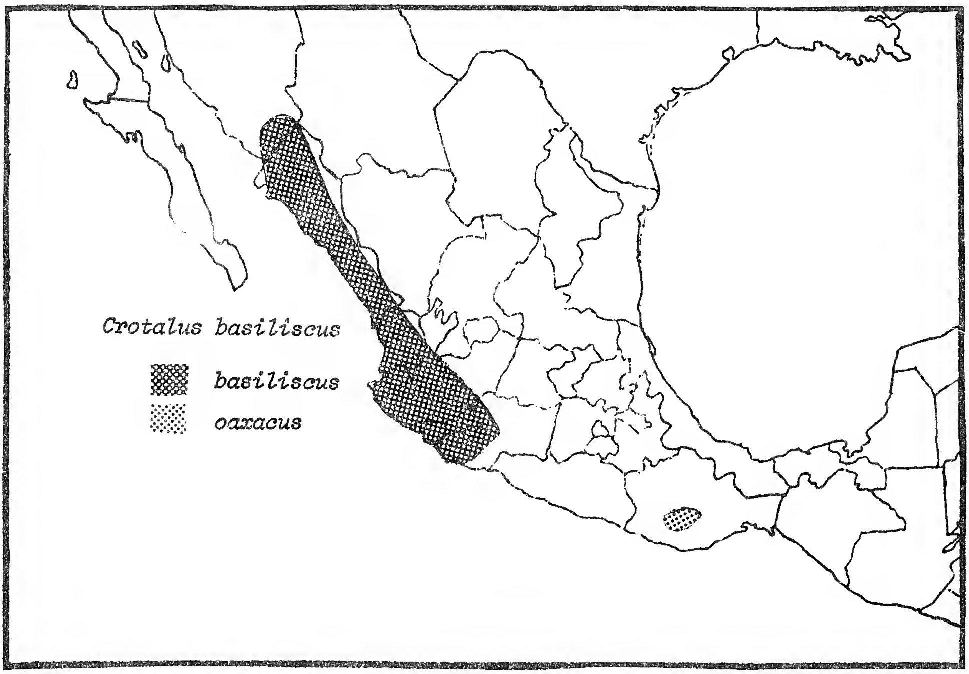


Map 2a. The distribution of *Crotalus atrox*.

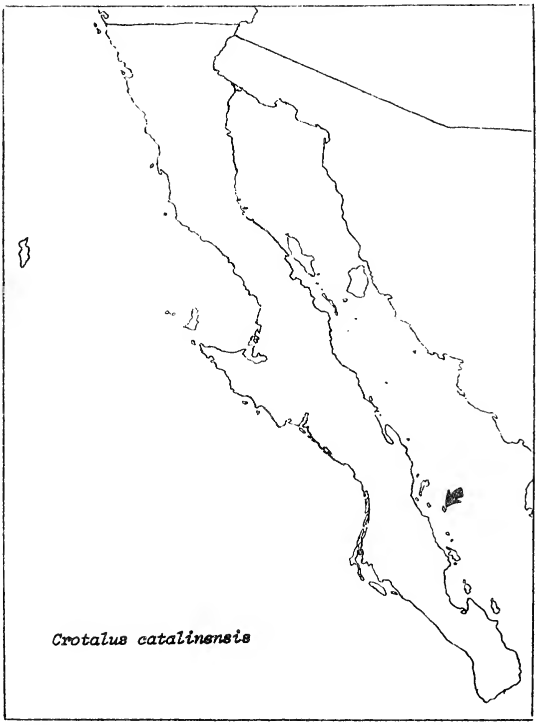


Map 2b. The island distribution, in the Gulf of California, of *Crotalus atrox* and including *Crotalus tortugensis*.

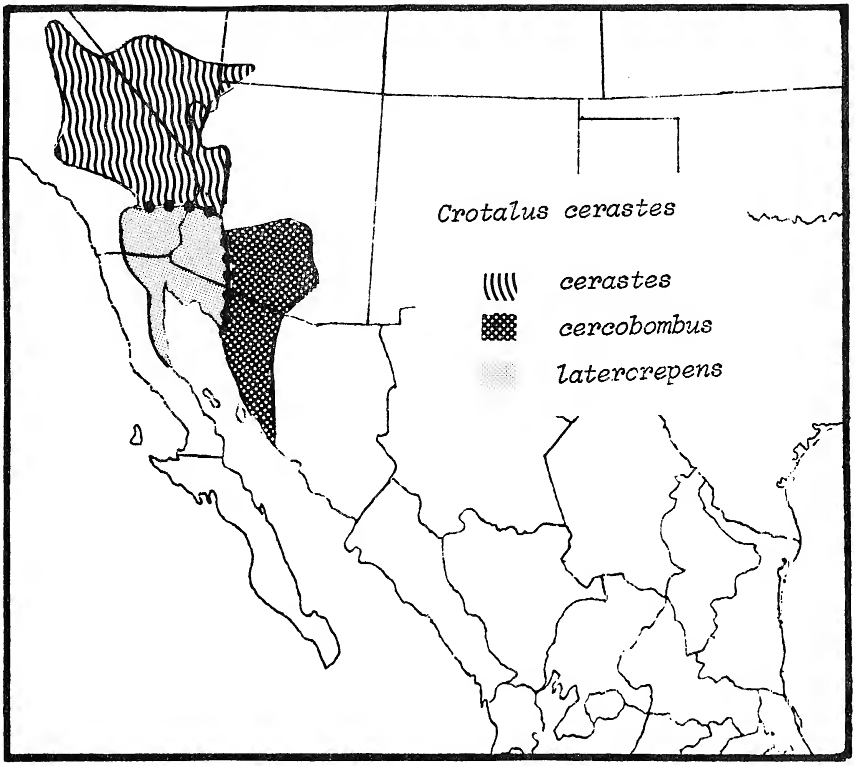
Map 3. The distribution of *Crotalus aquilus*.



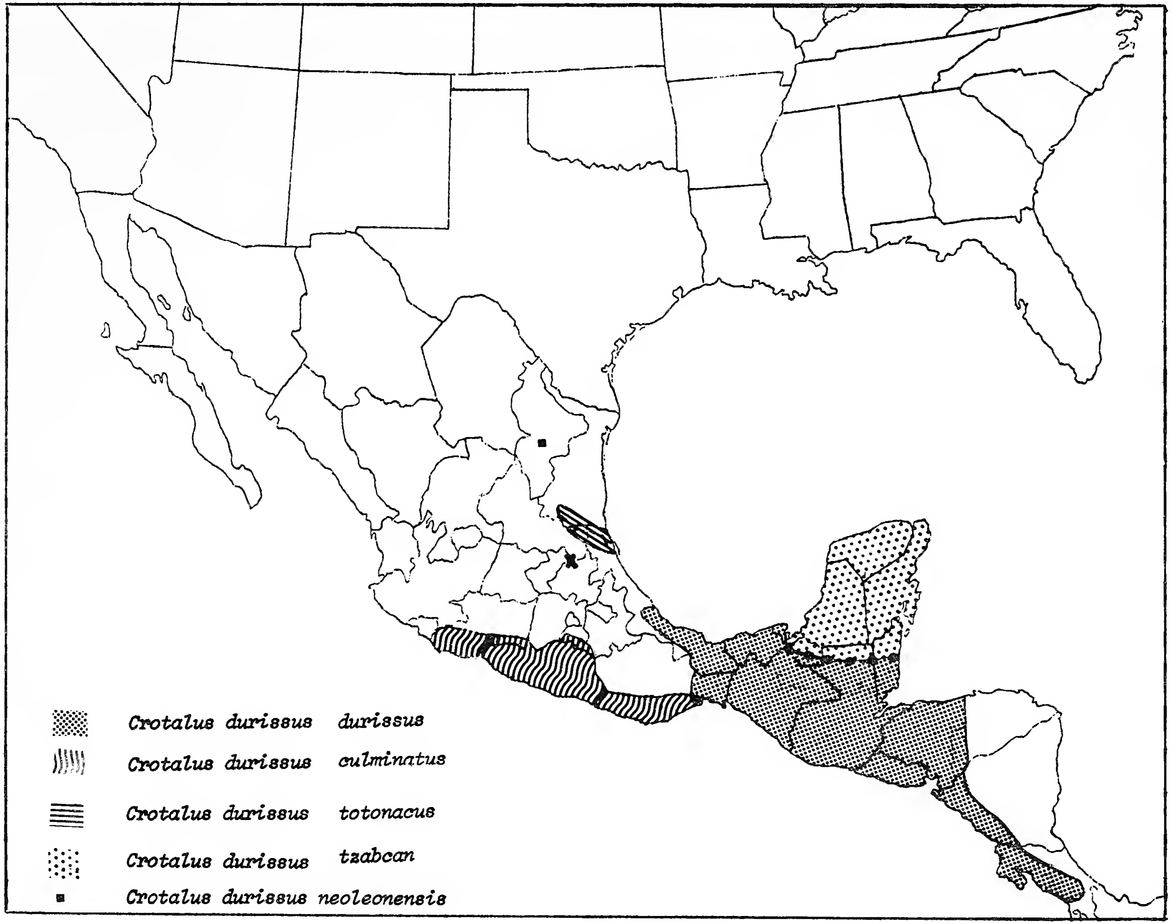
Map 4. The distribution of *Crotalus basiliscus*.



Map 5. The distribution of *Crotalus catalinensis*.

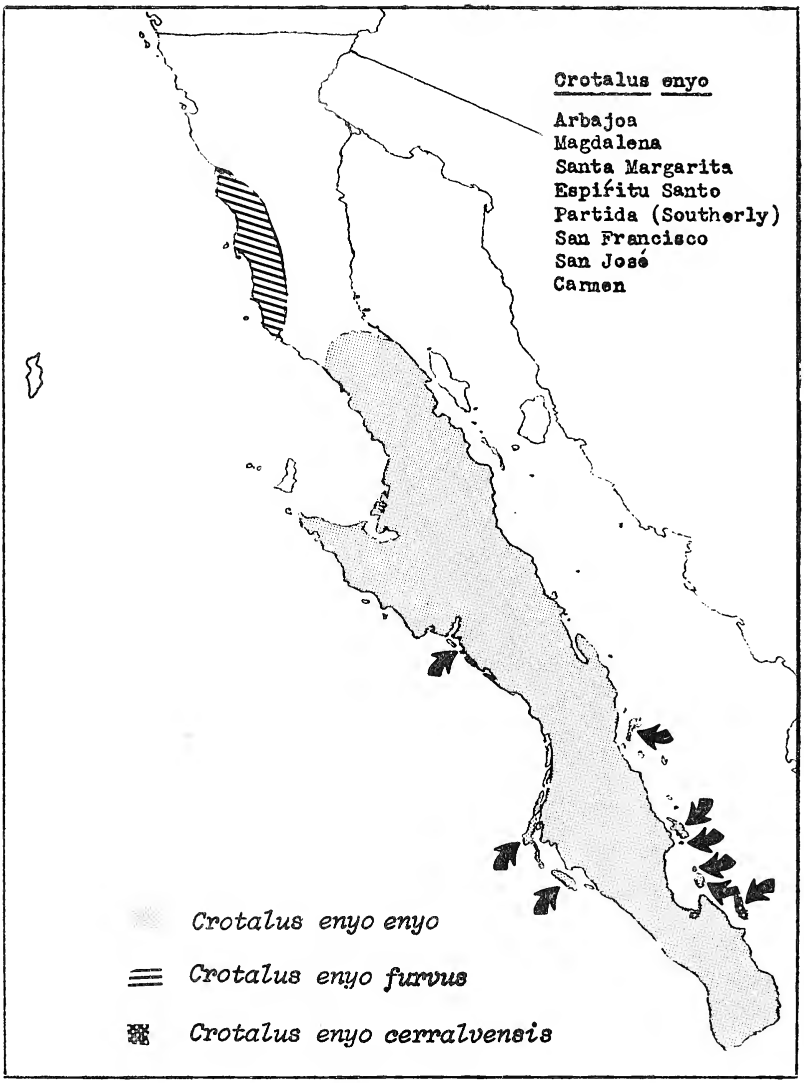


Map 6. The distribution of *Crotalus cerastes*.

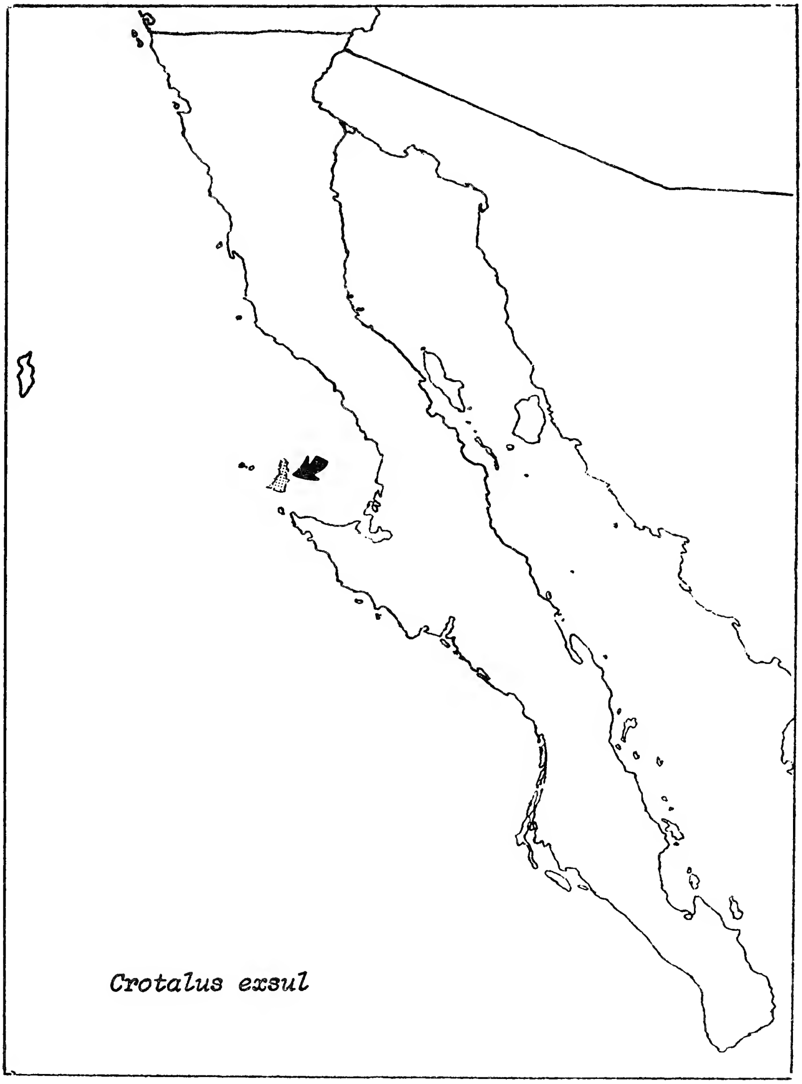


Map 7. The distribution of the Mexican and Central American subspecies of *Crotalus durissus*.

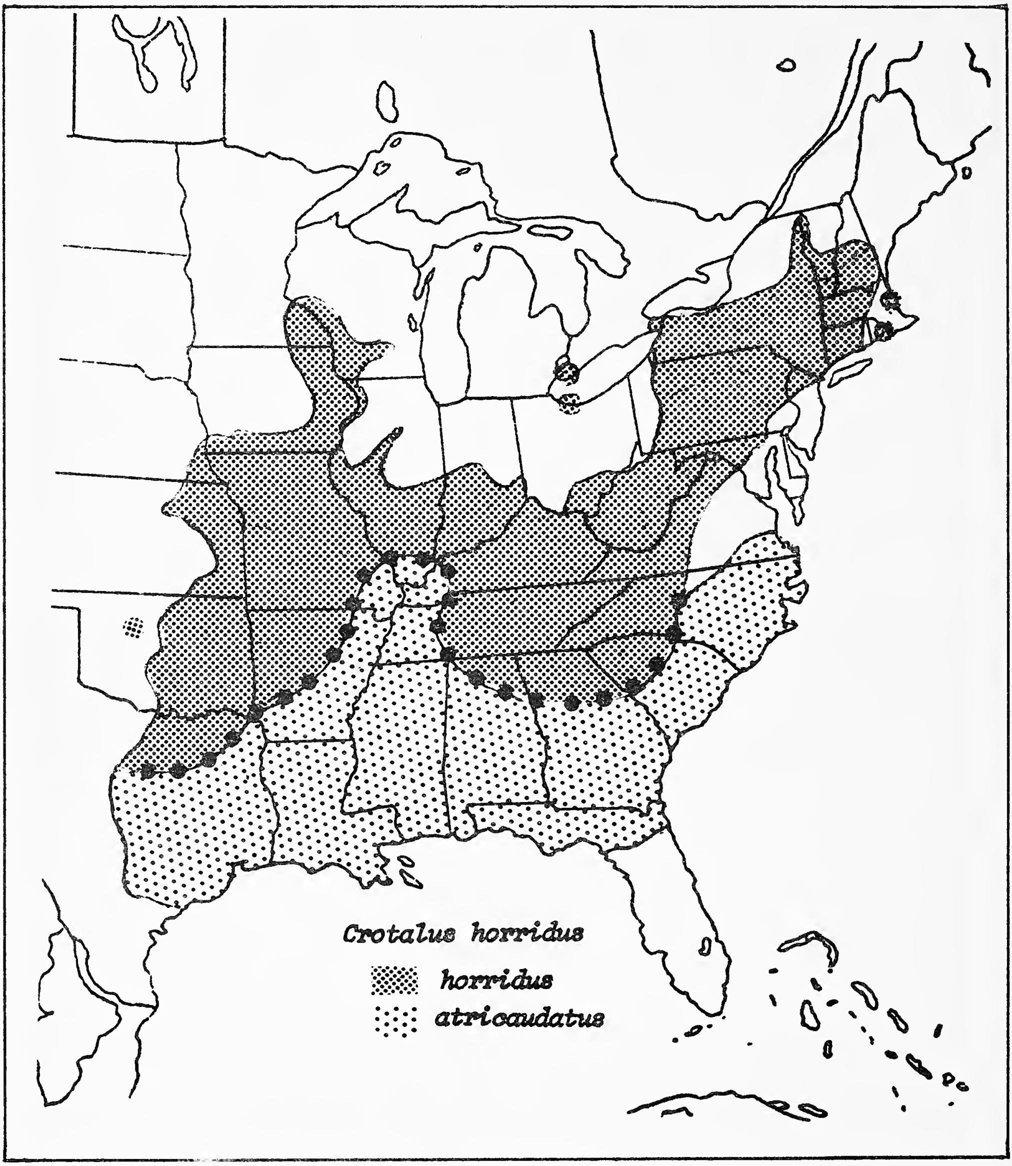
Map 8. The distribution of the South American subspecies of *Crotalus durissus* and including *Crotalus unicolor* and *Crotalus vegrandis*.



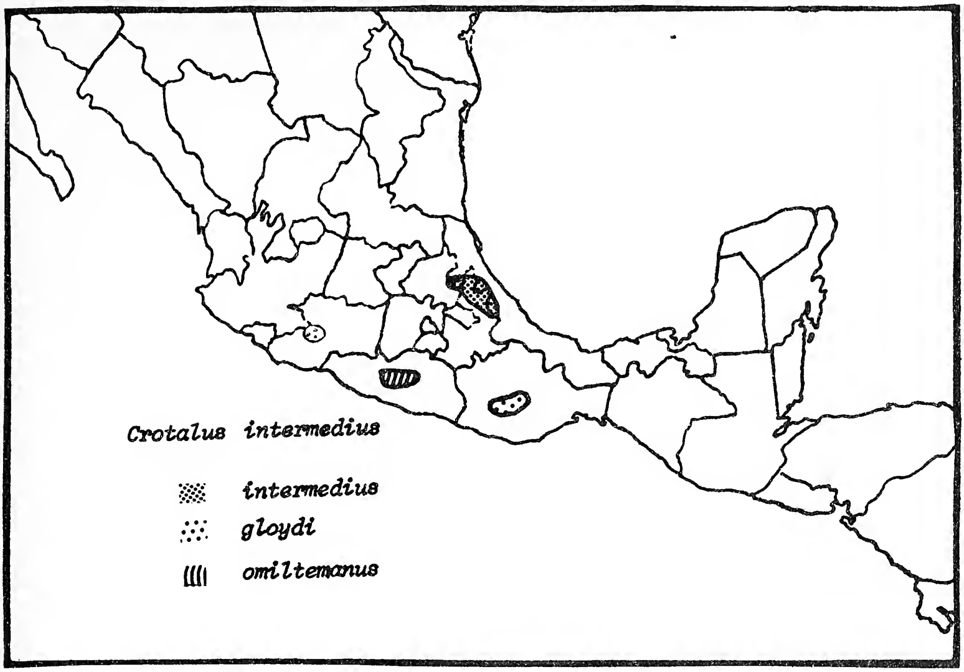
Map 9. The distribution of *Crotalus enyo*.



Map 10. The distribution of *Crotalus exsul*.

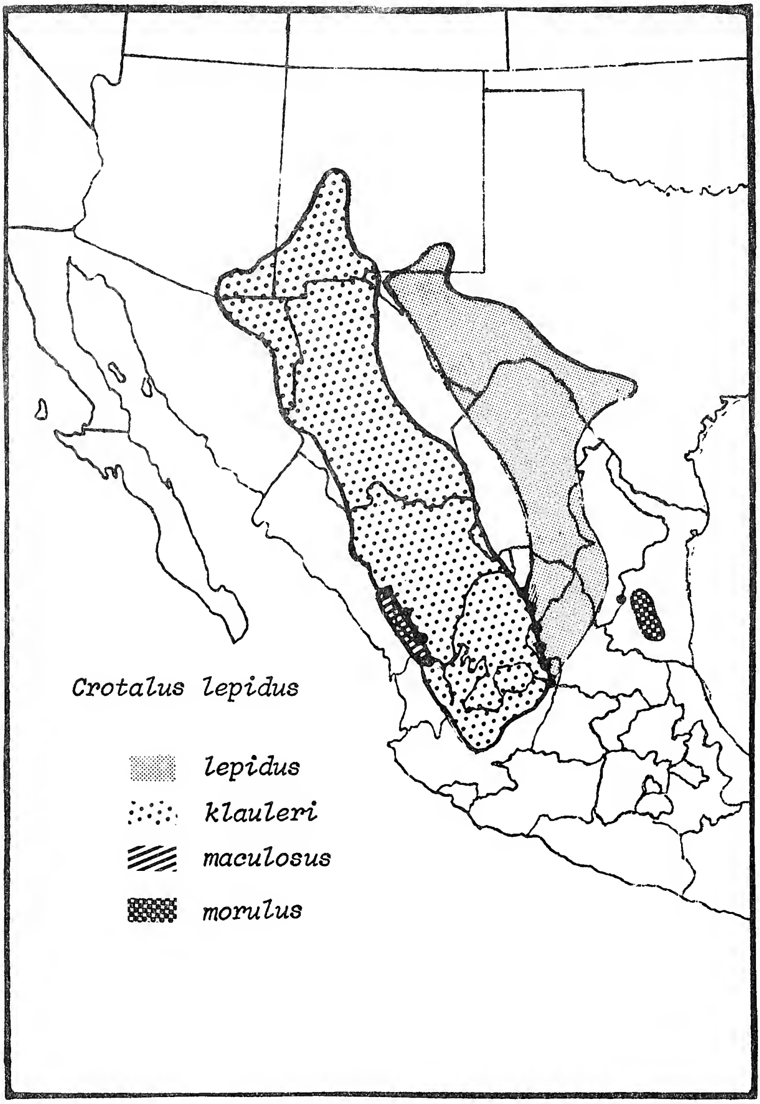


Map 11. The distribution of *Crotalus horridus*.

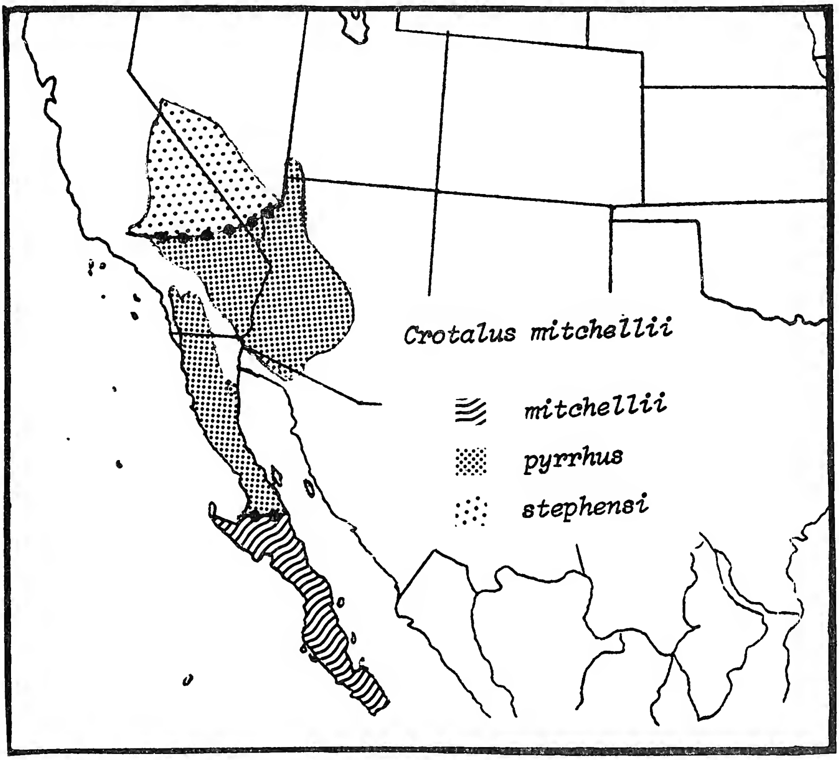


Map 12. The distribution of *Crotalus intermedius*.

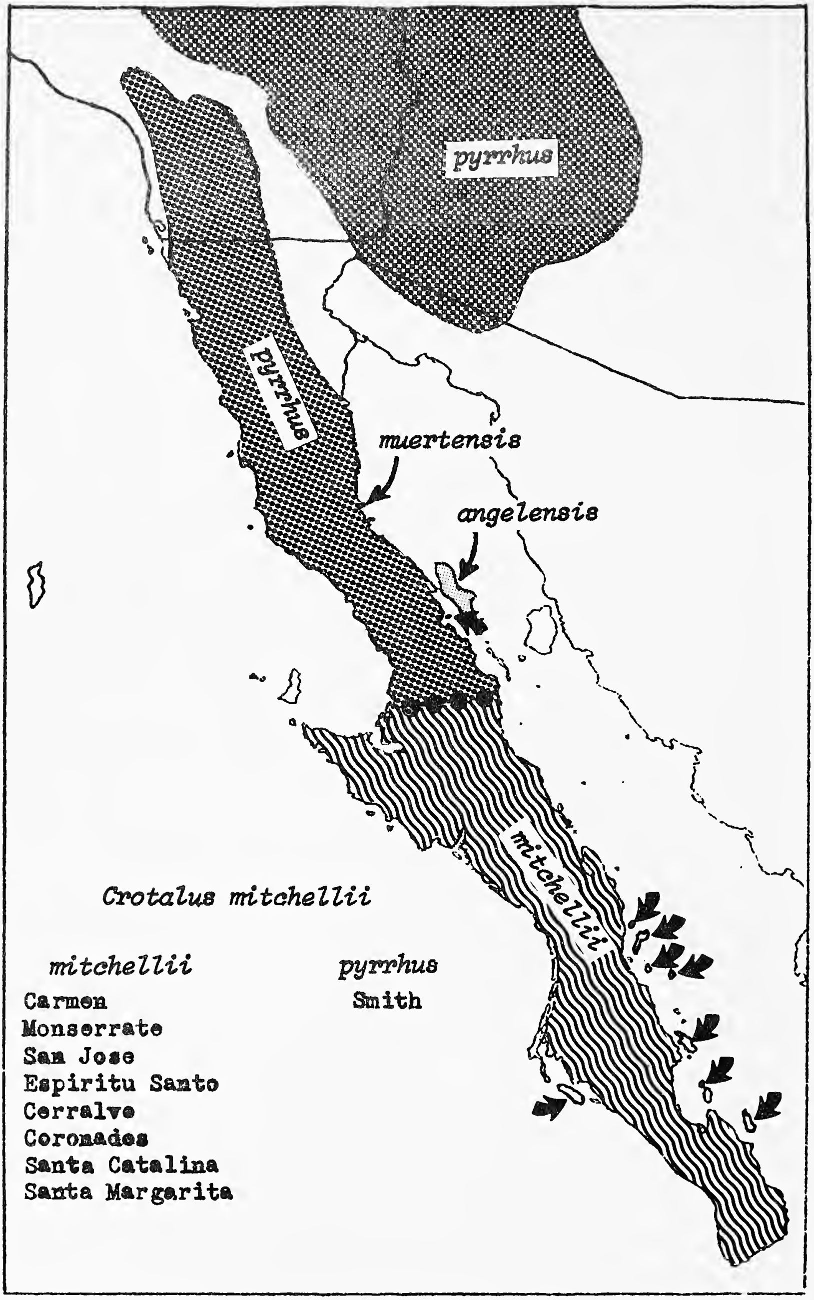
Map 13. The distribution of *Crotalus lannomi*.



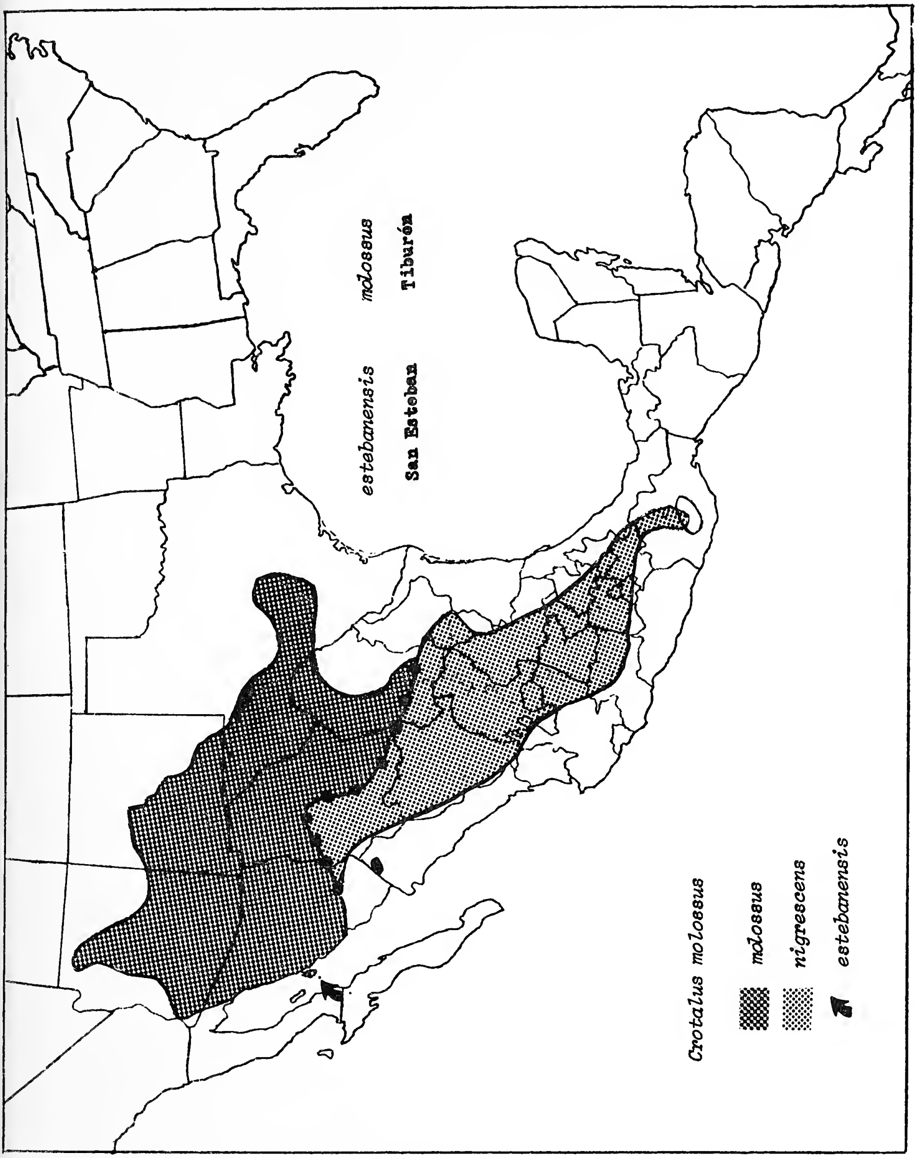
Map 14. The distribution of *Crotalus lepidus*.



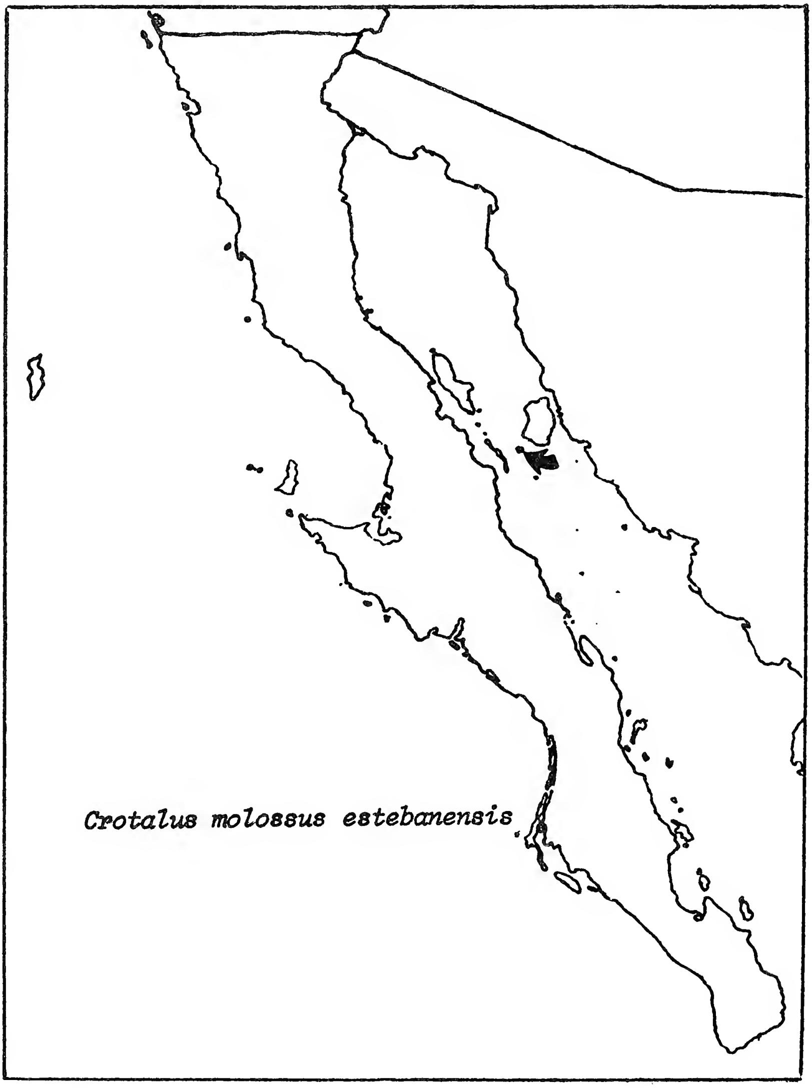
Map 15a. The distribution of *Crotalus mitchellii*.



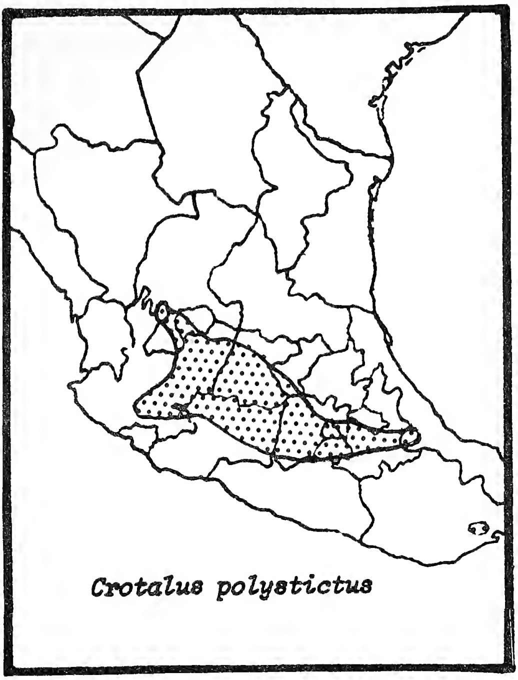
Map 15b. The distribution of the island populations, in the Gulf of California, of *Crotalus mitchellii* and including the Baja Peninsula.



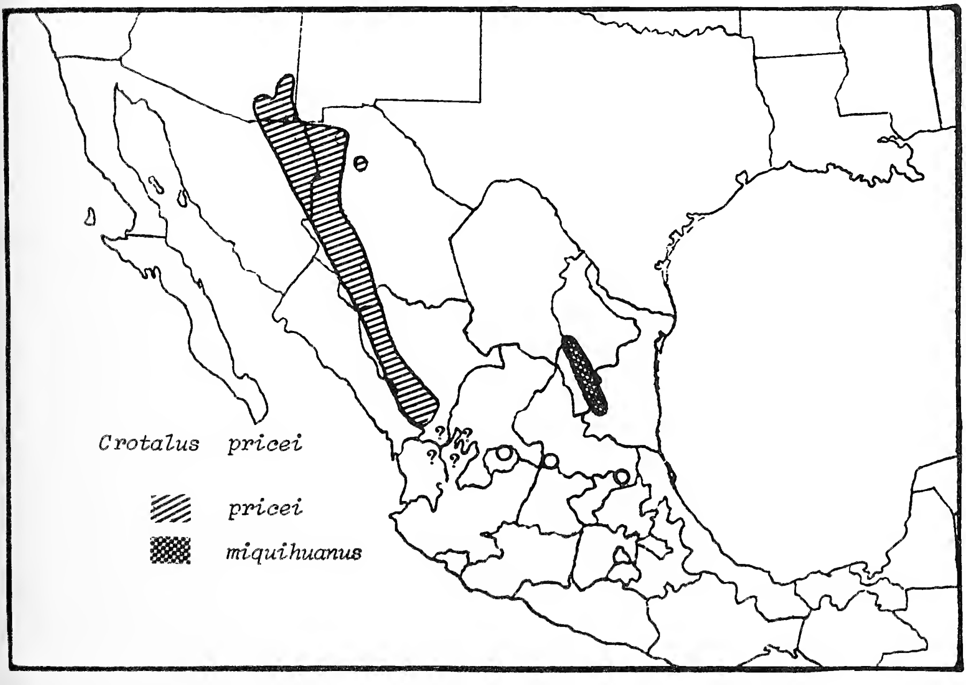
Map 16a. The distribution of *Crotalus molossus*.



Map 16b. The distribution of *Crotalus molossus estebanensis*.

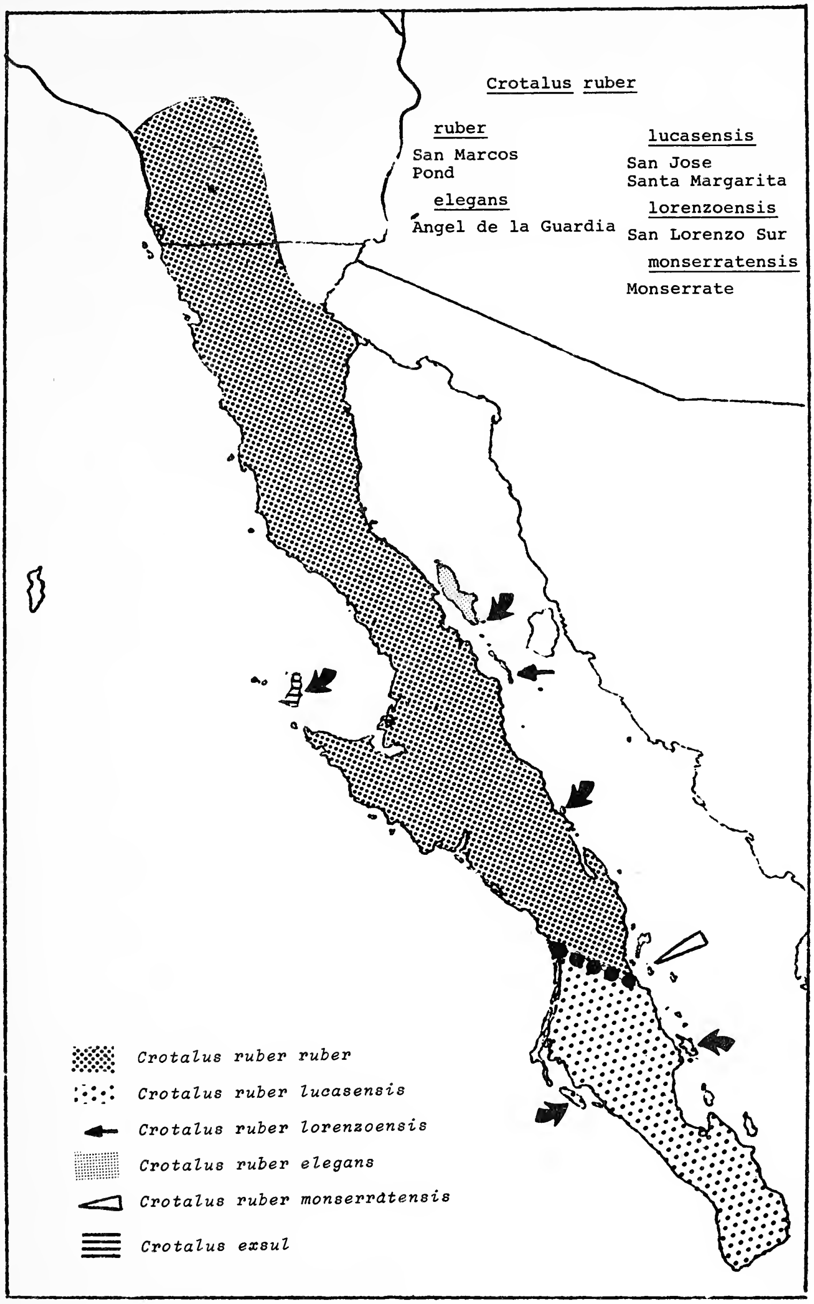


Map 17. The distribution of *Crotalus polystictus*.

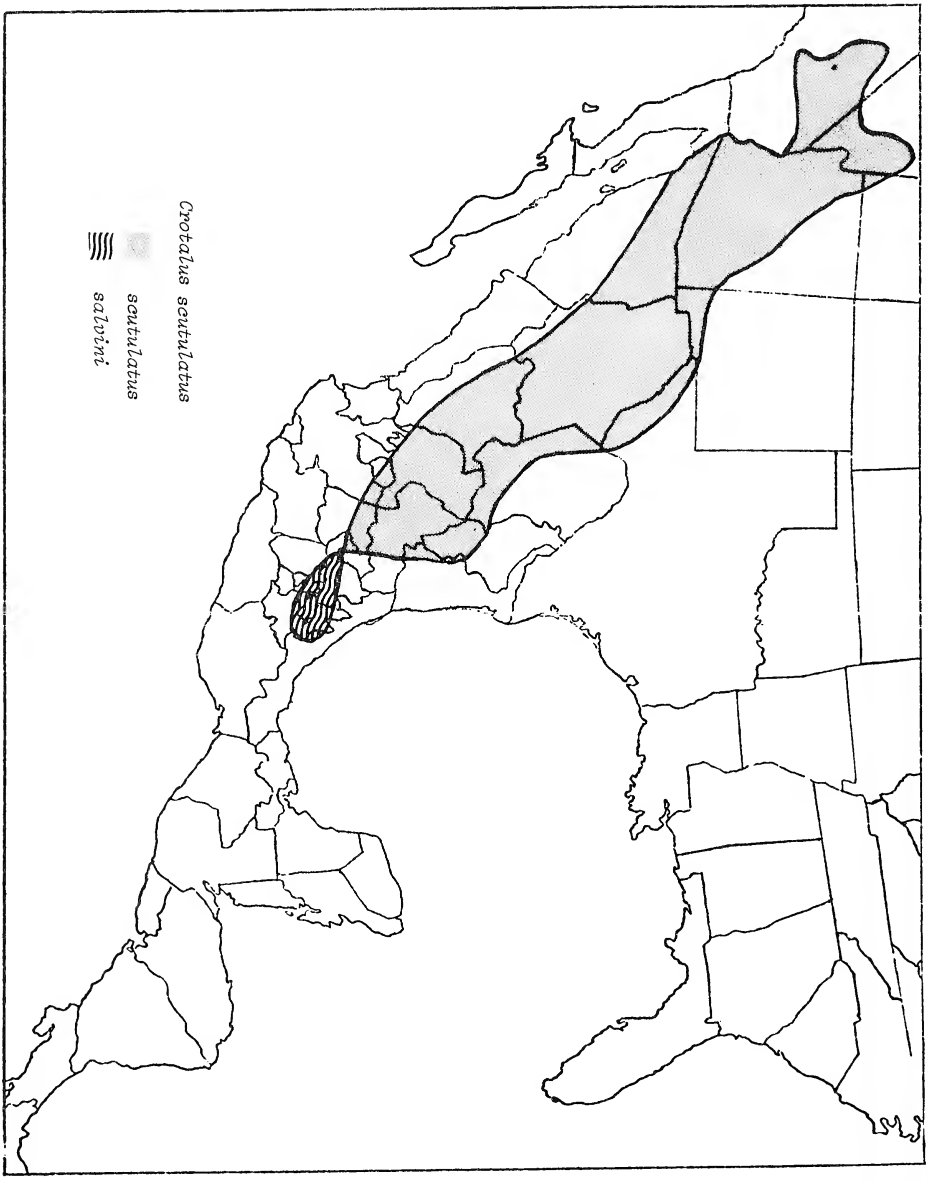


Map 18. The distribution of *Crotalus pricei*.

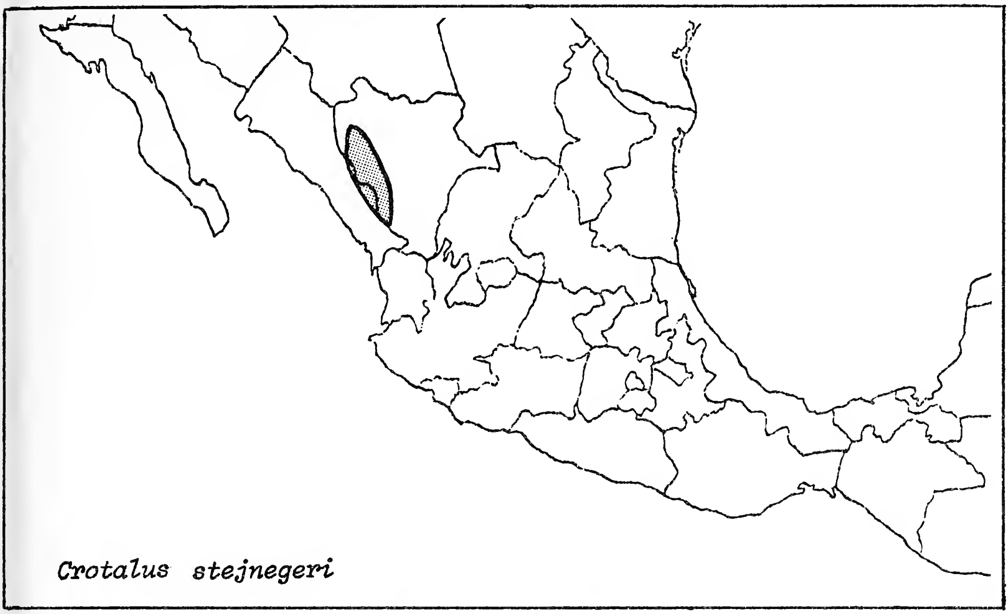
Map 19. The distribution of *Crotalus pusillus*.



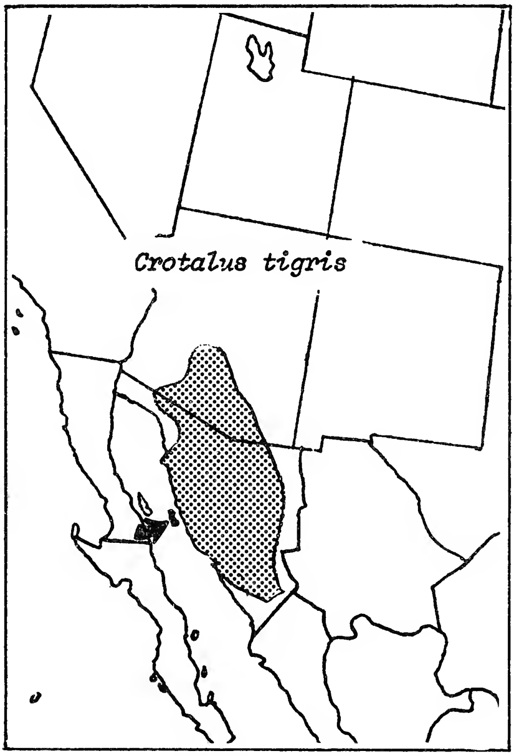
Map 20. The distribution of *Crotalus ruber* including *Crotalus exsul*.



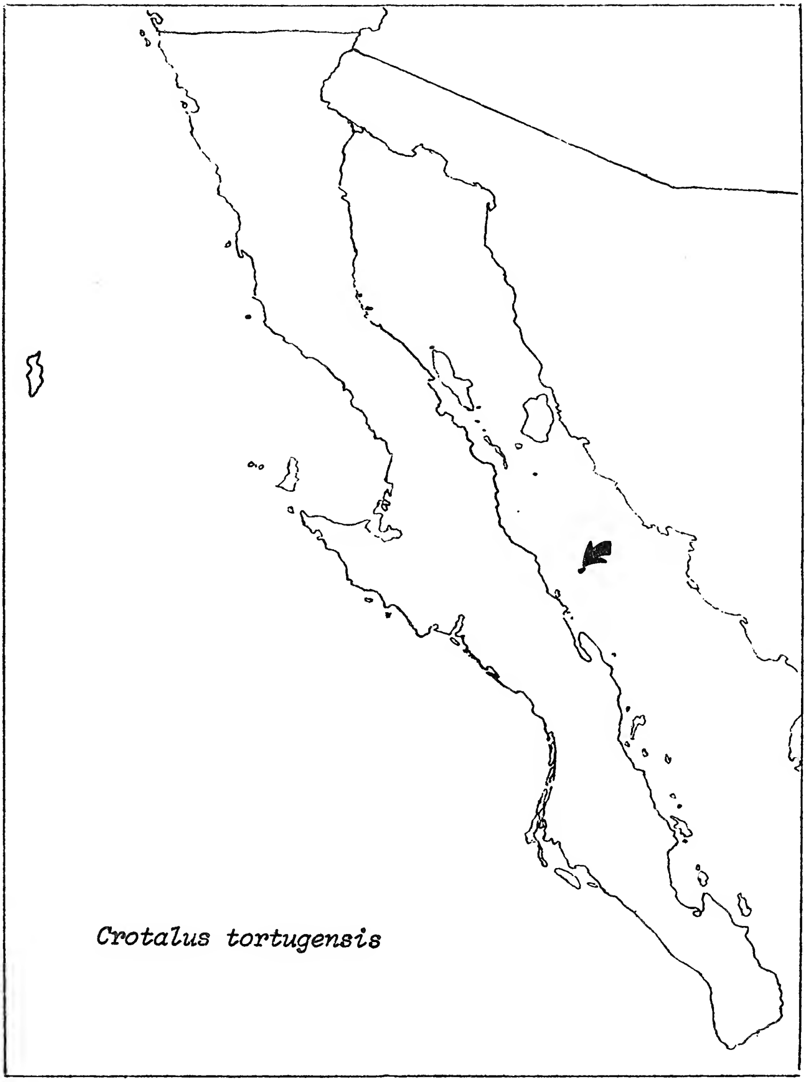
Map 21. The distribution of *Crotalus scutulatus*.



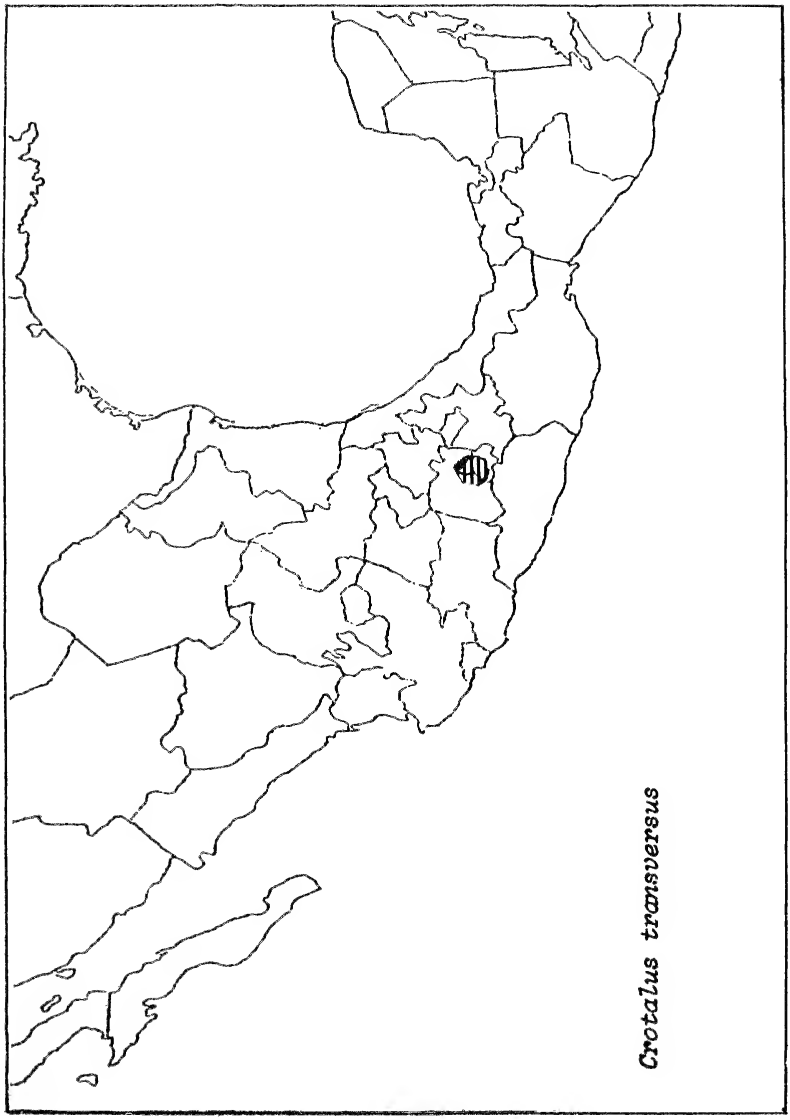
Map 22. The distribution of *Crotalus stejnegeri.*



Map 23. The distribution of *Crotalus tigris.*

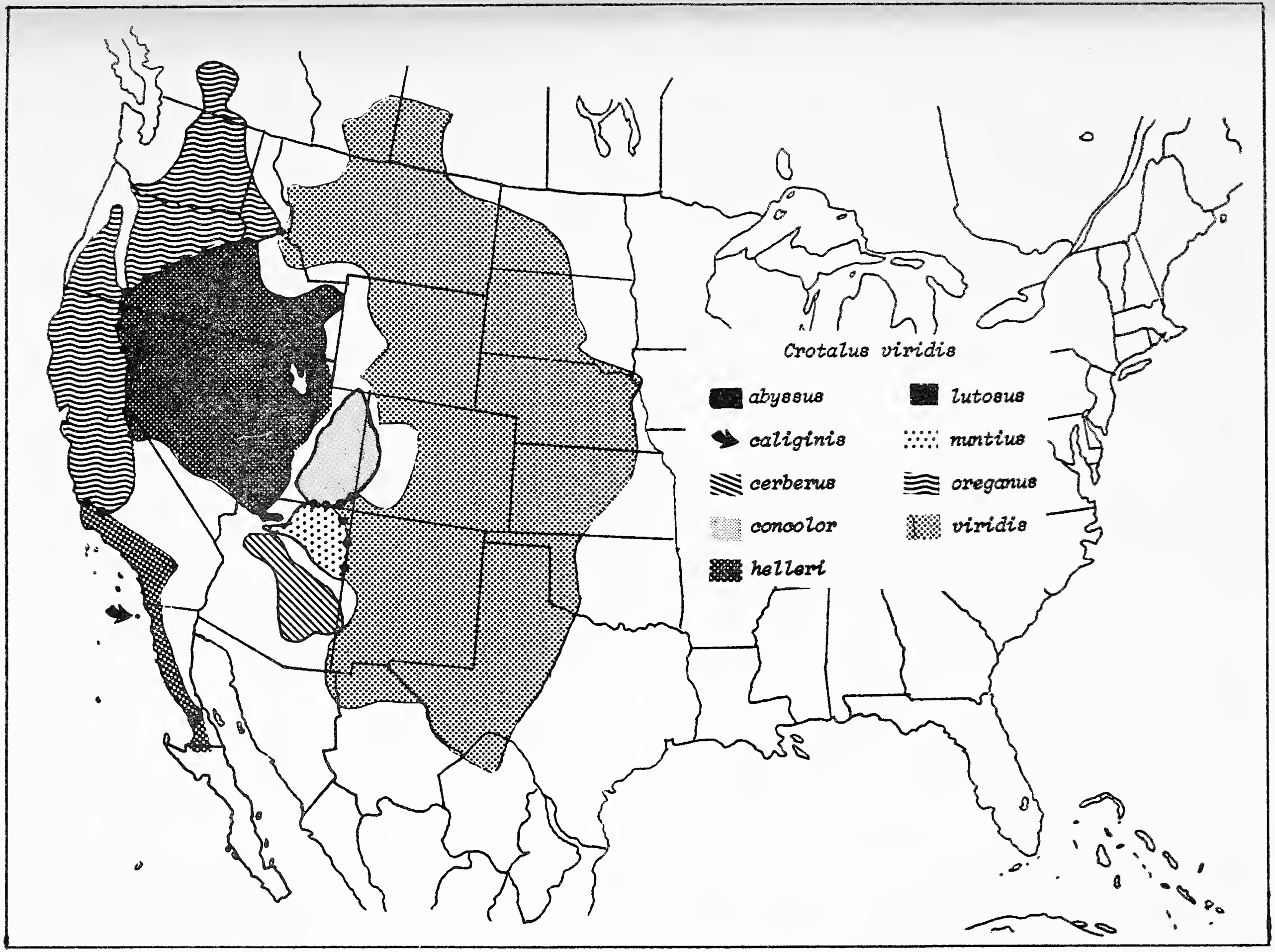


Map 24. The distribution of *Crotalus tortugensis*.

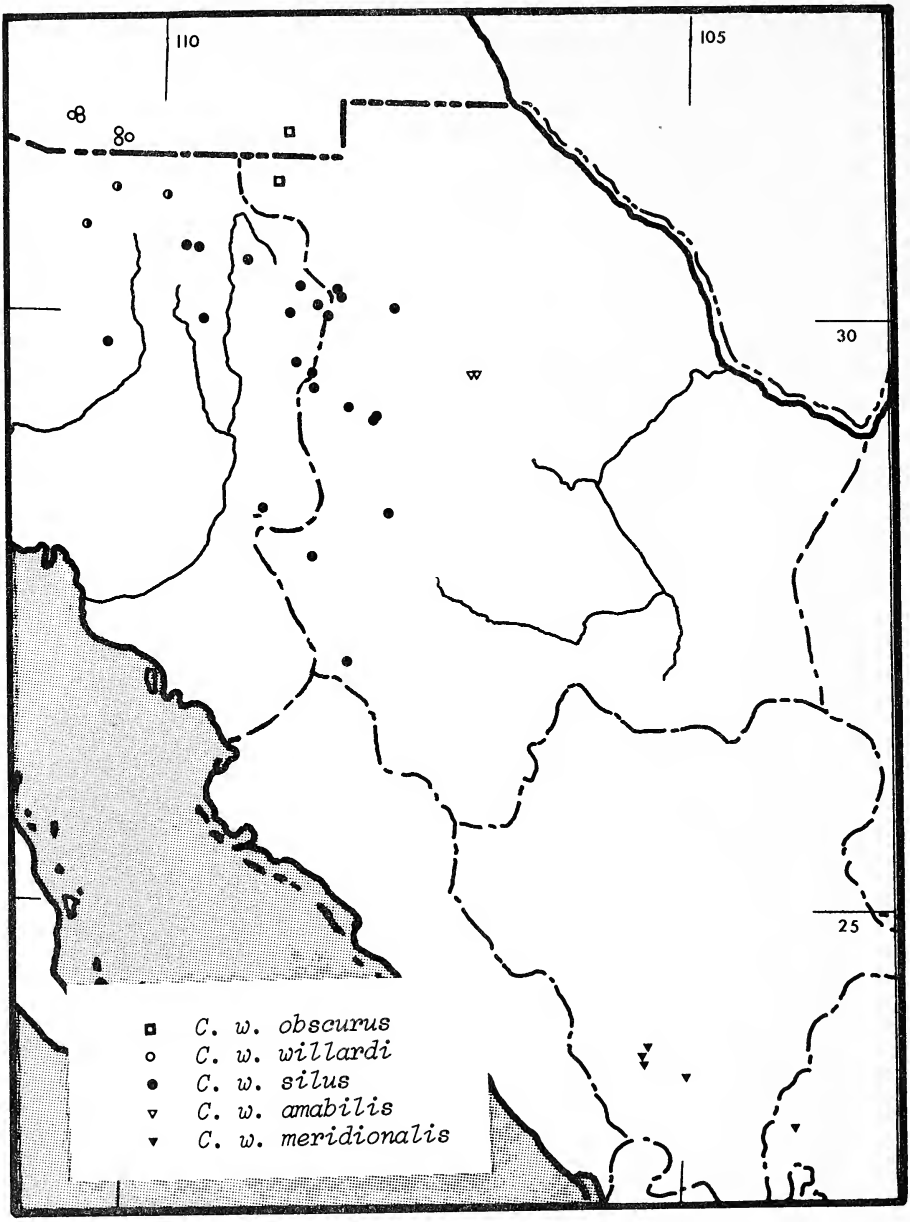


Map 25. The distribution of *Crotalus transversus*.

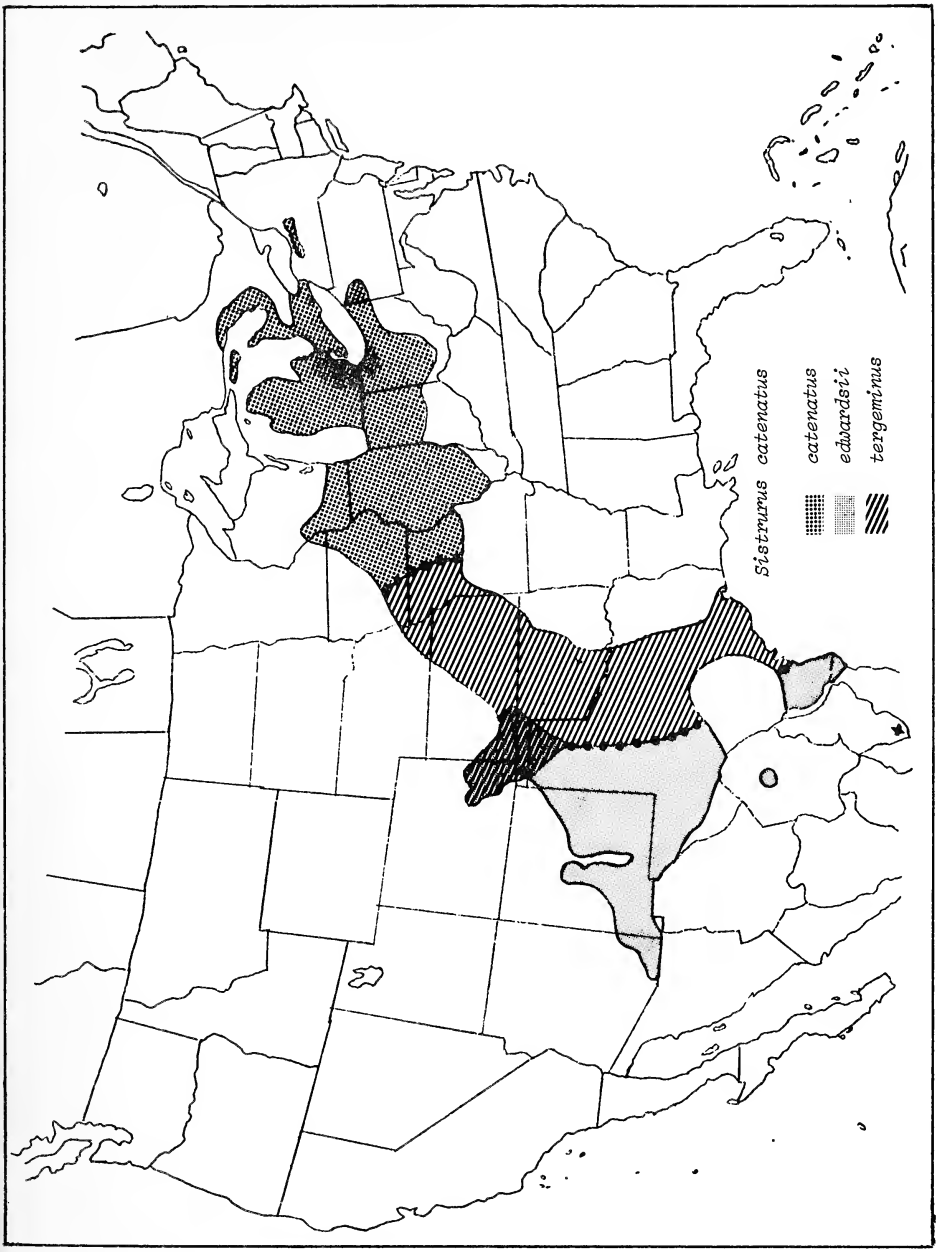
Map 26. The distribution of *Crotalus triseriatus*.



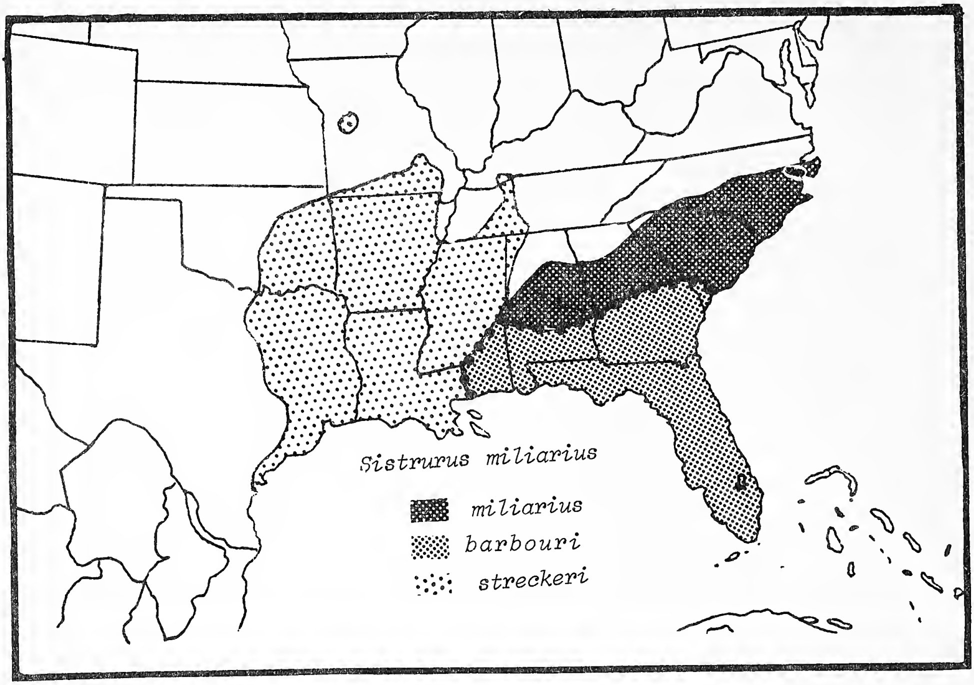
Map 27. The distribution of *Crotalus viridis*.



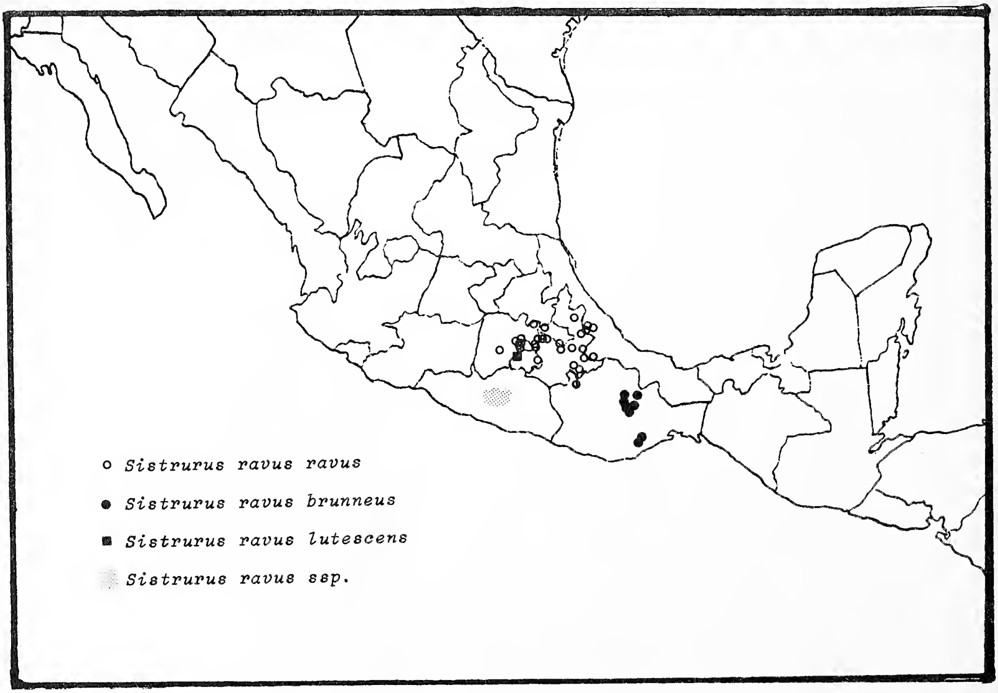
Map 28. The distribution of *Crotalus willardi.*



Map 29. The distribution of *Sistrurus catenatus*.



Map 30. The distribution of *Sistrurus miliarius*.



Map 31. The distribution of *Sistrurus ravus*.

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Place: Baird Auditorium, U.S. National Museum of Natural History (10th and Constitution Ave., N.W.), Washington, D.C.

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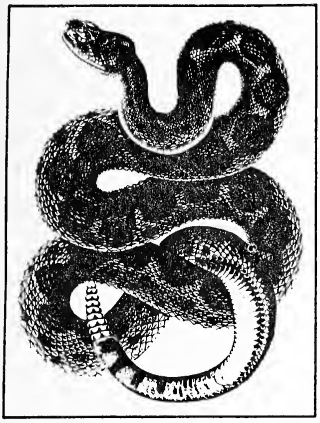

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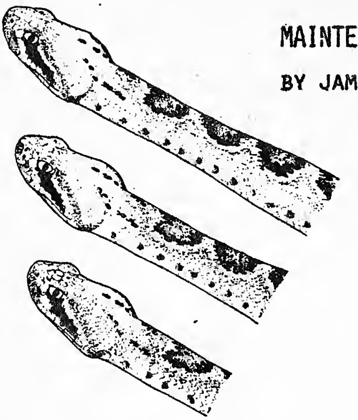

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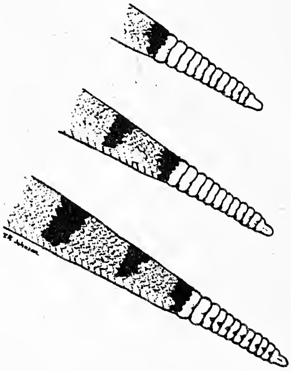

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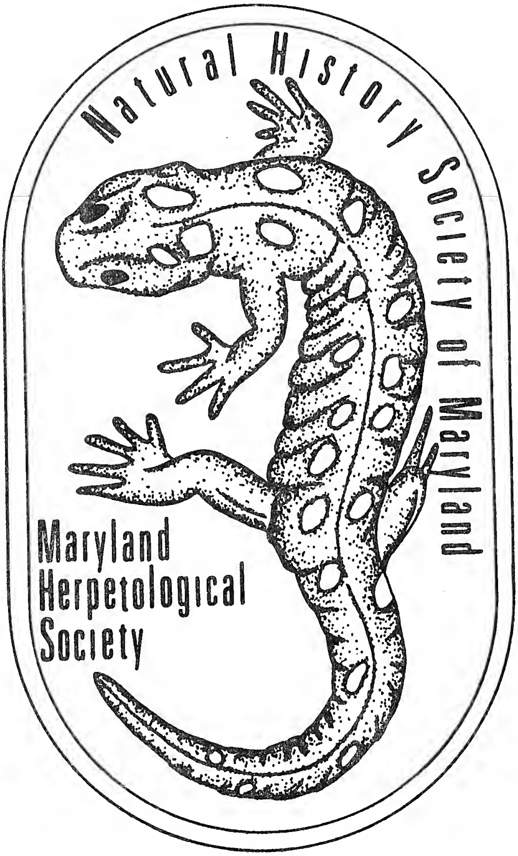
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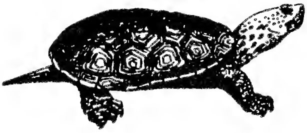

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DECEMBER 1978 VOLUME 14, NUMBER 4

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Volume 14 Number 4 December 1978

CONTENTS

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CHECK LIST OF FRESHWATER TURTLES OF VERACRUZ, MEXICO. I. SOUTHEASTERN PORTION OF THE STATE

(TESTUDINES: CRYPTODIRA)

Gonzalo Pérez Higareda

The freshwater turtle fauna of the state of Veracruz, Mexico, has not yet been investigated in detail. The only summary of any sort is that of Smith and Taylor (1950:228) who merely listed the species then known from the state. Otherwise, only synoptic works, notes or unpublished theses have concerned the species of Veracruz (e.g., Casas Andreu, 1967 and Cooper Blake, 1967).

In this state the turtle fauna has been notably disturbed, due to the use of some species as food for man; especially affected are *Dermatemys mawei* and *Chelydra serpentina*, now considered rare in many regions. Several localities where certain species have been reported before have been so extensively altered as to have resulted in extermination of the species, or at best of restriction to a few small refuges where they maintain a tenuous and continually threatened existence. For one of the threatened species, *Chelydra serpentina*, new distributional data have already been recorded (Pérez Higareda, 1978). However, the collection data for the other taxa obtained by my own recent work have not been summarized previously and are presented here.

Of the 11 taxa of freshwater or land turtles listed by Smith and Taylor (loc. cit.) for Veracruz, four do not occur in the southern part of the state: *Kinosternon herrerai* (northern only), *K. integrum* (does not occur in the state at all), *Pseudemys scripta cataspila* (northern and central), and *Terrapene carolina mexicana* (northern and central). To the list, however, are here added *K. scorpioides cruentatum* and *P.s. venusta*, as well as numerous localities of collection for the other seven species and subspecies. Thus nine species and subspecies of turtles (excluding marine turtles) are now known from southern Veracruz, and 12 for the entire state.

The present work is part of a statewide study of the freshwater turtles of Veracruz, and is put on record for the benefit of those concerned with the more general distribution of the species. The difficulties of completion of a thorough distribution survey are so great that the project is planned to be executed in three stages. The first part centers upon the southeastern portion of the state, considering the regions between the Rio Papaloapan Basin (from Laguna de Alvarado on the Gulf of Mexico and Ciudad Alemán, near Oaxaca), through the Basin of Rio Tonalá, on the border with Tabasco (Figure 1.). In that process it was necessary to sample all possible rivers, lakes, ponds and swamps in the basins of the Papaloapan, Playa Vicente, San Juán, Coatzacoalcos, Uspanapa, and Tonalá rivers, and the regions of Los Tuxtlas and Uspanapa. The second and third parts of the project, now in process, will cover the central and northern portions of the state, respectively.

GENERAL CHARACTERISTICS

Southeastern Veracruz embraces three climatic zones. The Warm-Subhumid zone occurs over much of its extent, in the low regions of the Papaloapan, Playa Vicente and San Juán rivers. The Warm-Humid zone is restricted to the Gulf of Mexico littoral, from the region of Los Tuxtlas through Tabasco; this zone characterizes the region of Coatzacoalcos, and only at elevations over 600 m in the Sierra de Los Tuxtlas does the Temperate climate occur (Garcia, 1970).

In the region of Papaloapan, the plains predominate, with extensive swamps ("popales") and palm groves with scattered remnants of rain forest. The rain forest is continuous over most of the region of Los Tuxtlas, covering the mountain volcanic zone, to elevations of 1200 m above sea level; to the southeast the region of Pajapan, where oak groves are found, and thence to the limits of Tabasco are zones with savanna characteristics.

The collecting sites were selected to form a grid covering the entire fluvial network of the region under study. Most success was encountered in zones of low elevation, from 6 to 64 m above sea level; less success was experienced at intermediate elevations, between 175 and 360 m; and the results were absolutely negative at elevations of more than 400 m above sea level. Not one specimen was obtained at an elevation greater than 360 m (see locality list). In the arid and eroded savannas of Colorado (4 km W of Allende, and 5 km N of Pajaritos), unexpectedly some specimens of *Chelydra serpentina* were found in small ponds surrounded by uninhabitable terrain, in a habitat quite different from the usual for this subspecies.

LOCALITIES SAMPLED

Attempts were made to collect turtles at all of the following localities, listed with the nearest town or the containing municipality (arranged in alphabetical order) and elevation. An asterisk indicates sites where no turtles were found.

Town or Municipality	Locality	Elevation (in m) above Sea Level
Alemán, Cd.	Los Aguajes	29
Alvarado	Laguna de Alvarado	9
"	Rio Papaloapan	9
Catemaco	Laguna de Catemaco	360
"	Laguna Verde	360

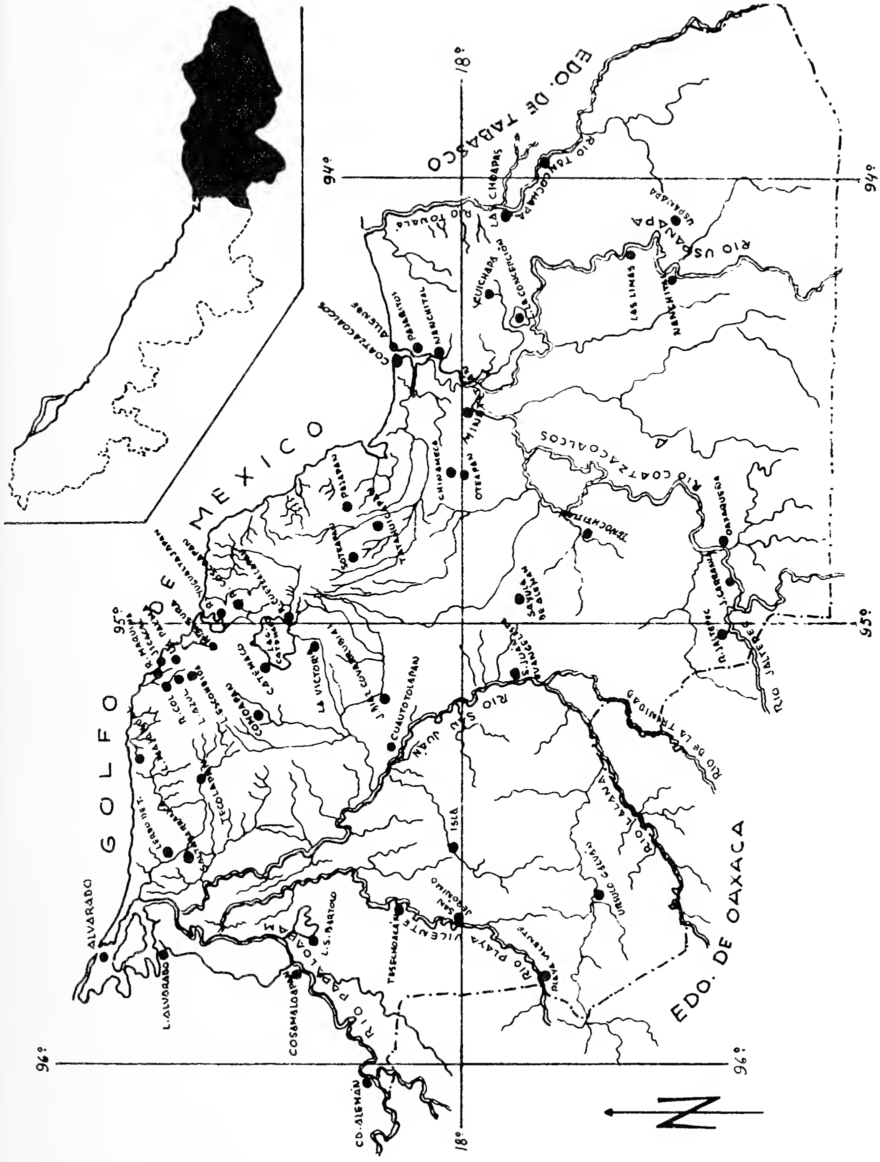

Fig. 1. Map of southern Veracruz, showing localities of collection of turtles. All specimens are in the U.N.A.M. collection, and will be housed at least temporarily, for the most part, at the Estación de Biologia Tropical "Los Tuxtlas".

"	La Victoria	360
"	Jicacal	3
"	Rio Basura	110
"	Rio Coscoapan	15
"	Rio Cuetzalapan	360
"	Rio de La Palma	60
"	Rio Los Pollos	5
"	Rio Yugualtajapan	15
"	Sontecomapan	30
Chinameca	streams	110
Coatzacoalcos	Colorado	20
"	swamp	14
"	Rabón Grande	14
Comoapan	Rio de San Andrés	300
Cosamaloapan	Rio Papaloapan	6
"	Laguna de San Bartolo	16
Cuautotolapan	Rio San Juan	14
Cuichapa	*streams	560
"	Laguna La Concepción	300
"	El Paraíso	310
Hidalgotitlán	Tenochtitlán	90
Isla	Laguna de Guerrero	18
"	Tesechoacán (swamps)	20
"	Rio Playa Vicente	16
Jesús Carranza	Rio Jaltepec	26
Juán Díaz Covarrubias	streams	40
Las Choapas	Rio Tancochapan	17
Lerdo de Tejada	Rio de Lerdo	150
"	Saltabarranca	150
Minatitlán	Rio Minatitlán	64
Nanchital	Rio Uspanapa	19
Oteapan	streams	110
Pajapan	Laguna de Tatahuicapan	200
Playa Vicente	Ursulo Galván	25

San Andrés Tuxtla	Laguna Escondida	180
"	Laguna Azul	180
"	Rio Col	35
"	Rio Máquina (Montepío)	15
San Jerónimo	Rio Playa Vicente	20
San Juán Evangelista	swamps	32
Santiago Tuxtla	*Laguna del Majahual	100
"	Rio Tecolapan	175
Sayula de Alemán	streams	100
Soteapan	*Rio Naranjo	400
Uspanapa	near Uspanapa	20

LIST OF SPECIES

In the following list, for each species the first paragraph gives the localities at which it was found in the present survey. The second paragraph summarizes published information on distribution, both within and extraneous to southern Veracruz.

Dermatemys mawei Gray

Localities of capture. Minatitlán; Cuautotolapan: Rio San Juán; Rio Uspanapa; Cuichapa: Laguna de La Concepción ("la Concha"). Restricted now to these localities.

Additional data. Veracruz, Oaxaca, Tabasco, Yucatán and Campeche (Smith and Taylor, 1950). Tabasco: Basin of Rio Usumacinta; Veracruz: Minatitlán; Arroyo Hondo; Basin of Rio Papaloapan (Casas Andreu, 1967). Northern and northeastern Chiapas (Alvarez del Toro, 1972).

Chelydra serpentina rossignoni (Bocourt)

Localities of capture. Alvarado: Rio Papaloapan (2 km S Laguna de Alvarado); Lerdo de Tejada: Rio Lerdo, Saltabarranca; Isla: Laguna de Guerrero, swamps of Tesechoacán; San Andrés Tuxtla: Laguna Escondida, rivers Máquina and Col (Montepío); Catemaco: Rio Yugualtajapan (Sontecomapan), Rio Coscoapan, Laguna Verde; Coatzacoalcos: Rabón Grande (Allende), ponds of Colorado (4 km W of Allende and 5 km N of Pajaritos); Cuichapa: Laguna de La Concepción ("La Concha").

Additional data. Atlantic slopes south to the Yucatan Peninsula; recorded only from the states of Veracruz and Campeche (Smith and Taylor, 1950). Veracruz: Basin of Rio Papaloapan "probably near Alvarado", and Catemaco-Acayucan road (Casas Andreu, 1967). Chiapas (Alvarez del Toro, 1972). Veracruz: Isla, San Andrés Tuxtla, Catemaco; Oaxaca: Valle Nacional (Pérez Higareda, 1978).

Kinosternon acutum Gray

Localities of capture. Cosamaloapan: Rio Papaloapan; Cd. Alemán: Los Aguajes, Laguna de San Bartolo; San Andrés Tuxtla: Laguna Escondida; Jesús Carranza: Rio Jaltepec.

Additional data. Central Veracruz and Tabasco (Smith and Taylor, 1950).

Kinosternon scorpioides cruentatum (Duméril, Bibron and Duméril)

Localities of capture. Rio Tecolapan (between Santiago Tuxtla and Lerdo de Tejada).

Additional data. Atlantic and Pacific drainages in Oaxaca, Tabasco, Campeche and Chiapas; Cozumel Isl.; Progreso and Telchac Puerto, Yucatan (Smith and Taylor, 1950). Oaxaca (between Tehuantepec and San Mateo del Mar) and Tamaulipas (Tampico) (Casas Andreu, 1967). Chiapas (Tonalá to Tepachula) Alvarez del Toro, 1972).

Kinosternon leucostomum leucostomum (Duméril, Bibron and Duméril)

Localities of capture. Minatitlán; Catemaco: Sontecomapan (channels), La Palma; Santiago Tuxtla: swamps of Rio Tecolapan; San Andres Tuxtla: Laguna Escondida; Las Choapas: Rio Tancochapan. In one specimen a small posterolateral section of each abdominal lamina, about one-fourth the size of the whole scute, is anomalously separated from the remainder as a distinct lamina.

Additional data. Puebla, Veracruz, Tabasco, Campeche and Chiapas (Smith and Taylor, 1950). Tabasco: Teapa and Tepijulapa, El Chico Zapote, Villahermosa; Veracruz: Alvarado, Minatitlan and Coatzacoalcos (Casas Andreu, 1967). Northern Chiapas (Alvarez del Toro, 1972).

Claudius angustatus Cope

Localities of capture. Santiago Tuxtla: Rio Tecolapan; Isla: Tesechoacan; San Andrés Tuxtla; Catamaco: Jicacal, Rio La Palma; Alvarado; Coatzacoalcos: Rabón Grande (Allende); swamps of Coatzacoalcos-Minatitlán; Diaz Covarrubias; Cuautotolapan; Rio Uspanapa: Jesús Carranza.

Additional data. Southern Veracruz to Honduras; Tabasco and Campeche (Smith and Taylor, 1950). Alvarado and Tlacotalpan, Ver., El Chico Zapote, Tab. (Casas Andreu, 1967). Juarez, Chis. (Alvarez del Toro, 1972).

Staurotypus triporcatus (Wiegmann)

Localities of capture. Lerdo de Tejada: Rio Lerdo, Saltabarranca; Santiago Tuxtla: RioTecolapan; Catemaco: Laguna deCatemaco, LaVictoria, Laguna Verde, RioCoscoapan, Rio LaPalma; San Andrés Tuxtla: RioMáquina, Laguna Escondida, Laguna Azul; Jesús Carranza: RioJaltepec; Coatzacoalcos: Rabón Grande (Allende), Colorado; Cuichapa: Laguna de LaConcepción; Las Choapas: Rio Tancochapan; Minatitlán; Isla; Tesechoacán.

Additional data. Veracruz coasts and Tabasco (Smith and Taylor, 1950). Alvarado, Minatitlán, Laguna de Catemaco, Ver.; Villahermosa, Tab.; Laguna de Agua Fría, near Emiliano Zapata, Chiapas (Casas Andreu, 1967). Northern Chiapas (Alvarez del Toro, 1972).

Rhinoclemmys areolata (Duméril, Bibron and Duméril)

Localities of capture. Cuichapa: El Paraíso, around Laguna de La Concepción. Is presumed to be most abundant in the region near Tabasco.

Additional data. Central Veracruz, Tabasco, Campeche, Yucatán and Quintana Roo (Smith and Taylor, 1950). Northern Chiapas (Alvarez del Toro, 1972).

Pseudemys scripta venusta (Gray)

Localities of capture. Alvarado; Santiago Tuxtla: Rio Tecolapan; Isla: swamps of Tesechoacán; San Andrés Tuxtla: Rio Máquina; Comoapan: Rio de San Andrés; Catemaco: Laguna de Catemaco, La Victoria, Rio Coscoapan, La Palma; Juán Diaz Covarrubias; Cuautotolapan: Rio San Juán; Minatitlán; Coatzacoalcos: Colorado; Cuichapa: Laguna de La Concepción; Las Choapas: Rio Tancochapan; region of Uspanapa; Rio Playa Vicente; Rio Jaltepec.

Additional data. Tamaulipas and Veracruz (Smith and Taylor, 1950).

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Literature Cited

Alvarez del Toro, M.
1973. Los reptiles de Chiapas, Segunda edición. *Tuxtla Gutierrez, Chiapas, Gobierno del Estado, v,* 178 pp., 154 figs.

Casas Andreu, G.
1967. Contribución al conocimiento de las tortugas dulceacuícolas de México. *México, D. F., Univ. Nac. Auton. México, Fac. Ciencias, Dept. Biol., Thesis. (vii),* 96 pp., 19 pls., 7 maps.

Cooper Blake, C.
1967. Monografía de los quelonios y su importancia para el laboratorio de fisiologia. *Jalapa, Veracruz, Univ. Veracruzana, Dept. Med. Vet. Zootecnia, Thesis.* 64 pp.

Garcia, Enriqueta.
1970. Los climas de Veracruz. *Inst. Biol. Univ. Méx., Ser. Bot., 41*(1):3-22.

Pérez Higareda, G.
1978. New localities and a state record for *Chelydra s. rossignoni* (Testudinea: Chelydridae) in Mexico. *Bull. Md. Herp. Soc., 14*(1):47.

Smith, H. M. and E. H. Taylor.
1950. An annotated checklist and key to the reptiles of Mexico exclusive of snakes. *Bull. U.S. Nat. Mus., (199)*:i-iv, 1-253.

Estacion de Biologia Tropical "Los Tuxtlas", Instituto de Bologia,
Universidad Nacional Autónoma de México, Aptdo. Postal 94,
San Andrés Tuxtla, Veracruz, México

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VARIATION IN REPRODUCTIVE POTENTIAL AND GROWTH IN *CHRYSEMYS PICTA* WITHIN A SINGLE BODY OF WATER

John K. Tucker

ABSTRACT

The painted turtle *Chrysemys picta* was found to vary in growth rate and reproductive potential in four different populations from a single small lake in east-central Illinois. Turtles with the highest growth rate were found to have the highest reproductive potential and reach the largest sizes. The extent to which reproductive potential varies within the lake is nearly as extensive as that found in a previous study of a north to south transect from Wisconsin to Louisiana. Reproductive potential ranged from 12.44-21.12 eggs/♀/year. Variation in growth rate was also extensive. Females from all populations mature after 5-7 growth seasons but at different average plastral lengths suggesting that sexual maturity is at least partially related to age. The large amount of variation observed suggests that studies of ecological parameters that use turtles from widely separated geographic areas or that mix specimens of different populations from within the same body of water may not yield reliable data.

INTRODUCTION

The reproductive biology and growth of *Chrysemys picta* have been studied by many workers. However, few studies have been made to determine the extent to which these important features of *Chrysemys* natural history vary between populations. Studies of latitudinal and longitudinal variation in reproductive potential of *C. picta* include Christianson and Moll (1973) and Moll (1973). Gibbons and Tinkle (1969) demonstrated that the clutch size and growth rate of *C. picta* may vary within a single geographic area. The present paper reports the existence of extensive variation in clutch size, reproductive potential, and growth rate in *C. picta* from a single, relatively small body of water. This study confirms and extends the results of Gibbons and Tinkle (1969) and points out some of the possible implications of such variation.

MATERIALS AND METHODS

Specimens were collected periodically from May 1976 through September 1977. Hoop traps, dip nets, and hand collecting were the main collecting techniques used. Turtles were collected from four areas (Fig.1) of Lake Sara in Effingham County, Illinois. Two of the areas (1 and 3) are represented by larger samples and are considered in greater detail than the two smaller samples. *C. picta* in Effingham County were identified as *C. p. marginata* X *C. p. bellii* intergrades by Smith (1961).

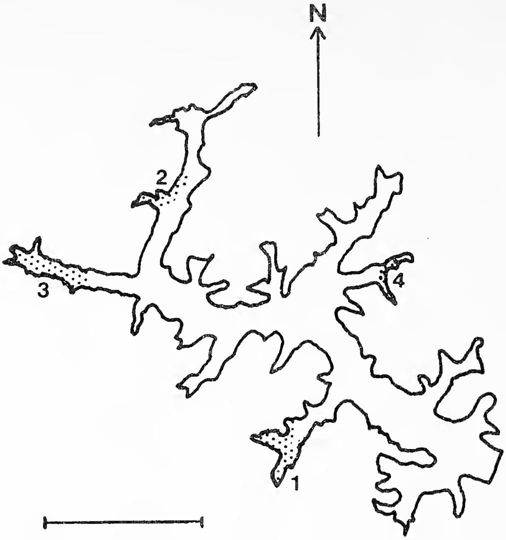

Fig. 1. Outline map of Lake Sara in Effingham County, Illinois showing the location and areal extent of the areas studied. Scale line equals 1 mile.

Age was determined by counting plastral annuli. Each visible annulus was measured parallel to the midabdominal seam for every specimen possible. The right abdominal scute was used in the great majority of cases. However, a few turtles had injuries to the right abdominal scute or had a more complete record of growth on the left abdominal sucte; the left abdominal scute was used in these cases. Measurements were made with vernier calipers. Sergeev's formula AB/PL = AB'/x (Sergeev, 1937) where AB is the present abdominal scute length, PL the plastral length, AB' the median length of a growth annulus, and x the plastral length at the time AB' was formed was used to determine changes in plastron length. This formula may only be used in its unmodified form if it can be shown that the relationship of AB and PL does not change with growth; that is, AB and PL grow isometrically with respect to each other. Consequently the allometric coefficients (α) for both males and females were determined following Simpson *et al.*, (1960). Since α was found to equal 1.05 for males (n = 71) and 1.06 for females (n = 88), the use of Sergeev's formula in its unmodified form is felt to be justified. α was also determined for turtles from areas 1 and 2. These did not differ significantly from each other or from the α determined for the total sample. The plastral length was determined for each full season of growth following the season of hatching (Class 0). Where possible the size at hatching and at the end of the season of hatching were determined. At least some turtles less than 2 seasons old showed no signs of a season of hatching indicating that some turtles overwinter in the nest. However, traces of the growth hiatus between the season of hatching and the first full season of growth is much less pronounced than those of subsequent growth hiatuses. This weak annulus was not detected on turtles over 4 seasons old and on only a few that were three seasons old. Consequently age class 0 is not considered to be representative since older turtles that grew during the season of hatching will not have evidence of this and since each sample is made up of varying percentages of each age class. In some cases palstral lengths for the season of hatching are given as they may prove to be of value for comparison to more reliable samples in later studies. The term significant refers to statistical significance at the 95% level (or higher) in a two sided test of significance.

Reproductive potential was determined from adult females collected in the last week of May and the first week of June in 1976. Sexual maturity in both males and females was determined in the manner used by Moll (1973). The ovaries of all females were removed; corpora lutea and oviducal eggs were counted and measured with vernier calipers. The number of clutches layed by each turtle was estimated in the manner used by Moll (1973). In order of reliability these are multiple sets of corpora lutea, sets of preovulatory follicles, and sets of enlarged follicles. Since at least two weeks remained in the nesting season (Moll, 1973), sets of preovulatory follicles were counted as potential clutches and used in the determination of average annual reproductive potential (Moll, 1973). However, it is doubtful that enlarged follicles would have had time to reach ovulatory size, be ovulated, and laid in turtles collected in late May and early June. Consequently, sets of enlarged follicles were totaled separately for comparative purposes.

RESULTS

Data on growth for areas 1 and 3 are summarized and compared in Figs. 2 and 3. Growth rates for areas 2 and 4 are not plotted due to small sample size. Even though sample size is small the data on growth and reproduction is consistent with those of areas 1 and 3 and are about intermediate between these two extremes. Further comparisons are limited to areas 1 and 3. Turtles from area 3 show the highest growth rate, reach the largest size, and have the highest reproductive potential. Sizes of the largest immature and smallest mature females from areas 1 and 3 suggest that females mature after 5-7 full seasons of growth but at differing plastral lengths (Table 1). Females from areas 1 and 3 differ significantly in mean sizes attained in age classes 1-4. Males, which mature at an earlier age and smaller size than do females, also show a similar pattern of variation (Tables 1 and 2). However, differences among males are much less pronounced than among females. Males from areas 1 and 3 differ significantly from each other in sizes attained at age class 1 (Table 2). Other comparisons are not significantly different. Turtles from area 3 have significantly larger clutches, higher reproductive potentials, and reach larger maximum sizes than turtles from any of the other areas. Turtles from area 1, on the other hand have, the smallest clutches and lowest reproductive potentials (Tables 3, 4 and 5).

DISCUSSION

Variation in growth rate and reproductive potential within Lake Sara is even more extensive than that reported by Gibbons and Tinkle (1969) and Gibbons (1967) for three populations of *C. picta* each in a separate body of water in the same general geographic area. The extent of the variation in reproductive potential found within Lake Sara approaches that found by Moll (1973) for *C. picta* from along a north to south (Wis-

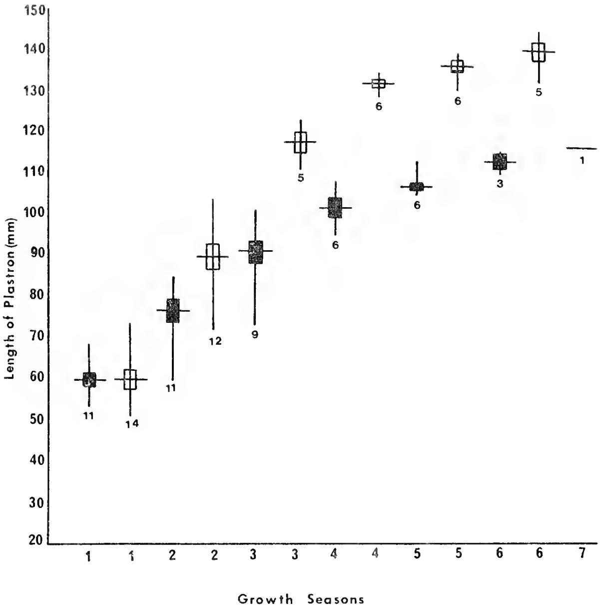

Fig. 2. Comparison of growth rates of area 1 females (solid boxes) and area 3 females (open boxes). Symbols: vertical line = range; horizontal line = mean; box = ± 1 standard error from the mean; number below each datum is sample size.

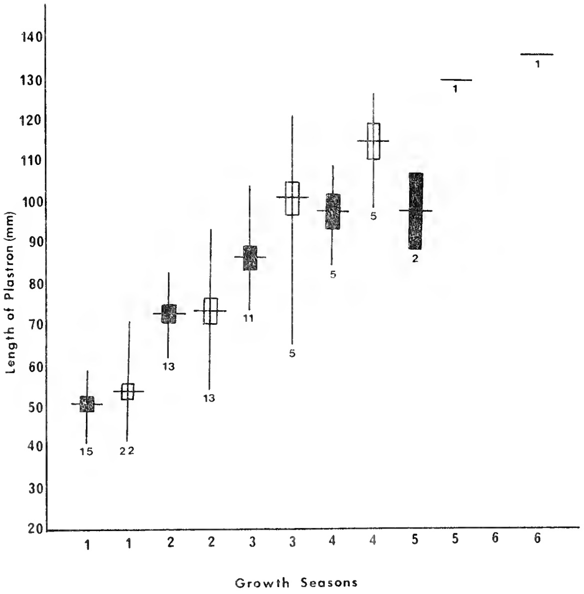

Fig. 3. Comparison of growth rates among area 1 males (solid boxes) and area 3 males (open boxes). Symbols are explained in Figure 2.

Table 1. Comparison of sizes at maturity of *Chrysemys Picta* from four different areas of Lake Sara, Effingham Co., Illinois.

Area	Sex	Largest Immature (mm)	Smallest Mature (mm)	Maximum Size Observed (mm)
1	♀	116	120	146
2	♀	126	128	147
3	♀	125	134	166
4	♀	124	131	149
1	♂	75	76	120
2	♂	86	82	128
3	♂	81	82	134
4	♂	76	77	122

Table 2. Comparison of sizes of age classes of female and male *C. picta* from areas 1 and 3 in Lake Sara.

		Age Class			
		1	2	3	4
Females	t	2.31	3.90	3.59	3.90
	p	*	*	*	*
	df	34	23	8	9
Males	t	4.37	1.35	1.22	0.86
	p	*	NS	NS	NS
	df	24	22	18	9

*indicates statistical significance at or greater than the 95% level.

Table 3. Estimates of annual reproductive potential and number of clutches produced by *Chrysemys picta* from Lake Sara.

Area	Clutch Size	n	# clutches / % of females producing 2	3	eggs/♀/yr
1	5.89	9	88.9	22.2	12.44
2	8.60	5	100.0	-	13.20
3	9.86	14	92.8	21.3	21.12
4	7.40	5	80.0	40.0	16.28

Table 4. Results of t-tests comparing mean clutch sizes between areas within Lake Sara.

Area	1		2		3	
	t	p	t	p	t	p
2	0.81	NS				
3	5.95	*	3.91	*		
4	2.80	*	1.36	NS	2.10	*

Table 5. Results of t-tests comparing mean annual reproductive potential between populations within Lake Sara.

Area	1		2		3	
	t	p	t	p	t	p
2	1.15	NS				
3	5.90	*	3.61	*		
4	2.73	*	1.09	NS	2.81	*

consin to Louisiana) transect that he studied. Many factors could possibly be reflected in the differences reported here. Growth in aquatic emydids including *C. picta* has been found to be influenced by food quality (Gibbons, 1967; D. Moll, 1976), food abundance (Cagle, 1946), water temperature (Cagle, 1946; Sexton, 1965; Gibbons, 1970b; Ernst, 1971, 1975), rainfall (Ernst, 1971), and possibly substrate (Quinn and Christiansen, 1972; *contra* Ernst and Ernst, 1972). Since so many factors could influence growth rate and reproductive potential in *C. picta*, and since my studies of the effects of some of these factors in Lake Sara will take a considerable amount of time to complete no precise explanations can be offered at this time. However, it is thought that the extreme degree to which the growth rate and reproductive parameters vary within this small body of water should be pointed out as these results have important implications for past and future studies of chelonian ecology.

Certain generalizations that have been more or less accepted may be in need of more critical study. Several authors (Cagle, 1944, 1950; Dobie, 1971; Einem, 1956; Gibbons, 1970a, 1970b; Iverson, 1977, Moll and Legler, 1971; Plummer, 1977; Shealy, 1976; Tinkle, 1961; and Webb, 1962, for instance) have stated that clutch size and plastral length are positively correlated. Gibbons and Tinkle (1969) found that the *C. picta* they studied showed such a correlation if all turtles were considered but that each population showed no correlation between plastral length and clutch size. The same is true for the Lake Sara populations (Tucker *et al.*, in press). Studies reporting positive correlations between clutch size and plastral length cannot be assumed to show that clutch size is directly related to plastral length unless it can be shown that the studies were based on turtles from the same population or living under similar environmental conditions. The variation found within a relatively small lake such as Lake Sara demonstrates that it is not safe to assume that turtles occupying the same body of water are experiencing similar environmental conditions. It is therefore possible that many previous studies have mixed turtles from more than one ecological unit, thus clouding relationships between various ecological parameters and population dynamics.

Certain studies, including Plummer's (1977) of *Trionyx muticus*, Shealy's (1976) of *Graptemys pulchra*, and Gibbons' (1970a) of *Sternotherus ordoratus* which have found that clutch size and plastral length are positively correlated are probably based on turtles from a single population reacting to similar exological conditions. This suggests that the reproductive ecology of each turtle species must be considered separately. The *Trionyx muticus* studied by Plummer (1977) were found to have relatively large home ranges. These turtles also inhabited a lotic habitat and thus may be more likely to experience different environmental conditions than turtles from lentic habitats. Turtles with large home ranges and samples from lotic habitats may effectively integrate the effects of the differing ecological parameters because demes are not discrete as they appear to be in the Lake Sara populations.

Several workers have pointed out that sexual maturity is more closely related to size than age (Gibbons, 1970b; Moll and Leger, 1971; Ernst *et al.*, 1973; Ernst, 1971; and D. Moll, 1976, for example). However data from Lake Sara suggest that this situation is more complex, at least for *C. picta*. The size at which female turtles reach maturity varies greatly between populations. However, the age at which sexual maturity is attained is relatively uniform, being 5-7 (usually 6) full seasons of growth in all populations studied at Lake Sara. Gibbons (1967), in a study of three populations of *C. picta*, suggested that individual size differences may be due to slowing of growth rate after maturity is reached; therefore the fastest growing turtles attained a size difference during initial growth and retained it in subsequent years. If sexual maturity were dependent on plastral length alone one would expect a relatively uniform minimum size at sexual maturity among turtles of different populations and a relatively wide range of ages between turtles of different populations, thus reflecting differing growth rates. This would be expected only if growth stops or slows greatly after sexual maturity is attained. If sexual maturity were determined by seasons of growth then one would expect that females from different populations would be uniform in age but would be different in size at sexual maturity between populations with different growth rates, again assuming that growth slows or stops once sexual maturity is attained. The latter appears to be true for *C. picta* from Lake Sara. If, as Gibbons (1967), has suggested, the fastest growing turtles reach maturity at the same size as slower growing turtles but then do not have as marked a slowing of growth after sexual maturity is reached, then at least some females from area 3 in Lake Sara should have been mature after 3-4 years at a size of 110-125 mm. Turtles in this size range from area 3 are all immature. It therefore appears that sexual maturity in Lake Sara *C. picta* is in some manner influenced by the age of the female. However, before my observations can be fully understood, it will be necessary to compare further populations of *C. picta* and other chelonians from relatively limited geographic areas with each other.

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Literature Cited

Cagle, F. R.
1944. Activity and winter changes in hatchling *Pseudemys*. *Copeia 1944*:105-109.

__________.
1946. The growth of the slider turtle *Pseudemys scripta elegans*. *Am. Midl. Nat. 36*:685-729.

__________.
1950. The life history of the slider turtle *Pseudemys scripta troostii* (Holbrook). *Ecol. Monogr. 20*:31-54.

Christiansen, J. L., and E. O. Moll.
1973. Latitudinal and reproductive variation within a single subspecies of the painted turtle, *Chrysemys picta bellii*. *Herpetologica 29*:152-163.

Dobie, J. L.
1971. Reproduction and growth in the alligator snapping turtle, *Macroclemys temmincki* (Troost). *Copeia 1971*:645-658.

Einem, G.
1956. Certain aspects of the natural history of the mud turtle, *Kinosternon bauri*. *Copeia 1956*:186-188.

Ernst, C. H.
1971. Growth in the painted turtle, *Chrysemys picta*, in southeastern Pennsylvania. *Herpetologica 27*:135-141.

__________.
1975. Growth of the spotted turtle *Clemmys guttata*. *J. Herpetol. 9*:313-318.

__________, R. W. Barbour, E. M. Ernst, and J. R. Butler.
1973. Growth of the mud turtle, *Kinosternon subrubrum* in Florida. *Herpetologica 29*:247-250.

__________, and E. M. Ernst.
1972. Biology of *Chrysemys picta bèllii* in southeastern Minnesota. *J. Minnesota Acad. Sci. 38*:77-80.

Gibbons, J. W.
1967. Variation in growth rates in three populations of the painted turtle *Chrysemys picta*. *Herpetologica 23*:296-303.

__________.
1970a. Reproductive characteristics of a Florida population of musk turtles (*Sternothaerus odoratus*). *Herpetologica 26*:268-270.

__________.
1970b. Reproductive dynamics of a turtle (*Pseudemys scripta*) population in a reservoir receiving heated effluent from a nuclear reactor. *Canadian J. Zool. 48*:881-885.

__________, and D. W. Tinkle.
1969. Reproductive variation between turtle populations in a single geographic area. *Ecology 50*:340-341.

Iverson, J. B.
1977. Reproduction of freshwater and terrestrial turtles of north Florida. *Herpetologica 33*:205-212.

Moll, D.
1976. Environmental influence on growth rate in the Ouachita map turtle, *Graptemys pseudogeographica ouachitensis*. *Herpetologica 32*:439-443.

Moll, E. O.
1973. Latitudinal and intersubspecific variation in reproduction of the painted turtle *Chrysemys picta*. *Herpetologica 29*: 307-318.

__________, and J. M. Legler.
1971. The life history of a neotropical slider turtle, *Pseudemys scripta* (Schoepff), in Panama. *Bull. Los Angeles County Mus. Nat. Hist. Sci.* (11):1-102.

Packard, G. C., C. R. Tracy, and J. J. Roth.
1977. The physiological ecology of reptilian eggs and embryos, and the evolution of viviparity within the class Reptilia. *Biol. Rev. 52*:71-105.

Plummer, M. W.
1977. Reproduction and growth in the turtle *Trionyx muticus*. *Copeia 1977*:440-447.

Quinn, A. J., and J. L. Christiansen.
1972. The relationship between pond bottom type and growth of western painted turtle *Chrysemys picta belli* in Iowa, a preliminary report. *Proc. Iowa Acad. Sci. 78*:67-69.

Sergeev, A.
1937. Some materials to the problem of the reptilian post-embryonic growth. *Zool. J. Moscow 16*:723-735.

Sexton, O. J.
1965. The annual cycle of growth and shedding in the midland painted turtle, *Chrysemys picta marginata*. *Copeia 1965*:314-318.

Shealy, R. M.
1976. The natural history of the Alabama map turtle, *Graptemys pulchra* Baur, in Alabama. *Bull. Florida State Mus., Biol. Sci. 21*:47-111.

Simpson, G. G., A. Roe, and R. C. Lewontin.
1960. Quantitative zoology, rev. ed. *Harcourt, Brace, and World, Inc., New York.*

Smith, P. W.
1961. The amphibians and reptiles of Illinois. *Bull. Illinois Nat. Hist. Surv. 28*:1-298.

Tinkle, D. W.
1961. Geographic variation in reproduction, size, sex ratio and maturity of *Sternothaerus odoratus* (testudinata: Chelydridae). *Ecology 42*:68-76.

Tucker, J. K., R. S. Funk, and G. L. Paukstis.
1978. The adaptive significance of egg morphology in two turtles (*Chrysemys picta* and *Terrapene carolina*). *Bull. Md. Herp. Soc. 14*(1):10-22.

Webb, R. G.
1862, North American recent soft-shelled turtles (Family Trionychiade). *Univ. Kans. Publ., Mus. Nat. Hist. 13*:429-611.

105 E. Fayette, Effingham, Illinois 62401, USA

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TERRESTRIAL CRITICAL HABITAT AND MARINE TURTLES

by

C. Kenneth Dodd, Jr.

The determination of Critical Habitat can be a powerful conservation tool for protecting Endangered and Threatened animals and plants by allowing the full measures of Section 7 of the Endangered Species Act of 1973 to be implemented. This paper discusses Section 7 and its meaning with respect to Fish and Wildlife Service responsibilities for the delineation of Critical Habitats of marine turtles (Cheloniidae and Dermochelyidae). Previous areas proposed as Critical Habitat are discussed briefly and additional areas of potential Critical Habitat are outlined. It is felt that Critical Habitat for sea turtles should be determined as soon as possible

When the Endangered Species Act of 1973 was signed into law, it contained a little noticed section (Section 7) regarding Federal involvement with the critical habitats of endangered and threatened species. This section reads as follows:

> "The Secretary shall review other programs administered by him and utilize such programs in furtherance of the purposes of this Act. All other Federal departments and agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act and by taking such action necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical."

A definition of the term "Critical Habitat" was published by the Fish and Wildlife Service and the National Marine Fisheries Service in the Federal Register of January 4, 1978 (43 FR 870-876) and is reprinted below:

> "'Critical habitat' means any air, land, or water area (exclusive of those existing manmade structures or settlements which are not necessary to the survival and recovery of a listed species) and constituent elements thereof, the loss of which would appreciably decrease the likelihood of the survival and recovery

> of a listed species or a distinct segment of its population. The constituent elements of critical habitat include, but are not limited to: physical structures and topography, biota, climate, human activity, and the quality and chemical content of land, water, and air. Critical habitat may represent any portion of the present habitat of a listed species and may include additional areas for reasonable population expansion."

As specified in the regulations for Interagency Cooperation as published in the January 4, 1978, Federal Register (43 FR 870-876), the Director of the Service will consider the physiological, behavioral, ecological, and evolutionary requirements for survival and recovery of listed species in determining what areas or parts of habitat are critical. These requirements include, but are not limited to:

(1) Space for individual and population growth and for normal behavior;
(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
(3) Cover or shelter;
(4) Sites for breeding, reproduction, or rearing of offspring;

and generally,

(5) Habitats that are protected from disturbances or are representative of the geographical distribution of listed species.

There may be many kinds of actions which can be carried out within the Critical Habitat of a species which would not be expected to adversely affect that species. This point has not been well understood by some persons. There has been widespread and erroneous belief that a Critical Habitat designation is something akin to establishment of a wilderness area or wildlife refuge, and automatically closes an area to most human uses. Actually, a Critical Habitat designation applies only to Federal agencies, and essentially is an official notification to these agencies, that their responsibilities pursuant to Section 7 of the Act are applicable in a certain area.

A Critical Habitat designation must be based solely on biological factors. There may be questions of whether and how much habitat is critical, in accordance with the above interpretation, or how to best legally delineate this habitat, but any resultant designation must correspond with the best available biological data. It would not be in accordance with the law to involve other motives, for example, to enlarge a Critical Habitat delineation, so as to cover additional habitat under Section 7 provision, or to reduce a delineation so that actions in the omitted area would not be subject to evaluation.

There may indeed be legitimate questions of whether, and to what extent, certain kinds of actions would adversely affect listed species. These questions, however, are not relevant to the biological basis of Critical Habitat delineations. Such questions should, and can more conveniently, be dealt with after Critical Habitat has been designated. In this respect the Service, in cooperation with other Federal agencies, has drawn up a set of regulations which, in part, establish a consultation and assistance process for helping to evaluate the possible effects of actions on Critical Habitat. The regulations for Interagency Cooperation were published on January 4, 1978, in the Federal Register (43 FR 870-876) to assist Federal agencies in complying with Section 7 of the Endangered Species Act of 1973.

In accordance with the July 18, 1977, Memorandum of Understanding between the Fish and Wildlife Service and National Marine Fisheries Service, the Fish and Wildlife Service was given the responsibility for sea turtles while on land. Such responsibility includes the determination of Critical Habitat.

Because the Memorandum of Understanding with the National Marine Fisheries Service restricts Fish and Wildlife Service responsibility to terrestrial areas, the main concern of the Service with regard to marine turtle Critical Habitat is nesting beaches. However, since the Hawaiian Islands National Wildlife Refuge contains islands of importance to green turtle basking, such islands may also be considered as potential Critical Habitat. Therefore, nesting beaches and hauling-out sites for all species of listed species of sea turtles are currently under review as potential Critical Habitat.

The criteria used in determining whether an area should be proposed to the Director of the Service as Critical Habitat for sea turtles are really quite simple: Do sea turtles nest on the beach, or use the area for basking, and to what extent is the activity occurring? Other criteria of lesser importance include ownership of the beach (Federal and State owned property will usually be considered before privately owned beaches) and overall importance to the species involved (a major nesting beach for a diffuse nester such as the hawksbill may actually contain a far lower number of actual nests than a more aggregate nester such as the loggerhead and yet be of higher priority). In reality, a subjective judgement is called for but it must be based on the best available biological data.

At present, three species and several populations of two other species of sea turtles are listed on the U.S. List of Endangered and Threatened Wildlife and Plants as Endangered: Kemp's ridley, *Lepidochelys kempii*, the hawksbill, *Eretmochelys imbricata*, the leatherback, *Dermochelys coriacea*, the green sea turtle, *Chelonia mydas* (Florida and Pacific Coast of Mexico populations only), and the olive ridley (Pacific Coast of Mexico population only). All other populations of the green and olive ridley, as well as all loggerheads, *Caretta caretta*, are now listed federally as Threatened (Federal Register, July 28, 1978; 43 FR 32800-32811). No subspecies are recognized as far as the Act is concerned.

Of the six listed species of marine turtles, only four have significant nesting or basking areas within U.S. jurisdiction which may be potential Critical Habitat. While Kemp's ridley does nest very sporadically on Padre Island in Texas, it is not felt that this area qualifies as Critical Habitat at this time. However, the results of the Kemp's ridley restoration program currently underway may influence future decisions about Critical Habitat for this species; if the program is successful, Critical Habitat designation may be warranted. The olive ridley is not known to nest anywhere within territories of U.S. jurisdiction.

The most important sea turtle beaches within U.S. jurisdiction are located on the South Atlantic coast from Virginia to Florida, the Florida Gulf Coast, the U.S. Virgin Islands, particularly the island of St. Croix, various islands within the Commonwealth of Puerto Rico, the Hawaiian Islands National Wildlife Refuge, and numerous islands within the jurisdiction of American Samoa and the Trust Territory of the Pacific. The most extensive nesting areas involve the loggerhead, followed in descending order of importance by the green, hawksbill, and leatherback. Critical Habitat for these species has either been proposed, at least in part, or is presently under extensive review with an eye on proposal. To do this, literature and reports have been reviewed, and interested parties within the scientific community, Interior Department (National Wildlife Refuge System and National Park Service), and National Marine Fisheries Service (especially the Southeastern Regional Office) have been contacted.

THE LEATHERBACK

During the early summer of 1977, the Fish and Wildlife Service became aware of a newly discovered nesting aggregation of leatherback sea turtles occurring at the western end of the island of St. Croix, U.S. Virgin Islands. Personnel of the Fish and Wildlife Service, National Marine Fisheries Service, U. S. Coast Guard, and Government of the Virgin Islands conducted observations on St. Croix during the month of June. 76 to 79 leatherback nests were discovered, and evidence of poaching and potential development were noted. Nesting activity was seen to occur primarily on the 0.8 mile long by 0.1 mile wide strip of Sandy Point Beach. This small area constitutes the only known beach under U. S. jurisdiction used extensively for nesting by the Endangered leatherback. Consequently, this area became the first nesting beach of any marine turtle to be proposed as Critical Habitat (Federal Register, March 23, 1978; 43 FR 12050-12051).

Since the proposal appeared, the Service has received additional information from Mr. Otto Tranberg and Mr. John Yntema which indicates that nesting may be more extensive than originally believed and that an enlargement of the area may be warranted. Mr. Tranberg has recommended that the designation be fixed at a total length of 1.9 miles instead of 0.8 mile (i.e. by adding 0.7 mile to the south shore and 0.4 mile to the north shore) because as much as 10% of the total leatherback nesting activity may be taking place within these extension areas. He indicated that 86 leatherback nests were finally counted through the end of 1977 and that 17 leatherback nests had been deposited in 1978 as of the date of his letter (May 18). Shoys Beach near Christiansted had at least 15 clutches laid early in 1978 although this beach had not been monitored in 1977. Mr. Yntema has indicated that the area should be expanded to a depth of 0.2 mile instead of 0.1 mile. Both recommendations are under serious consideration.

Several other beaches in the Caribbean are also under consideration as Critical Habitat for the leatherback although more data are needed to determine if Critical Habitat designation is justified. These are:

(1) Puerto Rico - Isla Culebra: the beaches of Playa Brava and Playa Resaca.

(2) U.S. Virgin Islands - beaches on St. Johns Is. (Virgin Islands National Park)
- beaches on Buck Is. (Buck Island Reef National Monument).
- St. Croix: Shoys beach

THE HAWKSBILL

The hawksbill sea turtle is a diffuse nester, and occurs as a tropicopolitan resident of the world's seas. Within the U.S. and its territories, hawksbills occur occasionally along the South Atlantic Coast, Gulf of Mexico, Caribbean, Hawaii, and Pacific Trust Territories.

Work by several individuals, notably Tom Carr, J. R. Hendrickson, Jean Thurston, Peter Pritchard, and Tom Wiewandt, has established the importance of particular nesting beaches within U.S. jurisdiction to hawksbill turtles. Several areas within the Commonwealth of Puerto Rico have recently been proposed as Critical Habitat for the species (Federal Register, May 24, 1978; 43 FR 22224-22225). Included are:

> Puerto Rico. (1) Isla Mona. All areas of beachfront on the west, south, and east sides of the island from mean high tide inland to a point 0.1 mile from shore. This includes all 7.2 kilometers of beaches on Isla Mona. (2) Culebra Island. All the areas of beachfront on the north shore of the island from mean high tide inland to a point 0.1 mile from shore. This includes the following beaches: Playa Blanca, Playa Flamenco, Playa Resaca, Playa Brava, and Playa Larga. (3) Cayo Norte. South beach, from mean high inland to a point 0.1 mile from shore. (4) Isla Culebrita. All beachfront areas on the southwest facing shore, east facing shore, and northwest shore of the island from mean high tide inland to a point 0.1 mile from shore.

Hawksbill sea turtles are known to nest on all of Mona Island's 7.2 kilometers of beaches. The offshore areas appear to support a somewhat stable and resident population. In addition, green and leatherback sea turtles also nest on Mona. The entire island of Mona is already Critical Habitat for the federally listed yellow-shouldered blackbird, Mona ground iguana, and Mona boa.

Nesting of hawksbill sea turtles occurs on suitable sandy beaches on the north shore of Culebra Island, as well as the nearby islands of Cayo Norte and Isla Culebrita. Turtles are known to feed on the rich offshore reefs around these islands. In addition to hawksbills, occasional nesting has been reported for leatherback, loggerhead, and green sea turtles on these beaches.

In addition to the areas proposed, the following beaches are under review as potential Critical Habitat for the hawksbill:

(1) American Samoa - Tutuila Island
- Rose Atoll: Rose and Sand Islands
- Swains Island

(2) Puerto Rico - southern beaches of Isla Culebra
- beaches on Isla Vieques

(3) U.S.Virgin Islands - St. Croix: Sandy Point, Isaacs Beach, Jacks Beach, East End Bays, western Manchenil Bay
  - St. John: Saltpond and Fish Bays beaches
  - St. Thomas: Inner Brass and Hans Loilik Cays
  - Buck Island: beaches (Buck Island Reef Nat. Monu.)

(4) Trust Territory of the Pacific
  a) Palau District - In the Palau Lagoon: Eomogan, Ngerugelbtang, Aulong, Ngeangas, Ngobadangel, Unkaseri, Abappaomogan Islands
  b) Truk District - Truk Lagoon: Holap, Tora, Ruac, Lap, Falalu, Alanenkobwe, Ushi, Onao, Tonelik, Pis, Lemoil Islands
  - Lower Mortlocks: Lukunor, Satawan, Etal Islands

GREEN TURTLE

The green sea turtle has recently been added to the federal list and the Office of Endangered Species is reviewing all U.S. jurisdictional areas known to support nesting activity by this species, as well as on-land basking sites, to determine if any should be recommended to the Director as Critical Habitat. Nesting is known to occur in Puerto Rico, the U.S. Virgin Islands, Florida, Hawaii, American Samoa, and the Trust Territories of the Pacific. Specific sites under consideration are as follows:

(1) Florida - Hutchinson and Jupiter Islands, Merritt Island N.W.R., beaches at Cape Canaveral

(2) Hawaii - Hawaiian Islands National Wildlife Refuge: entire atoll complex of French Frigate Shoals including all beaches within the boundaries of Hawaiian Islands N.W.R. (East, Whale-Skate, Trig, Round, Mullet, Disappearing, Gin, Little Gin, Shark, Laysan, Lisianski, Pearl and Hermes Reef, Necker).

(3) Puerto Rico - Isla Mona
  - Isla Culebra: Playa Brava, Playa Resaca.

(4) U.S.Virgin Islands - St. Croix: Sandy Point Beach and East End Bay
  - Buck Island (Buck Island Reef Nat. Monu.)
  - Green Cay N.W.R.

(5) American Samoa - Tutuila Island
  - Rose Atoll: Rose and Sand Islands
  - Swains Island

(6) Trust Territory of the Pacific
  a) Palau District - Helen Reef, Ngaraungl Is., Honeymoon Beach on Pelelieu Is., Merir Is., Fana Is. north of Sonsorol Is., western and southern part of Sonsorol Is., Tobi Is.
  b) Yap District - Ulithi atoll (Gielap, Iar, Pig Is.), Ngulu atoll (North, Merseran Is.), Sorol atoll (Geferut, Pikelot, West Fayu Is.), Ifaluk atoll (Ella Islet), Olimarao (two islets), Lalolior Is. south of Elato.
  c) Truk District - East Fayu, Nomwin atoll (Fanang Islet), Murilo atoll (northern part of the atoll)

d) Ponape District - Ponape (Peina, Bigen, Karakar, Jirup, Bigen Kelang, Piken Mategan, Dekehnman, Wat), Antatoll, Oroluk atoll

e) Marshall Islands District - Bikar atoll, Jemo Is., Arno atoll, Erikub atoll (Enego and Loj Is.) Ujelang atoll, Enewatak atoll (Alice, Bell, Runit, Leroy, Wilma, Bera, Glen, Keith), Jaluit atoll (Lijeron Islet), Bikini atoll, taongi atoll.

THE LOGGERHEAD

The South Atlantic Coast contains one of the major rookeries of the loggerhead turtle in the world. Fortunately, many of the individual nesting beaches have already been set aside within National Wildlife Refuges or are located within units of the National Park system. Others however are not so fortunate and are threatened by encroaching development. The loggerhead is now federally protected as Threatened. Consequently, nesting beaches, especially those within the continental U.S., are currently under review as potential Critical Habitat for this species. Included are:

(1) Virginia - Wallops Is., N.W.R., Chincoteague N.W.R., Assateague Nat. Seashore, various barrier islands.

(2) North Carolina - Bear Island, Browns, Camp Lejeune (Onslow Beach), Cape Lookout beaches, Pea Island N.W.R., Cape Hatteras Nat. Seashore.

(3) South Carolina - Cape Romain N.W.R. (Raccoon Key, South Cape Is., Cape Is., Bulls Is.), Debidue Is., North Is., South/Sand Is., Cedar Is., Murphy Is., Kiawah Is., Botany Bay and "Goat Is.", Eddingsville Beach, Edisto Beach, Otter Is., Harbor/Hunting Is., Fripp Is., Pritchards Is., Little Capers Is., St. Phillips Is., Bay Point, Hilton Head Is., Dolphin Head Beach, and areas along the "Grand Strand".

(4) Georgia - beaches on Little Tybee, Wassaw, Pine, Little Wassaw, Raccoon, Ossabaw, St. Catherines, Blackbeard, Sapelo, Wolf, Little St. Simons, Sea, St. Simons, Jekyll, Little Cumberland, Cumberland islands.

(5) Florida
- Areas near or on Sanibel Is., Captiva Is., Egmont Key, Passage Key
- Everglades National Park (Cape Sable Sea Turtle rookery, Rabbit Key, Pavilion Key).
- Florida Keys Wildlife Refuges and nearby beaches including Bahia Hondo State Park, east side of Marquesas Keys in Key West Refuge, north side of Sawyer Key in Great White Heron Refuge, Rest Beach in Key West.
- an area stretching from northern Volusia Co. in the north to Lake Worth inlet in Palm Beach Co. to the south to include barrier island beaches. Included are beaches on Merritt Is. N.W.R., Hobe Sound N.W.R., and the John F. Kennedy Space Center.
- Casey Key, Manasota Key, Lover's Key, Bonita Beach, Vanderbilt Beach, Naples Beaches (Seagate, North

section of Parkshore, Naples), Cape Romano (Kice Is., Morgan Beach).
- St. Vincent N.W.R. and St. George Is., Dog Is.

CONCLUSION

The beaches and islands named in the above discussion are by no means the sum total of all areas which may or may not eventually be delineated as Critical Habitat for sea turtles. It is provided solely to give an idea of the scope of evaluation being undertaken by the Office of Endangered Species.

Although sufficient data are available for many of these areas for a decision to be made on whether to recommend a proposal for Critical Habitat, much more data are needed to make decisions on many of the other areas. It is hoped that the presentation of such information will aid in drafting any proposals that may eventually be forthcoming. It is also important to stress that a proposal for Critical Habitat does not have to be all inclusive, that is, additional areas may be proposed as data become available. In the meantime, it would seem to be best to propose those areas for which we have sufficient information available on nesting activity as soon as possible since the provisions of Section 7 would then be fully applicable and management and acquisition programs could immediately be instituted. Critical Habitat determination can be a very important conservation tool for working with sea turtle survival. The process of its determination on land is well under way; hopefully the full benefits of Section 7 will soon be available to all nesting beaches and terrestrial basking sites within the United States and its Territories.

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DISTRIBUTIONAL PATTERNS OF NORTH AMERICAN SNAKES: SOME EXAMPLES OF THE EFFECTS OF PLEISTOCENE GLACIATION AND SUBSEQUENT CLIMATIC CHANGES

by

Roger Conant

Although general interest in zoogeography has waned during recent years, partly because of the biological community's preoccupation with molecular biology and ethology, it remains a subject of prime importance to many disciplines, including such widely diverse ones as ecology, geology, palynology, taxonomy, and investigations involving continental drift. Also, data accumulated by students of animal distribution are indispensable to persons charged with the writing of environmental impact statements, which are now required by law in the United States. Much work remains to be done in this field, and time becomes more of the essence almost daily as habitats and sometimes even entire environments are disturbed or destroyed by mankind in various parts of the world.

This paper is concerned with several aspects of distributional patterns that may not be familiar to herpetologists living outside North America.

Because northern North America was repeatedly subjected to glaciation during the Pleistocene, the ranges of many organisms native to the continent were drastically altered by the advance and recession of the ice sheets. According to some authorities, Deevey (1949, p. 1375) and Blair (1958, p. 433) among others, many species retreated to refugia far south of the glacial front, perhaps even to Florida and Mexico. Other authorities, notably Braun (1951; 1955, p. 321, *et. seq.*) and Thomas (1951), contended that the southward displacement of ranges was minimal in a great many cases and that numerous organisms maintained themselves relatively close to the ice border, much as certain plants and animals thrive today near glaciers in the Alps of Europe or those of high mountains in other parts of the world.

Regardless of whether populations survived near or far from the ice sheets, the glaciers of North America had a profound effect on the distributional patterns of many components of the biota. Moreover, the phenomenon was not confined to the northern United States and Canada. Climatic events associated with glaciation affected many species far to the south. For example, as the ice fronts retreated, the storm tracks also moved northward resulting in a presumably gradual but marked reduction of precipitation in areas where humid conditions had prevailed. Thus, in the southwestern United States and adjacent Mexico, many populations of plants and animals became trapped at high elevations in moist mountainous regions. The reduced rainfall eventually transformed the lower slopes and the valleys between ranges into arid regions that mesic adapted organisms could not cross.

This information, which is overly simplified, is offered as a background for what is to follow. The effects of glaciation on the biota is a highly complex subject that has attracted the attention of a large number of investigators. Because of the nature of this Congress, I shall confine my remarks largely to the snakes, although I will mention other key animals or natural communities to illustrate various points.

For the purpose of this discussion I am defining North America as consisting of Canada, the United States of America, and Mexico. Central America is regarded as a separate entity and will not be mentioned further.

THE GLACIAL BOUNDARY

The classical stratigraphic sequence (Flint, 1971, p. 541, *et. seq.*) indicates there were at least four major glaciations, some of them multiple, that descended to mid-latitudes of North America during the Pleistocene (the late-Cenozoic of some authors). These were interrupted by interglacial stages during which the ice retreated northward. The most recent glacial age, the Wisconsin for the state of that name, terminated about 10,000 years ago, and all plants and animals now living in Canada and much of the northern United States are migrants that entered the region since that time. Lobes of each of the three earlier glaciations extended farther south than the Wisconsin, at least in some places, and as they decayed northward they also exposed broad areas that were later colonized by various organisms.

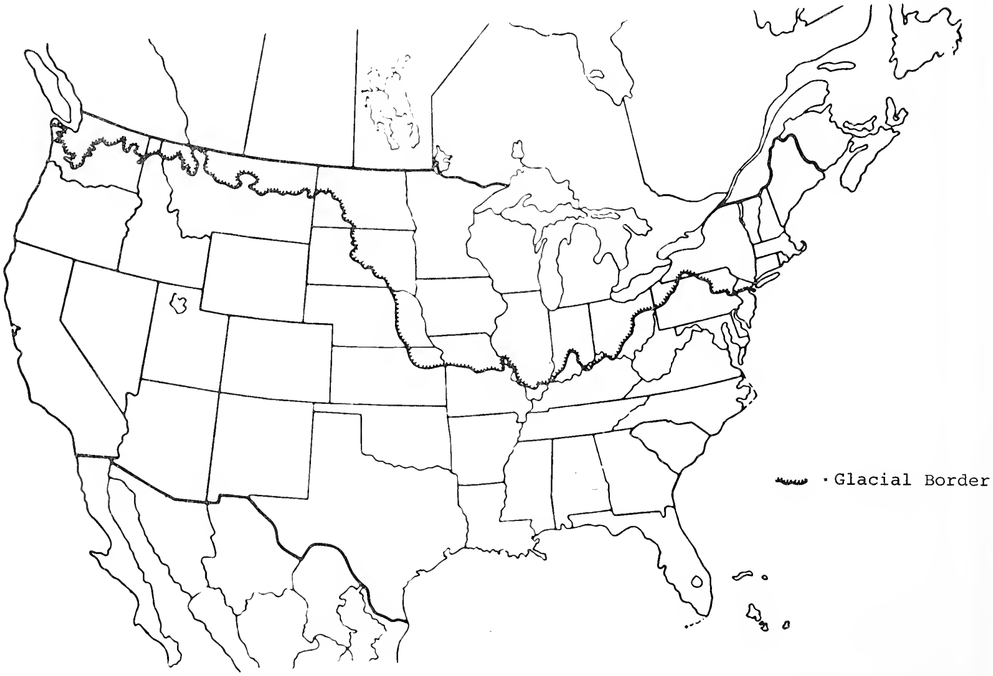


Fig. 1. Map of the glacial border in North America showing the southernmost limits of the Pleistocene ice sheets. (Map adapted from Flint, 1971, p. 490.)

The collective southern limits of the glacial drift areas have been traced with considerable accuracy in the eastern United States (Fig. 1). The Glacial Boundary extended from the level of New York City westward, with a loop northward in mountainous Pennsylvania, and then well to the south in the central Lowlands involving the states of Ohio, Indiana, Illinois, and Missouri. In the Great Plains region, with its much higher elevation above sea level, the boundary, as mapped by Flint (1971, p. 490), swung sharply northward and then westward, roughly paralleling the Canadian border. In the Western United States the picture is less clear because the ice sheets were diverted in part by the lofty mountains of the North American cordillera -- the Rocky Mountains and the equally high satellite ranges near the Pacific coast.

Among the 114 species of snakes indigenous to the United States, at least 37 (32%) have succeeded in crossing the Glacial Boundary for considerable distances. In the east where the ice advanced much farther south the percentage is considerably higher. In the broad region that extends from the Atlantic coast to the westernmost limits of the tributaries of the Mississippi River, there are 66 species of snakes and 35 of them (53%) have crossed the drift border. In terms of new territory occupied, the garter snake, *Thamnophis sirtalis*, has been the most successful; it is known to occur northward to the 50th parallel in the east and to the 60th in the west (Fig. 2). Among the crotaline snakes (the pit vipers), four species have widely invaded glaciated terrain, three in the east and one in the west. These are the copperhead, *Agkistrodon contortrix* (Fig. 3), and the rattlesnakes, *Sistrurus catenatus* (Fig. 4), *Crotalus horridus* (Fig. 5), and *Crotalus viridis* (Fig. 6). All four, as is clearly indicated by the maps, are wide-ranging species that occupy a variety of habitats and physiographic regions; all have differentiated into two or more subspecies. All presumably survived in refugia south of the Glacial Boundary and then considerably expanded their ranges north-

Fig. 2. Range of the Common Garter Snake, *Thamnophis sirtalis*, indicating its marked advance into glaciated territory toward the north and the disjunction of its former range in the arid southwest.

ward after the retreat of the ice sheets. How far south of the glacial fronts the populations managed to survive is debatable, but, in all probability, the copperhead, *Agkistrodon*, and the timber rattlesnake, *C. horridus*, found sanctuary in the southeastern United States; the massasauga, *Sistrurus*, in or near the present state of Texas; and the Western rattlesnake, *C. viridis*, in the Southwest.

In some cases a species may have been forced southward into two or three disjunct refugia where the surviving populations were separated by natural barriers that prevented gene flow. Under such conditions differentiation undoubtedly progressed and, by the time the descendants of the original refugees were able to return northward, two or three more or less different populations may have evolved. When their ranges met as they occupied new territory, gene flow was resumed, but the separate populations probably remained distinct except in intergrading areas between them. Such hypothetical situations might explain the many instances of pairs of present-day, well-differentiated subspecies, eastern and midland, and midland and western, and, indeed, triads representing all three areas. One or more of the races of snakes of the genera *Carphophis, Diadophis, Farancia, Pituophis,* and *Virginia,* and of the species *Elaphe guttata* and *Lampropeltis calligaster* may have originated in this way, to mention only a few examples (see maps in Conant, 1975). Bleakney (1958) even suggested that two forms of the painted turtle, now designated as *Chyrsemys picta belli* and *C. p. dorsalis,* after surviving in southern refugia, contributed their genes toward the formation of a new subspecies, *C. p. marginata,* that populated a large part of the formerly glaciated American middlewest.

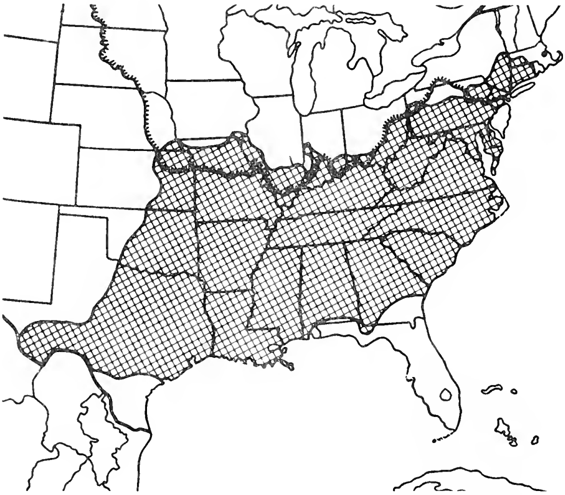


Fig. 3. Range of the Copperhead, *Agkistrodon contortrix*.

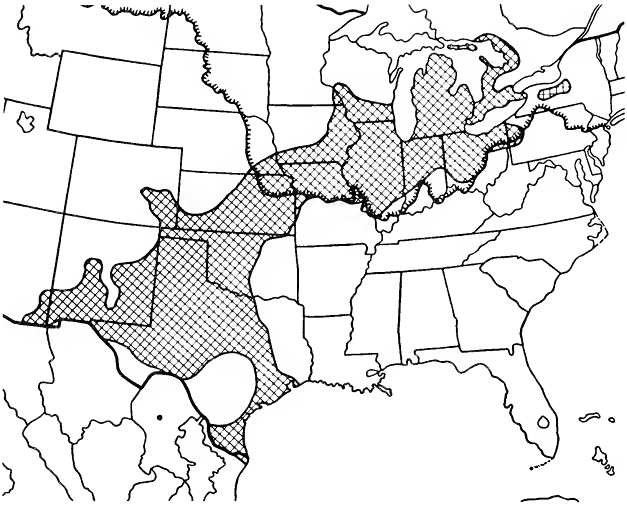


Fig. 4. Range of the Massasauga Rattlesnake, *Sistrurus catenatus*.

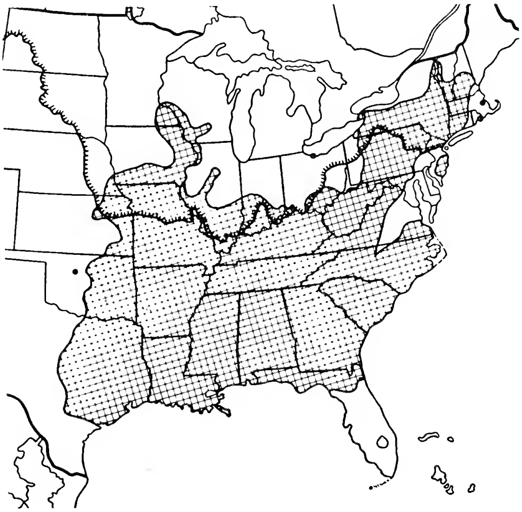


Fig. 5. Range of the Timber Rattlesnake, *Crotalus horridus*.

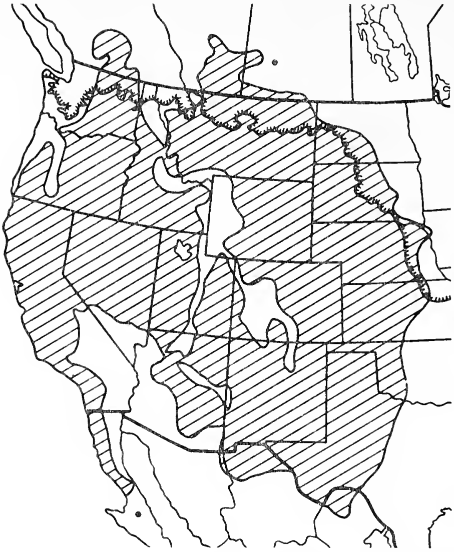


Fig. 6. Range of the Western Rattlesnake, *Crotalus viridis*.

Conversely, some closely related forms have maintained their identities where their ranges now meet and overlap. Among them are the ribbon snakes, *Thamnophis sauritus* and *T. proximus*, and the narrow-mouthed toads, *Gastrophryne carolinensis* and *G. olivacea*.

The opportunity for local differentiation was present during each of the four major glaciations, and that complication no doubt affected the levels of speciation and subspeciation observable in various parts of North America. Changes among reptiles of that continent have been chiefly at the subspecific level since the Pliocene, according to Auffenberg and Milstead (1965, p. 562).

DESICCATION AND DISJUNCTION

The range of *Crotalus willardi* is an excellent example of montane disjunction. This small rattlesnake occurs in uplands from southern Arizona in the United States to western Zacatecas in Mexico. It is primarily an inhabitant of pine-oak forests that occur at elevations from 1650 to 2450 meters. The pine-oak zones, which are sandwiched vertically above encinal (live oak forest) and below coniferous forest, were at one time more or less continuous, probably at least until the Middle Pliocene (Axelrod, cited in Harris & Simmons, 1976, p. 14). Increasing desiccation, much of it since the close of the glacial epoch, and the development of deserts have resulted in the fragmentation of the pine-oak forest and its restriction to the upper slopes of currently well separated mountains (Fig. 7). Concomitantly the range of *Crotalus willardi* also is now fragmented, and isolation has been of such long duration that some of the disjunct populations have developed characteristics of their own, and five distinct subspecies are now recognized. Gene flow from one population to another obviously has been impossible.

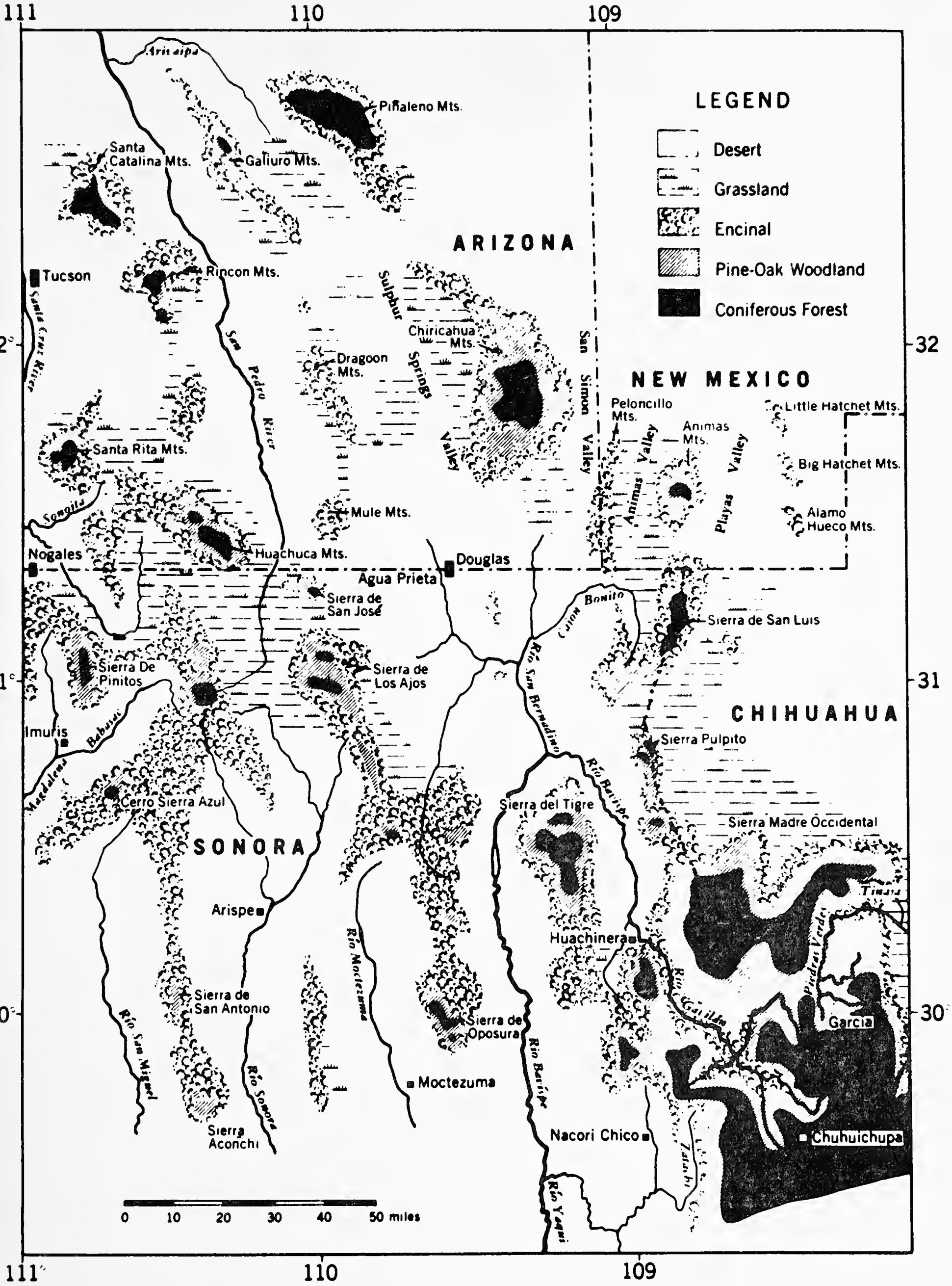


Fig. 7. Vegetation of disjunct mountain ranges of southern Arizona, southern New Mexico, and adjacent Mexico. (Map from Bogert and Degenhardt, 1961, p. 4.)

There are many other examples of montane disjunctions involving animals and plants of the arid southwestern United States and adjacent Mexico, among which those of the two mountain kingsnakes, *Lampropeltis zonata* (Fig. 8), and *L. pyromelana* (Fig. 9), may be mentioned.

Fig. 8. Disjunct populations of the California Mountain Kingsnake. (Map from Zweifel, 1952, p. 6.)

Fig. 9. Disjunct populations of the Sonora Mountain Kingsnake. (Map from Tanner, 1953, p. 6.)

Another type of disjunction, but one that also resulted from a marked reduction in precipitation since the retreat of the glaciers, involves aquatic and semiaquatic organisms inhabiting rivers that debouch into the desert. Classic examples are the faunas of the Ríos Nazas and Aguanaval that rise in the highlands of western Mexico and flow eastward through arid terrain (Fig. 10). Before their manipulation by mankind for agricultural and industrial purposes, those rivers emptied into playas in the Chihuahuan Desert. During one or more pluvial periods they were part of a master stream that had a confluence at a still unknown point with the Rio Grande (the Río Bravo of the Mexicans) that forms part of the boundary between the United States and Mexico (Conant, 1963b, p. 473-478). Their faunas, which include fishes, turtles, and snakes, were obviously derived from that of the Rio Grande, but isolation has been of sufficiently long duration to permit subspeciation among the snakes of the genus *Natrix* (Conant, 1953; 1963a) and probably also among some of the other components, notably a turtle (*Chrysemys*).

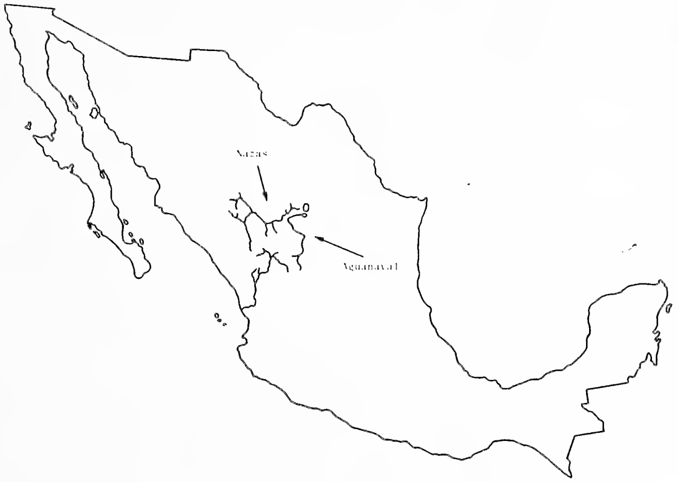


Fig. 10. The isolated drainage systems of the Rios Nazas and Aguanaval in the Chihuahuan Desert.

The remarkable assemblage of species in the desert bolsón of Cuatro Ciénegas in the Mexican state of Coahuila (see references in Minckley, 1969) may owe some of its derivation to changes in climate associated with or subsequent to the glacial period. The high rate of endemism in that restricted region, however, would suggest that factors affecting isolation have exerted an influence for a much longer period of time. The rivers that cross or traverse the Chihuahuan Desert in part contain many relict species (Conant, 1978) the distribution of which offer clues to past events in the history of that arid region.

The ranges of many species of reptiles exhibit fragmentation in arid parts of North America. To mention a few examples: (1) The garter snake, *Thamnophis sirtalis*, that has been so successful in colonizing a vast northern region that once was ice covered, has lost ground in the southwest where it survives only in isolated colonies and along a few streams

(Fig. 2). (2) The copperhead, *Agkistrodon contortrix*, which ranges eastward to the Atlantic seaboard, still exists within the limits of the Chihuahuan Desert, but only at oases, near springs and seeps, or in the *carrizo* (cane) jungles along the Rio Grande. (3) The two turtles, *Chrysemys picta* and *C. scripta*, that are widespread and abundant throughout much of the rest of their ranges, are reduced in the southwestern United States and northern Mexico to isolated populations centered along streams flowing through otherwise arid terrain.

All these species, as well as a large number of other kinds of animals and plants, at one time had broad ranges during pluvial periods of the past, but they now survive only as relict colonies where suitable habitats still exist. Such isolated colonies face a precarious future. Because of the exploding human population and the need for water to support industry and food production on an ever broadening scale, mankind is turning more and more to deserts and sub-arid lands and using their often meager water resources for his own purposes. The Rio Grande, which once flowed freely from Colorado to the Gulf of Mexico, is now usually dry downstream from the twin cities of El Paso and Ciudad Juárez, in the United States and Mexico, respectively, all the way to its former confluence with Mexico's Río Conchos, a distance of 370 kilometers or more. All aquatic and semiaquatic organisms have vanished from that part of the former river, although some have managed to find sanctuary in a few minor tributaries or in nearby cattle tanks and ponds. The Río del Carmen in northern Mexico no longer flows in the lower portion of its former course; it has vanished below the impoundment dam at Las Lajas from which water excapes only through a flume en route to irrigation ditches. Beyond the dam all the components of the river fauna and flora, including the gallery forest, have been extirpated.

THE PRAIRIE PENINSULA

A series of post-glacial events that greatly affected the distribution of many organisms included the development of the Prairie Peninsula, a long tongue of grassland and other steppe vegetation that, at its maximum, extended eastward from well west of the Mississippi River in the Great Plains to, in all probability, the Atlantic coast. Figure 11 is adapted from Smith (1957, p. 211) who reviewed the distributions of terrestrial vertebrate populations in relation to the Prairie Peninsula. Schmidt at an earlier date (1938) offered herpetological evidence for the postglacial extension of the steppe in North America. Despite meager evidence, there is more or less general agreement that a band of tundra followed the ice sheets as they decayed northward. In the case of the Wisconsin, the last of the four major glaciations, the tundra phase was succeeded by three major climatic sequences that have been well documented by pollen profiles accumulated by palynologists and by the findings of zoogeographers and phytogeographers. These, in brief, were a cool moist period, followed by a warm period, and then a return to cool moist conditions that have continued until the present time. Smith (1965, p. 633) believed that the warm period consisted of two parts, each of which lasted for an estimated 20 centuries: (1) the Climatic Optimum, a warm moist phase from 8,000 to 6,000 years before the present; and (2) the Xerothermic Interval, a warm dry phase from 6,000 to 4,000 years before the present.

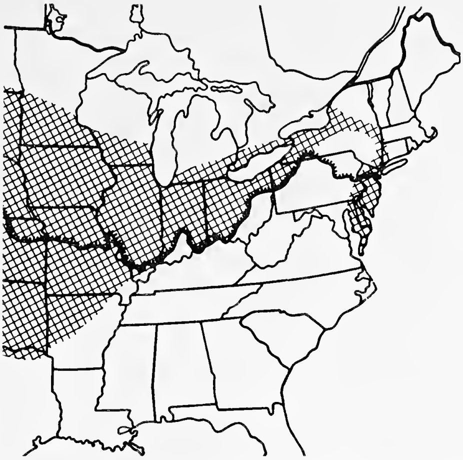


Fig. 11. The Prairie Peninsula at the Xerothermic Maximum. (Map adapted from Smith, 1957, p. 211.)

During the Climatic Optimum many southern organisms moved northward from their refugia below the drift border and occupied apparently wide areas that formerly had been covered with ice. Later, after the onset of the Xerothermic Interval, they were replaced in large part by other plants and animals that were better adapted for warm dry conditions. A considerable number of the earlier invaders, however, survived as relicts in suitable habitats well north of their now continuous ranges. Among these the water snake, *Natrix erythrogaster* (Fig. 12), and the mud turtle, *Kinosternon subrubrum* (Fig. 13), may serve as examples. During the Xerothermic there was an invasion from the west and southwest, and numerous species that are characteristic of the Great Plains became well established in the Prairie Peninsula. Many of these, like the organisms that preceded them, are still represented by relict populations that have survived in sand prairies, in swales or marshes, or other habitats that were not readily occupied by the third wave of invading plants and animals that, during the most recent period, moved in from the eastern and southern forests. Herpetological examples of prairie relicts are the western hognose snake, *Heterodon nasicus* (Fig. 14), lined snake, *Tropidoclonion lineatum* (Fig. 15), mud turtle, *Kinosternon flavescens* (Fig. 16), box turtle, *Terrapene ornata* (Fig. 17), and chorus frog, *Pseudacris streckeri* (Fig. 18). A range of unusual interest (Fig. 19) is that of the small water snake, *Natrix kirtlandi*, which closely fits the boundaries of the Prairie Peninsula, even to the extent of having disjunct former colonies near the Atlantic Coast (compare with Fig. 11). Thomas (1951, p. 161) postulated that it survived the Wisconsin glaciation somewhere close to the ice front and spread northward after the retreat of the ice.

The presence of still existing but gradually disappearing relict populations in one of the most heavily utilized parts of the United States points up the need for documenting and, wherever and whenever possible, preserving living samples, in their natural habitats, of the components of the biota that have survived from former times. A look at what was left of the Prairie Peninsula (Fig. 20) when Europeans entered the North American continent in numbers is instructive. The black areas indicate grasslands, the white ones show woodlands and forests. Prairie was almost continuous from Illinois westward, and trees were restricted largely to the water courses of the region. In the opposite direction only scattered remnants remained of the once extensive prairies that, during the Xerothermic maximum, stretched almost uninterruptedly far to the east. Most of the prairie areas, with their rich black soils, were converted into farms soon after the pioneers from the eastern seaboard moved into the area during the last of the eighteenth and the early part of the nineteenth centuries. This broad district is still one of the most important agricultural belts within the borders of the United States, but its intensive use by mankind has been disastrous to much of the wildlife and the native prairie flora. Remnants survive mainly in places that are unsuited for farming -- in sandy or poorly drained areas--or along railroad rights of way where narrow strips of land support minute samples of the original prairie flora, and to a much lesser extent, the fauna.

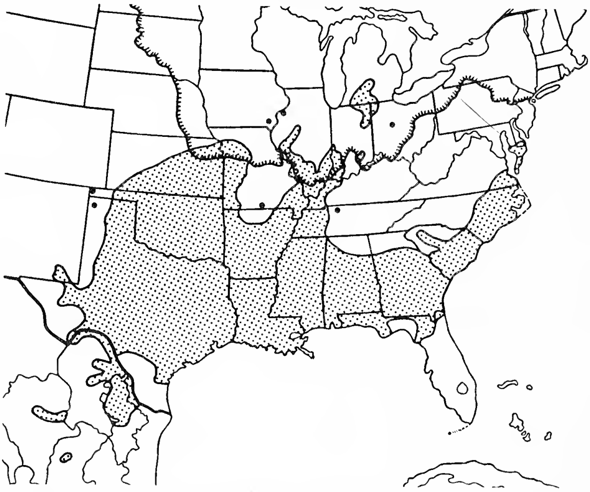


Fig. 12. Range of the Plain-bellied Water Snake, *Natrix erythrogaster*.

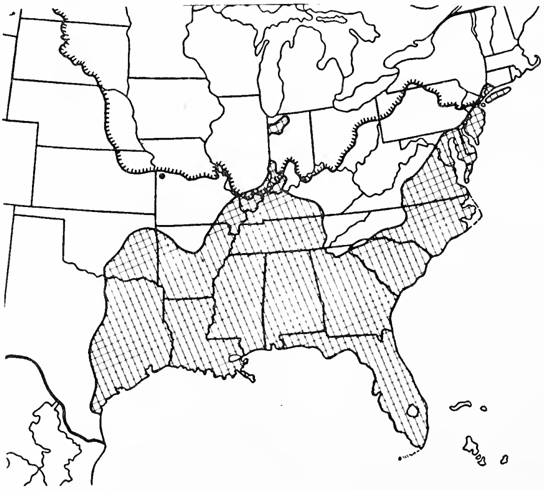


Fig. 13. Range of the Eastern Mud Turtle, *Kinosternon subrubrum*.

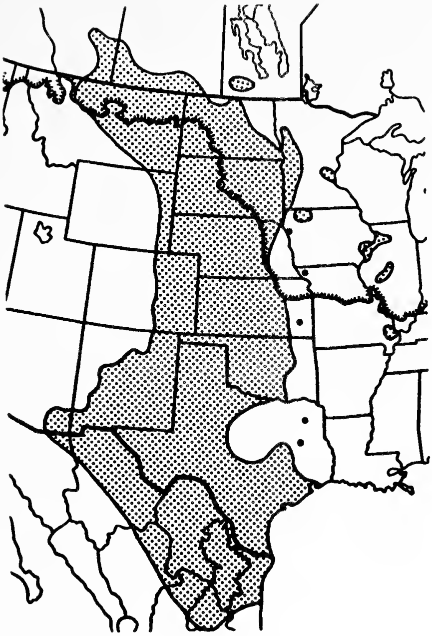


Fig. 14. Range of the Western Hognose Snake, *Heterodon nasicus*.

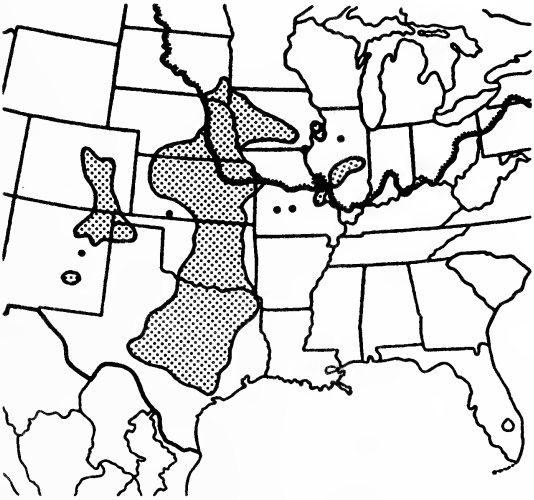


Fig. 15. Range of the Lined Snake, *Tropidoclonion lineatum*.

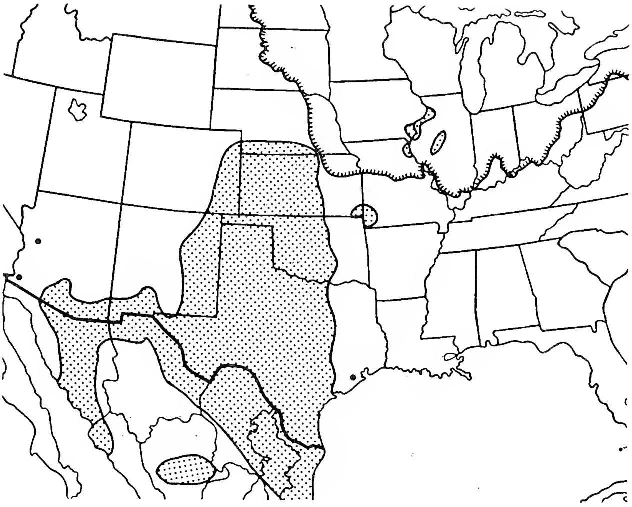


Fig. 16. Range of the Yellow Mud Turtle, *Kinosternon flavescens*.

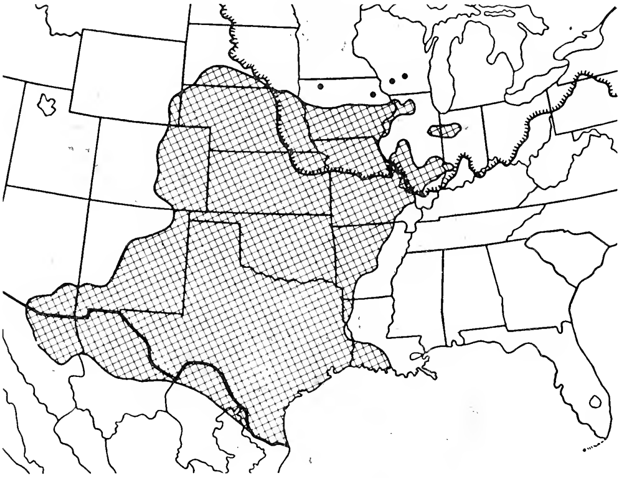


Fig. 17. Range of the Ornate Box Turtle, *Terrapene ornata*.

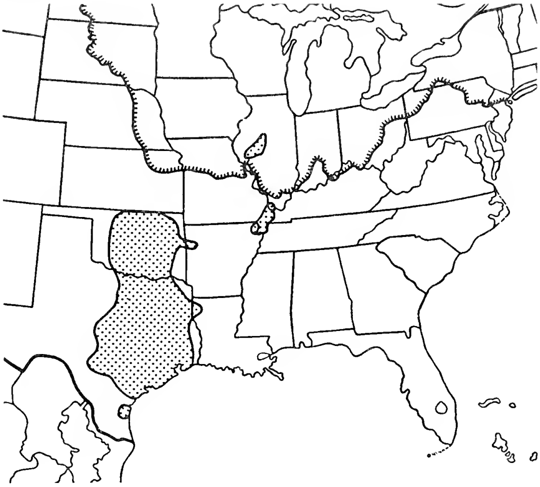


Fig. 18. Range of Strecker's Chorus Frog, *Pseudacris streckeri*.

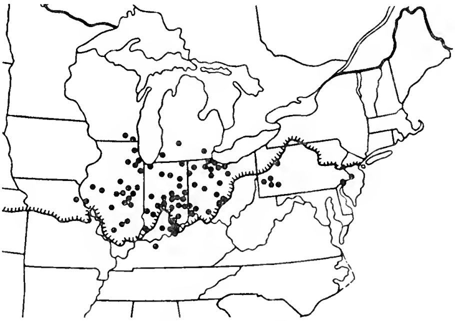
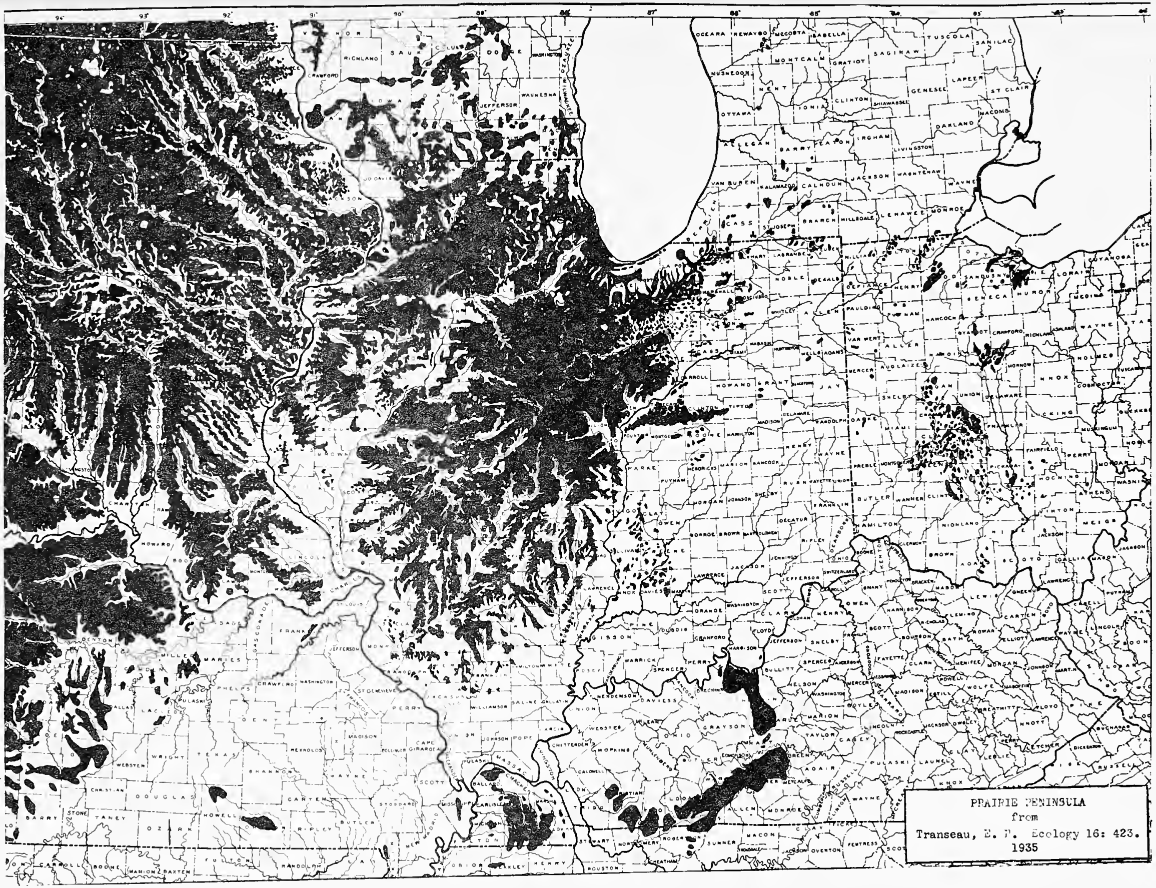


Fig. 19. Range of Kirtland's Water Snake, *Natrix kirtlandi*. (Map updated from Conant, 1943, p. 324.)

Efforts, some of them already successful, are being made, through the Nature Conservancy and other conservation organizations, to preserve a large number of natural areas throughout the United States. Included among them are habitats where relicts still exist, within the former Prairie Peninsula, in the arid southwest, and in a number of other places I would like to mention but which I must omit because of time limitations. Also, many of our states, following the lead of the national government, have designated rare and endangered animals and plants that are now protected within their jurisdictions and which, through law enforcement and education of the public, should have a better chance for survival. Similar conservation measures are in progress in other parts of the world, or they are being advocated by students of our wildlife heritage from the past.

Our inventory of relicts and other rare and endangered organisms within the borders of the United States is not complete, but it is well advanced. We hope that similar progress in other countries will move steadily forward and that within a few years we may have a written record, on a world-wide basis, of what is protected and what needs help.



PRAIRIE PENINSULA
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Transeau, E. N. Ecology 16: 423.
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Fig. 20. The Prairie Peninsula, reduced to remnants toward the east, at the time of European settlement in the American Midwest. (Map from Transeau, 1935, p. 423.)

Currently the international community, with few exceptions, is aware of the plight of most of the large mammals, the spotted cats, the great apes, and the whales, for example, and many of the birds, but few people as yet pay attention to the lesser species, the snakes among them.

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Literature Cited

Auffenberg, Walter, and William W. Milstead.
1965. Reptiles in the Quaternary of North America. *In* Wright, H. E., Jr., and David G. Frey (eds.), Quaternary of the United States. *Princeton Univ. Press*, pp. 557-568, fig. 1.

Blair, W. Frank.
1958. Distributional patterns of vertebrates in the southern United States in relation to past and present environments. *In* Hubbs, Carl L. (ed.), Zoogeography, Publ. *Amer. Assoc. Adv. Sci.*, no. 51, pp. 433-468, figs. 1-11.

Bleakney, Sherman.
1958. Postglacial dispersal of the turtle *Chrysemys picta*. *Herpetologica*, vol. 14, pp. 101-104, fig. 1.

Bogert, Charles M., and William G. Degenhardt.
1961. An addition to the fauna of the United States, the Chihuahua ridge-nosed rattlesnake in New Mexico. *Amer. Mus. Novitates*, no. 2064, pp. 1-15, figs. 1-3.

Braun, E. Lucy.
1951. Plant distribution in relation to the glacial boundary. *Ohio Jour. Sci.*, vol. 51, pp. 139-146, figs. 1-16.

______________.
1955. The phytogeography of unglaciated eastern United States and its interpretation. *Bot. Rev.*, vol. 21, pp. 297-375.

Conant, Roger.
1943. Studies on North American water snakes - I: *Natrix kirtlandii* (Kennicott). *Amer. Midland Nat.*, vol. 29, pp. 313-341, figs. 1-2, pl. 1, map.

______________.
1953. Three new water snakes of the genus *Natrix* from Mexico. *Nat. Hist. Misc.*, no. 126, pp. 1-9.

______________.
1963a. Another new water snake of the genus *Natrix* from the Mexican plateau. *Proc. Biol. Soc. Washington*, vol. 76, pp. 169-172.

______________.
1963b. Semiaquatic snakes of the genus *Thamnophis* from the isolated drainage system of the Río Nazas and adjacent areas in Mexico. *Copeia*, pp. 473-499, figs. 1-10.

______________.
1975. A field guide to reptiles and amphibians of eastern and central North America. *Boston, Houghton Mifflin Co.*, 2nd ed., pp. i-xviii, 1-429, figs. 1-105, pls. 1-48, maps 1-311, 1 map, 33 illust.

______________.
[1978.] Semiaquatic reptiles and amphibians of the Chihuahuan Desert and their relationships to drainage patterns of the region. *In* Wauer, Roland H. and David H. Riskind (eds.), Trans. Symposium on the biological resources of the Chihuahuan Desert region, United States and Mexico, 1974. *Trans. &Proc. Ser., no. 3, U.S. Natl. Park Serv., 1977*, pp. 455-491, maps 1-32.

Deevey, Edward S., Jr.
1949. Biogeography of the Pleistocene. *Bull. Geol. Soc. Amer.*, vol. 60, pp. 1315-1416, figs. 1-27.

Flint, Richard Foster.
1971. Glacial and Quaternary geology. *New York, John Wiley and Sons, Inc.*, pp. i-xiv, 1-892, profusely illust.

Harris, Herbert S., Jr., and Robert S. Simmons.
1976. The paleogeography and evolution of *Crotalus willardi*, with the formal description of a new subspecies from New Mexico. *Bull. Maryland Herp. Soc.*, vol. 12, pp. 1-22, figs. 1-5.

Minckley, W. L.
1969. Environments of the bolsón of Cuatro Ciénegas, Coahuila, México. *Texas Western Press, Univ. Texas at El Paso, Sci. Ser.*, no. 2, pp. 1-65, figs. 1-27.

Schmidt, Karl P.
1938. Herpetological evidence for the postglacial eastward extension of the steppe in North America. *Ecology*, vol. 19, pp. 396-407.

Smith, Philip W.
1957. An analysis of post-Wisconsin biogeography of the prairie peninsula region based on distributional phenomena among terrestrial vertebrate populations. *Ecology*, vol. 38, pp. 205-218, figs. 1-46.

______________.
1965. Recent adjustments in animal ranges. *In* Wright, H. E., Jr., and David G. Frey (eds.), Quaternary of the United States. *Princeton Univ. Press*, pp. 633-642.

Tanner, Wilmer W.
1953. A study of taxonomy and phylogeny of *Lampropeltis pyromelana* Cope. *Great Basin Nat.*, vol. 13, pp. 47-66, figs. 1-2, pl. 1.

Thomas, Edward S.
1951. Distribution of Ohio Animals. *Ohio Jour. Sci.*, vol. 51, pp. 153-167, figs. 1-14.

Transeau, Edgar N.
1935. The prairie peninsula. *Ecology*, vol. 16, pp. 423-437, figs. 1-28.

Zweifel, Richard G.
1952. Pattern variation and evolution of the mountain kingsnake, *Lampropeltis zonata*. *Copeia*, pp. 152-168, figs. 1-6, pl. 1.

Adjunct Professor, Department of Biology, University of New Mexico and Director and Curator of Reptiles Emeritus, Philadelphia Zoological Garden.

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Editor's Note: The paper in this issue by Roger Conant was one of many presented 5 November 1976 at the Primer Congreso Mundial de Ofidiología, Caracas, Venezuela. A "Proceedings" of that meeting was to be published prior to 31 December 1976, but has never materialized. The Conant paper, therefore, has been withdrawn from inclusion in any proceedings of the Congreso that may appear in print.

H.S.H.

NEW LOCALITY RECORDS AND RANGE EXTENSIONS FOR *Thamnophis brachystoma* (REPTILIA: SERPENTES) IN PENNSYLVANIA

Thamnophis brachystoma (Cope) is a small colubrid endemic to the unglaciated Allegheny High Plateaus physiographic region (Fenneman, 1938) of northwestern Pennsylvania and extreme southwestern New York, west of the divide between the Allegheny and Susquehanna river drainage systems (Richmond, 1952; Fig. 1). *T. brachystoma* apparently evolved during the Wisconsin glaciation, when it was isolated from an ancestral *T. radix* stock that also gave rise to the closely related *T. butleri* (Barton, 1956; Smith, 1945).

Specimens (Carnegie Museum No. 53678) were collected 1.6 km south of Wesleyville, Erie Co., in 1970. I collected *T. brachystoma* (CM 58751-58754) in two small, open fields 3 km west of Wesleyville in the city of Erie on 22 June 1974. The fields are separated by about a half-kilometer of dense woodland and developed area. These latter localities represent two distinct populations that have been in existence at least since the summer of 1972. An additional Erie County locality is represented by CM 61959, collected in Presque Isle State Park in 1976. The Erie County localities are 40 km northwest of the nearest published locality for *T. brachystoma* (Richmond, 1952) and 54 km north of the Wisconsin terminal moraine (Shepps, et al., 1959).

Richmond (1952) reported three specimens from glaciated localities in western Mercer and extreme southwestern Venango Counties, Pennsylvania. Additional localities from this physiographic region are: Mercer Co., 3.2 km south of Stonelick (CM 56468), taken in 1972; Warren Co., Benson Swamp, 3.3 km east of Columbus (CM 27678), taken in 1947, and 8.3 km east of Columbus (CM 27685-27687, 27688(20)), taken in 1947; Crawford Co., 7.5 km southeast of Spartansburg (University of Michigan Museum of Zoology No. 122702(3)), taken in 1961. I collected *T. brachystoma* (CM 58758-58759) 16 km west of Titusville, Crawford Co., on 23 June 1974. The previous westernmost locality in Crawford Co. is at Titusville, located in the unglaciated Allegheny High Plateaus.

Three specimens (CM 34359, 34392-34393) were taken in the city of Butler, Butler Co., in 1954 and one (CM 32384) at Oneida Lake, 9 km northeast of Butler in 1953. The nearest approach of the Wisconsin terminal moraine is 33 km northwest of Butler; the southernmost previous locality for *T. brachystoma* is Grove City, 32 km to the north of Butler.

There are several recent records from Pittsburgh, Allegheny Co., (CM 29380(1949), 38720(1963), 41223(1965)). The 1949 record was probably not from an established population (C. J. McCoy, pers. comm.), whereas the population represented by the 1965 record is still extant in 1978 (P. G. Haneline, pers. comm.). I collected *T. brachystoma* (CM 58760-58761) near Frick Park in Pittsburgh on 8 July 1974 (Fig. 2). Several snakes of this species in addition to those collected were seen. The collection area consists of low herbaceous growth-old field habitat. All snakes were found beneath boards, cardboard pieces, and other miscellaneous

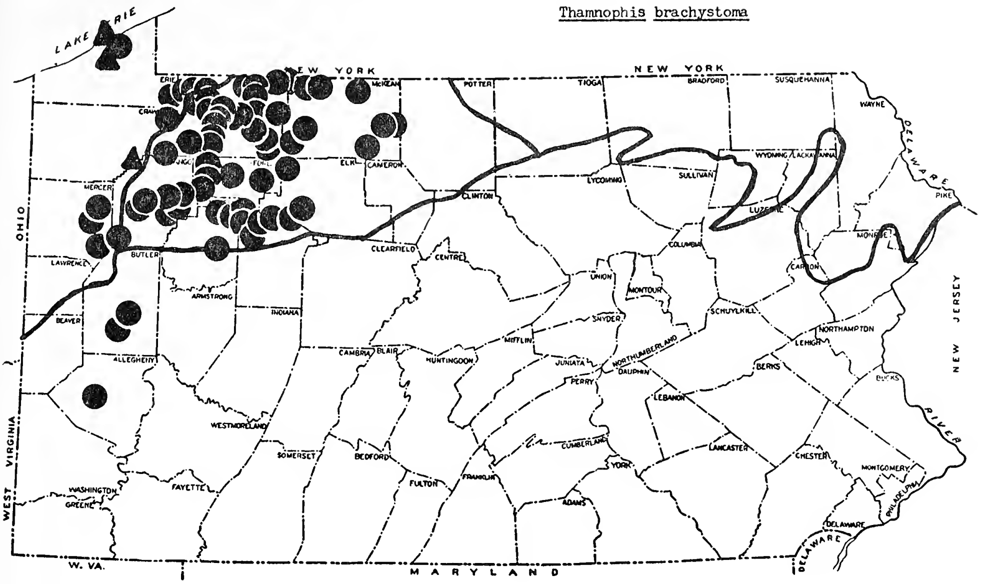

Fig. 1. Map of Pennsylvania showing localities for *Thamnophis brachystoma* (circles) with the Allegheny High Plateaus (middle) and Glaciated (left and right) Physiographic Regions outlined in black. New localities reported here are indicated by the solid triangles.

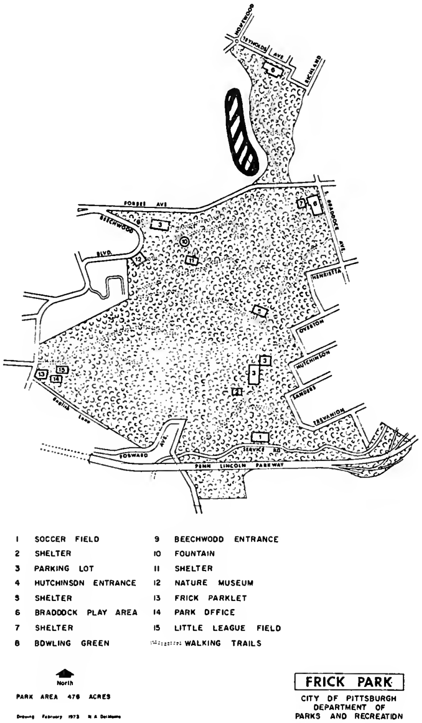

Fig. 2. Map of Frick Park in Pittsburgh showing the locality for *T. brachystoma* reported here (hatched area).

objects. There is an extensive and dense area of brush cuttings from Park maintenance at the south end of the collection area around which several snakes were seen, and which presents an ideal refugium for the population. This population is apparently viable, having existed at least since the spring of 1973. Pittsburgh is 80 km south of Grove City.

Thamnophis brachystoma is able to survive and multiply in suitable habitat outside of its natural range, once it is introduced and becomes established. Pisani and Bothner (1970) indicate that it has or is in the process of evolving a biennial reproductive cycle, permitting it to exist in habitats that do not provide sufficient quality to support an annual reproductive cycle. The urban records from Erie, Butler and Allegheny Counties, in the absence of intervening populations, must be attributed to human introduction. The major range of *T. brachystoma* lies within the Allegheny National Forest, a popular resort area during spring and summer and a likely source for the introductions. More work needs to be done, however, to determine if there are intervening natural populations of *T. brachystoma* between the urban localities and the Allegheny High Plateaus.

Netting (in Conant, 1950) suggests the range of *T. brachystoma* to be primarily unglaciated territory, while Smith (1945) and Conant (1950) indicate that it is expanding northward into glaciated territory. Bothner (1976) suggests, however, that *T. sirtalis* may be replacing *T. brachystoma* in the northern part of the latter's range. Conant (1950) concurred with the opinion that the Mercer County records are accidentals, possibly carried in the balled roots of trees or shrubs. The records from the glaciated region west of the Allegheny High Plateaus suggest a possible limited range extension for *T. brachystoma*. Barton (1956) hypothesized the evolution of *T. brachystoma* and *T. butleri* from a common pre-Wisconsin stock occupying a continuous geographical range that is now occupied by both species with a 128 km gap between them. It must yet be determined, however, exactly what is happening at the westernmost and easternmost edges of the ranges of *T. brachystoma* and *T. butleri*, respectively.

There is no question that the urban locality records for *T. brachystoma* in Pennsylvania are due to artificial introduction. The records from the glaciated region of northwestern Pennsylvania suggest one of two possibilities: (a) *T. brachystoma* is actively expanding its range from the Allegheny High Plateaus, or (b) the post-glacial range of this snake is more extensive than has been recognized.

Acknowledgments

I would like to thank Carl and Linda Price, Marian Mizejewski and Rich Magram for companionship in the field, Gary Breitenbach, The University of Michigan Museum of Zoology (UMMZ), for information on specimens held there, and Dr. C. J. McCoy, Carnegie Museum of Natural History (CM) for use of specimens and numerous helpful comments and criticisms of the manuscript.

Literature Cited

Barton, A. J.
1956. A statistical study of *Thamnophis brachystoma* (Cope) with comments on the kinship of *Thamnophis butleri* (Cope). *Proc. Biol. Soc. Wash. 69*:71-82.

Bothner, Richard C.
1976. *Thamnophis brachystoma*, Catalogue of American Amphibians and Reptiles: 190.1-190.2.

Conant, Roger.
1950. On the taxonomic status of *Thamnophis butleri* (Cope). *Bull. Chicago Acad. Sci. 9*:71-77.

Fenneman, Nevin M.
1938. Physiography of the Eastern United States. *McGraw-Hill Co., New York.* xiii + 714 p.

Pisani, George R. and Richard C. Bothner.
1970. The annual reproductive cycle of *Thamnophis brachystoma. St. Bonaventure College, Science Studies 26*:15-34.

Richmond, Neil D.
1952. First record of the Green Salamander in Pennsylvania, and other range extensions in Pennsylvania, Virginia and West Virginia. *Ann. Carn. Mus. 32*:313-318.

Shepps, V. C., G. W. White, J. B. Droste and R. F. Sitler.
1959. The glacial geology of northwestern Pennsylvania. *Pa. Geol. Survey*, 4th ser., Bull. G. 32, 64 p., 11 figs., 1 map.

Smith. A. G.
1945. The status of *Thamnophis butleri* (Cope), and a redescription of *Thamnophis brachystoma* (Cope). *Proc. Biol. Soc. Wash. 58*:147-154.

—Andrew H. Price, *Section of Amphibians and Reptiles, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, Pennsylvania.*
Present address: *Department of Biology, Box 3AF, New Mexico State University, Las Cruces, New Mexico 88003.*

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NOTES ON REPRODUCTION IN *Lampropeltis getulus* FROM SOUTHERN NEW MEXICO

On 8 June 1975 a pair of Sonoran desert kingsnakes (*Lampropeltis getulus splendida*) was captured shortly before sunset (approximately 2000 hrs MDT) at the La Mesa Lake, 3800' elevation, T25S R2E sec 15, Doña Ana County, New Mexico. The male and female were approximately 1.0 and 0.9 meter in length, respectively. The latter was considerably heavier bodied and its tail had been severed about 1 cm posterior to the vent. At the time of capture, the two individuals were intertwined beneath a dense shrub on a sandy substrate.

On the next day, 9 June, the pair was placed in a glass-fronted cage in the Department of Biology, New Mexico State University, Las Cruces and maintained at room temperature. On two occasions during the afternoon of the same day the pair was observed copulating. In both instances the male grasped the female by the neck from the right side (one and two cm posterior to the head) and intromission was achieved with the right hemipenis. This behavior is consistent with that described for the species by Porter (1972). No subsequent copulations were observed.

On 22 July 1975, a clutch of seven eggs (approximately 40-50 mm in length) was discovered in the cage. This size clutch is somewhat below the average of 10.1 reported by Fitch (1970) for the species. Assuming that fertilization occurred as a result of the 8 or 9 June matings, the gestation period was 43 or 44 days in length. This period is considerably shorter than the 73 days reported by Meade (1932, cited by Fitch 1970) and the possibility of other, earlier matings in the wild cannot be ruled out. However, 44 days is within the possible range (39 to 54 days) reported by Martin (1976) for *L. pyromelana* from Southern Arizona.

An unsuccessful attempt was made to hatch the eggs by incubating them on moist sand in a closed plastic bag. On 11 August they were found to be covered with mold and were discarded.

Literature Cited

Fitch, Henry S.
1970. Reproductive cycles in lizards and snakes. *Univ. Kans. Mus. Nat. Hist.*, Misc. Pub. No. 52:1-247.

Martin, Brent E.
1976. Notes on breeding behavior in a captive pair of Sonoran mountain kingsnakes, (*Lampropeltis pyromelana*). *Bull. Md. Herp. Soc.*, *12*(1):23-24.

Meade, G. P.
1932. Notes on the breeding habits of Say's king snake in captivity. *Bull. Antivenin Inst. Amer.*, *5*(3):70-71. (Cited by Fitch, 1970).

Porter, Kenneth R.
1972. Herpetology. *Saunders. New York.* 524 pp.

—Michael S. Alberico, *Department of Biology, New Mexico State University, Las Cruces, New Mexico 88003.*

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PRELIMINARY NOTES ON LOCOMOTOR BEHAVIOR IN JUVENILE SNAPPING TURTLES, *Chelydra serpentina*, UNDER CONTROLLED CONDITIONS

The common snapping turtle, *Chelydra serpentina*, has been described by Ernst and Barbour (1972) as sluggish by day and active at night. Walls (1934) found numerous rods in addition to cones in the retina of this species. Such anatomical evidence lends support to the scattered casual references to nocturnality in *Chelydra*. However, my field observations indicate that snapping turtles of all sizes are quite active in the daytime, as well as at night. While hunting for *Chelydra* for a recent growth study (Graham and Perkins, 1977) I noted adults and young actively foraging in both the morning and afternoon during August. The present study was done to determine the pattern of locomotor activity and relative amounts of nocturnal and diurnal behavior in juvenile *Chelydra serpentina* under controlled conditions of light and temperature.

Five young snapping turtles 80-120 mm in carapace length were obtained from a small pond on the campus of Worcester State College, Worcester County, Massachusetts in the summer of 1977. They were placed in covered clear plastic containers with about 3 cm of tapwater and acclimated to 25 ± 1 °C in a constant temperature chamber. The experimental photoperiod used during acclimation was LD 8:16 (8 h of light alternating with 16 h of darkness). The light period (photophase) was centered at 1200 h EST and lighting was from 40 W incandescent bulbs suspended above the turtle containers in the chamber. Lights were turned on and off at 0800 h and 1600 h, respectively, and were controlled by a twilight simulator (Graham and Hutchison, 1977). Illuminance was about 50 lux during the photophase and 0 lux in the scotophase (dark period). After a two week acclimation each animal was wired for activity recording in the fashion described by Graham and Hutchison (1978). Event recorder tracings were inspected under a dissecting microscope and individual blips (representing animal movements) were tallied for each hour.

Fig. 1 shows the hourly activity of five turtles represented as the mean per cent of daily activity. Comparison of activity during the photophase and scotophase shows that: 1) photophase activity was minimal from 1200-1300 h, and scotophase activity was minimal from 2300-2400 h; 2) photophase activity was maximal from 0800-0900 h, and scotophase activity was maximal from 0500-0600 h; 3) a slight increase in activity occurred just after the onset of the light period, and a gradual decrease in activity took place during the first half of the scotophase.

About two-thirds (66.5%) of the mean daily activity occurred in the scotophase. A t-test on the paired observations of total nocturnal and diurnal movements each day indicates that the *Chelydra* tested were significantly more active at night ($P<0.025$, $t = 2.185$, d.f. = 23).

During the scotophase 81% of the activity occurred from 2400-0800 h and the remaining 19% occurred from 1600-2400 h. A t-test on the paired observations of total movements during the midnight-dawn (2400-0800 h) and sunset-midnight (1600-2400 h) portions of the scotophase shows that young *Chelydra* are significantly more active (P<0.005, t = 3.008, d.f. = 23) from midnight to dawn than from sunset to midnight. Over half (54%) of the total activity each day took place in the second half of the scotophase.

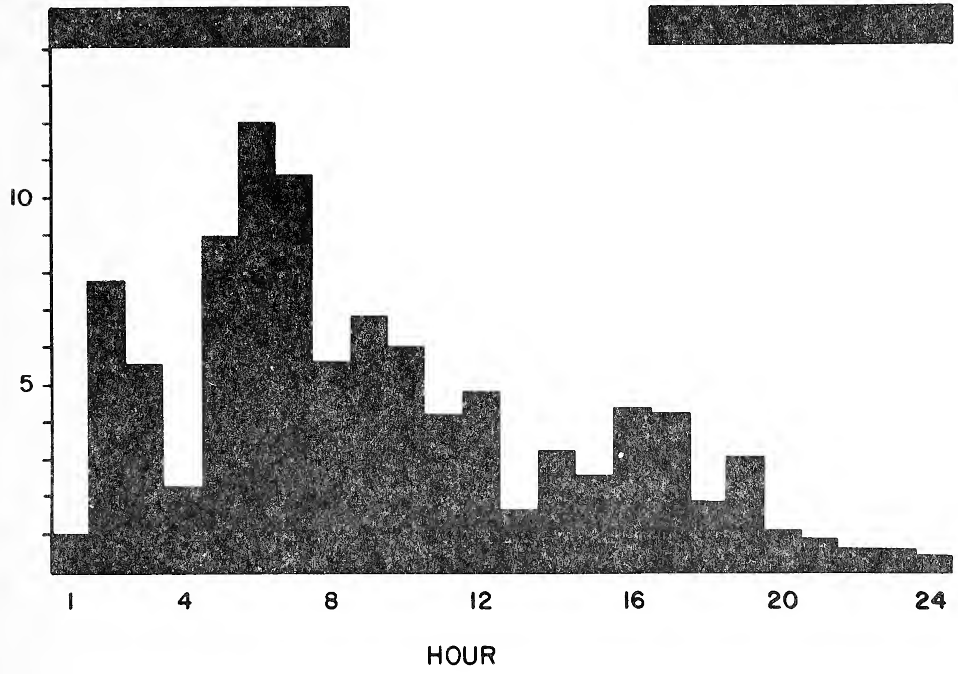

Fig. 1. The activity of five juvenile *Chelydra serpentina* (total days = 24) expressed as mean per cent of daily activity each hour. The shaded bar at the top indicates the position of the scotophase.

The locomotor pattern of these turtles is similar to those of *Chrysemys picta, Clemmys guttata,* and *Sternotherus odoratus* at 25 °C, LD 8:16 (Graham, 1972) in having a scotophase minimum around midnight and a photophase minimum around noon. The midday inactivity may be an adaptive avoidance of high temperature which prevails around solar noon in the summer. Individual *Chelydra* showed variation in their responses to the onset of the photophase but the activity appears to be less entrained by light onset than it is in other species (Graham, 1972). This may be related to the highly aquatic and non-heliothermic (avoidance of exposed basking) lifestyle of young snappers.

In conclusion, juvenile *Chelydra* kept at 25 °C, LD 8:16 are significantly more nocturnal than diurnal, but a third of their activity occurs during the light period. Movement is reduced around midnight and noon and they concentrate more than half of their diel (24-h day) activity during the midnight-dawn portion of the scotophase.

Literature Cited

Ernst, C. H., and R. W. Barbour.
1972. Turtles of the United States. *The University Press of Kentucky, Lexington.*

Graham, T. E.
1972. Temperature-photoperiod effects on diel locomotor activity and thermal selection in the turtles, *Chrysemys picta* (Schneider), *Clemmys guttata* (Schneider), and *Sternotherus odoratus* (Latreille). *Ph.D. Dissertation, University of Rhode Island, Kingston.*

__________ and R. Perkins.
1976. Growth of the common snapping turtle, *Chelydra s. serpentina,* in a polluted marsh. *Bull. Md. Herp. Soc., 12*(4):123-125.

__________ and V. H. Hutchison.
1977. A device for simulating twilight in studies of animal activity. *Behav. Res. Meth. & Instru. 9*:395-396.

____________________.
1978. Locomotor activity in *Chrysemys picta*: response to asynchronous cycles of temperature and photoperiod. *Copeia 1978*:364-367.

Walls, G. L.
1934. The reptilian retina: I. A new concept of visual cell evolution. *Amer. J. Opthamol. 17*:892-915.

—Terry E. Graham, *Department of Biology, Worcester State College, Worcester, MA 01602.*

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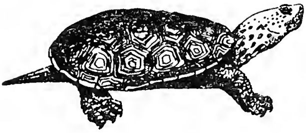

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MARCH 1979 VOLUME 15, NUMBER 1

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CONTENTS

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BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

VOLUME 15 31 MARCH 1979 NUMBER 1

SYNOPSIS OF PROTOZOANS PARASITIC IN NATIVE TURTLES OF THE UNITED STATES

Carl H. Ernst and Evelyn M. Ernst

ABSTRACT

Information concerning parasitic protozoans found in native turtles of the United States, including synonyms, anatomical habitat in host, host species, and distribution is summarized. Pertinent literature and comments are also given for some protozoans. A separate host catalogue of parasitic protozoans reported from each turtle species is given along with locality records.

INTRODUCTION

Several papers have been written on protozoans associated with North American turtles. While trying to identify and compile data on parasitic protozoans, it became apparent that the literature was scattered and that no synopsis has been published as to host records or geographical distribution of protozoan infections in our native turtles. The list presented by Ernst and Barbour (1972) is the best, but is incomplete and not up to date.

This paper summarizes published information on the hosts and geographical distribution of endoparasitic protozoans of native turtles of the United States. Canadian records are also listed since theoretically these turtle populations are continuous with those of the United States. The paper is divided into two sections; a synopsis of the protozoans and a list of protozoans by turtle host. In the synopsis, the protozoans are arranged by classes following the arrangement of Honigberg, *et al.* (1964). For each protozoan species we present its synonomy, anatomical habitat in the host, list of turtles parasitized, and geographical distribution. Often a list of pertinent literature is given which contains good descriptions, life cycles, systematics, etc. Occasionally included is a comment section where pertinent problems related to the host-parasite relationship, nomenclature, etc. are discussed. The host list includes all of the parasitic protozoans reported from a turtle with the pertinent geographical records. Cited references are indicated in the text by number only and are listed numerically in the literature cited section. Turtle nomenclature is taken from Ernst and Barbour (1972).

In addition to those parasitic, several other protozoans have been reported from turtles. Das Gupta (1935) found *Hexamita* sp., *Trepomonas* sp., and *Trichomonas* sp. in the intestines and caecum of *Chelydra serpentina, Kinosternon subrubrum,* and *Terrapene carolina*; and Gutierrez-Ballesteros and Wenrich (1950) reported *Octomastix parvus* and *Trimitus* sp. from the intestines of *Chrysemys concinna*. All of these are probably commensals. Commensal protozoans are also known to attach to the shells of turtles and Goodrich and Jahn (1943) listed the epizoic suctorians *Acineta limnetis, Anarma brevis, A. multiruga, Multifasciculatum elegans, Podophyra okobojienis, Squalorophyra macrostyla,* and *Tokophyra quadripartita* from *Chrysemys picta bellii*.

We wish to thank Mr. Jack A. Marquardt and the library staff of the National Museum of Natural History, Smithsonian Institution for their help in obtaining many of the older and foreign references.

PROTOZOAN CATALOGUE

PROTOZOA

Subphylum SARCOMASTIGOPHORA

Superclass MASTIGOPHORA

Class ZOOMASTIGOPHORA

Trypanosoma chrysemydis Roudabush and Coatney, 1937 ---
Habitat: blood; Hosts: *Chelydra serpentina* (experimental) 33, 58, 70; *Chrysemys picta* (experimental) 33, 58, 69, 70; *Graptemys geographica* (experimental) 70; *Trionyx ferox* (experimental) 33; *T. muticus* (experimental) 33; Distribution: Iowa 58; Nebr. 58; Ontario, Canada 69, 70; Pertinent Literature: 33, 70.

Trypanosoma testudinis Hunt, 1957 ---
Habitat: blood; Hosts: *Chelonia mydas* 32; Comment: This name represents either a *nomen nudum* or a misapplication of the trivial name *testudinis*.

Superclass SARCODINA

Class RHIZOPODEA

Endolimax clevelandi Gutierrez-Ballesteros and Wenrich, 1950 ---
Habitat: intestines; Hosts: *Chrysemys concinna* 27; *C. picta* (?) 60; "unidentified terrapin" (?) 27; Distribution: not given.

Entamoeba barreti (Taliaferro and Holmes, 1924) ---
Synonym: *Endamoeba barreti* Taliaferro and Holmes, 1924; Habitat: intestines; Hosts: *Chelydra serpentina* 3, 63; Distribution: Not given, but possibly either Maryland or North Carolina; Pertinent Literature: 3, 24, 47, 54, 62; Comment: Probably commensal rather than parasitic.

Entamoeba invadens Rodhain, 1934 ---
Habitat: Liver and intestinal tract; Hosts: *Caretta caretta* (accidental fatal infection at Zoologischer Garten Saarbrücken, Germany) 20; *Chelonia mydas* (accidental fatal infection at Zoologischer Garten Saarbrücken, Germany) 20; *Chelydra serpentina* (experimental) 23; *Chrysemys picta* (experimental) 23, 45; *C. scripta* (experimental) 23, 62; Distribution: Quebec, Canada 45; Pertinent Literature: 4, 20, 24, 47, 54, 62, 71.

Entamoeba terrapinae Sanders and Cleveland, 1930 ---
Synonym: *Endamoeba terrapinae*; Habitat: intestines; Hosts: *Chrysemys scripta* 60; *C. picta* 60; Distribution: unknown; Pertinent Literature: 47, 54, 62.

Entamoeba testudinis Hartman, 1910 ---
Synonym: *Endamoeba testudinis* Taliaferro and Holmes, 1924; Habitat: intestine; Hosts: *Chrysemys picta* 60; *Terrapene carolina* 37; Distribution: unknown; Pertinent Literature: 60, 62.

Entamoeba sp. ---
Habitat: intestines; Hosts: *Chelydra serpentina* 7; *Chrysemys concinna* 27; *C. picta* 60; *Kinosternon subrubrum* 7; *Terrapene carolina* 7; Distribution: not given.

Subphylum SPOROZOA

Class TELOSPOREA

Eimeria amydae Roudabush, 1937 ---
Habitat: intestines; Hosts: *Trionyx spiniferus* 57; Distribution: Iowa 57.

Eimeria carri Ernst and Forrester, 1973 ---
Habitat: intestines; Hosts: *Terrapene carolina* 17; Distribution: Ala. 17; Fla. 17; Pertinent Literature: 65.

Eimeria chelydrae Ernst, Stewart, Sampson and Fincher, 1969 ---
Habitat: intestines; Hosts: *Chelydra serpentina* 18; Distribution: Ga. 18.

Eimeria chrysemydis Deeds and Jahn, 1939 ---
Habitat: intestines; Hosts: *Chrysemys picta* 8, 65; Distribution: Iowa 8, 65; Pertinent Literature: 59, 65.

Eimeria delagei (Labbé, 1893) ---
Synonym: *Coccidium delagei* Labbé, 1893; Habitat: intestines; Hosts: *Chrysemys picta* 8, 65; *Graptemys geographica* 65; *G. pseudogeographica* 65; Distribution: Iowa 8, 65; Pertinent Literature: 8, 65; Comment: Deeds and Jahn (1939) described a variety of *E. delagei* (*Eimeria delagei* var. *marginata*) from an Iowa western painted turtle, *Chrysemys picta bellii*.

Eimeria dericksoni Roudabush, 1937 ---
Habitat: intestines; Hosts: *Trionyx spiniferus* 57, 66; Distribution: Iowa 57, 66; Pertinent Literature: 18, 65, 66.

Eimeria graptemydos Wacha and Christiansen, 1976 ---
Habitat: intestines; Hosts: *Chrysemys picta* 65; *Graptemys geographica* 65; *G. pseudogeographica* 65; Distribution: Iowa 65.

Eimeria juniataensis Pluto and Rothenbacher, 1976 ---
Habitat: intestines;Hosts: *Graptemys geographica* 53;Distribution: Pa. 53.

Eimeria lutotestudinus Wacha and Christiansen, 1976 ---
Habitat: intestines; Hosts: *Kinosternon flavescens* 65; Distribution: Iowa 65.

Eimeria mascoutini Wacha and Christiansen, 1976 ---
Habitat: intestines; Hosts: *Trionyx spiniferus* 65, 66; Distribution: Iowa 65, 66.

Eimeria megalostiedai Wacha and Christiansen, 1974 ---
Habitat: intestines; Hosts: *Clemmys insculpta* 64; Distribution: Iowa 64.

Eimeria mitrarium (LaVeran and Mesnil, 1902) ---
Synonym: *Coccidium mitrarium* LaVeran and Mesnil, 1902; Habitat: intestines; Hosts: *Chrysemys picta* 8, 65; *Graptemys geographica* 65; *G. pseudogeographica* 65; *Kinosternon flavescens* 65; Distribution: Iowa 8, 65.

Eimeria paynei Ernst, Fincher and Stewart, 1971 ---
Habitat: intestines; Hosts: *Gopherus polyphemus* 16; Distribution: Ga. 16.

Eimeria pseudemydis Lainson, 1968 ---
Habitat: intestines; Hosts: *Chrysemys scripta* 39; Distribution: Belise 39.

Eimeria pseudogeographica Wacha and Christiansen, 1976 ---
Habitat: intestines; Hosts: *Chrysemys picta* 65; *Graptemys pseudogeographica* 65; Distribution: Iowa 65.

Eimeria scriptae Sampson and Ernst, 1969 ---
Habitat: intestines; Hosts: *Chrysemys scripta* 59; Distribution: Mississippi River drainage (?) 59.

Eimeria tetradacrutata Wacha and Christiansen, 1976 ---
Habitat: bileducts; Hosts: *Chrysemys picta* 65; Distribution: Iowa 65.

Eimeria vesicostieda Wacha and Christiansen, 1977 ---
Habitat: intestines; Hosts: *Trionyx spiniferus* 66; Distribution: Iowa 66.

Eimeria sp. ---
Habitat: intestines; Hosts: *Graptemys barbouri* (?) (captive) 65; *G. geographica* 65; Distribution: Iowa 65.

Haemogregarina balli Paterson and Desser, 1976 ---
Habitat: blood; Hosts: *Chelydra serpentina* 12, 48; Distribution: Ontario, Canada 12, 48; Pertinent Literature: 12.

Haemogregarina pseudemydis Acholonu, 1974 ---
Habitat: blood; Hosts: *Chelydra serpentina* 2; *Chrysemys floridana* 2; *C. scripta* 2; *Graptemys kohni* 2; *Kinosternon subrubrum* 2; *Terrapene carolina* 2; *Trionyx spiniferus* 2; Distribution: La. 2; Pertinent Literature: 48.

Haemogregarina stepanowi Danilewsky, 1885 ---
Synonym: *Haemogregarina (cistudinis) stepanowi* Danilewsky, 1885; Habitat: blood; Hosts: *Chelydra serpentina* 1, 13, 28, 42, 58; *Chrysemys concinna* 13, 42; *C. picta* 13, 50, 51, 52, 58; *C. scripta* 1, 42; *Emydoidea blandingii* 58; *Kinosternon subrubrum* 1, 13; *Sternotherus minor* 13; *S. odoratus* 42; *Trionyx spiniferus* 13; *Terrapene carolina* 1; Distribution: Ill. 42; La. 1, Tenn. 13; Pertinent Literature: 2, 28, 43, 48, 55.

Haemogregarina sp. ---
Habitat: blood; Hosts: *Chelydra serpentina* 44, 67; *Chrysemys concinna* 67; *C. picta* 44; *C. scripta* 67; *Emydoidea blandingii* 44; *Kinosternon subrubrum* 67; *Sternotherus carinatus* 67; *Trionyx muticus* 67; *T. spiniferus* 67; Distribution: Nebr. 44, Tex. 67; Pertinent Literature: 44.

Haemoproteus metchnikovi (Simond, 1901) Wenyon, 1926 ---
Synonym: *Haemamoeba metchnikovi* Simond, 1901; *Simondia metchnikovi* Garnham, 1966; Habitat: blood; Hosts: *Chelydra serpentina* 67; *Chrysemys picta* 9, 10, 11, 50; *C. scripta* 10, 30, 42, 67; *Graptemys geographica* 10; *Trionyx spiniferus* 67; Distribution: Ill. 42; La. 10; Md. (Baltimore Seafood Market) 30; Mich. 10, 11; Tex. 67; Wis. 10; Pertinent Literature: 9, 11, 19, 22, 30, 41.

Mantonella hammondi Wacha and Christiansen, 1976 ---
Habitat: uncertain, as intestinal and gallbladder contents combined; Hosts: *Chrysemys picta* 65; *Graptemys geographica* 65; *G. pseudogeographica* 65; *Kinosternon flavescens* 65; *Trionyx spiniferus* 65; Distribution: Iowa 65; Comment: Possibly a crayfish parasite ingested with its host by *Kinosternon flavescens*.

Subphylum CNIDOSPORA

Class MYXOSPORIDEA

Myxidium americanum Kudo, 1919 ---
Habitat: urinary tubules of kidney; Hosts: *Trionyx spiniferus* 36; Distribution: Ill. 36; Pertinent Literature: 35, 46.

Myxidium chelonarum Johnson, 1969a ---
Habitat: gall bladder and bile duct; Hosts: *Chelydra serpentina* 35; *Chrysemys concinna* 35; *C. floridana* 35; *C. nelsoni* 35; *C. picta* 35; *C. scripta* 35; *Deirochelys reticularia* 35; *Graptemys pseudogeographica* 35; *G. pulchra* 35; *Kinosternon sonoriense* 35; *Sternotherus odoratus* 35; Distribution: Ala. 35; Fla. 35; N.C. 35; S. C. 35; Jalisco, Mexico 35.

Subphylum CILIOPHORA

Class CILIATEA

Nyctotherus sp. ---
Habitat: intestines, stomach (?); Hosts: *Gopherus polyphemus* 15; Distribution: Fla. 15; Pertinent Literature: 5, 15, 25.

TAXONOMIC POSITION QUESTIONABLE

Pirhemocyton chelonarum Acholonu, 1974 ---
Habitat: blood; Hosts: *Chelydra serpentina* 2; *Chrysemys floridana* 2; *C. scripta* 2; *Terrapene carolina* 2; Distribution: La. 2.

HOST CATALOGUE

CHELYDRIDAE: Snapping Turtles

Chelydra serpentina (Linnaeus, 1758)

Eimeria chelydrae --- Ga. 18; *Entamoeba barreti* --- 3, 63; *E. invadens* --- (experimental) 23; *Entamoeba* sp. --- 7; *Haemogregarina balli* --- Ontario, Canada 48; *H. pseudemydis* --- La. 2; *H. stepanowi* --- 58; Ill. 42; La. 1; Tenn. 13; *Haemogregarina* sp. --- Nebr. 44; Tex. 67; *Haemoproteus metchnikovi* --- Tex. 67; *Hexamita* sp. (?) --- 7; *Myxidium chelonarum* --- N. C. 35; *Pirhemocyton chelonarum* --- La. 2; *Trepomonas* sp. (?) --- 7; *Trichomas* sp. (?) --- 7; *Trypanosoma chrysemydis* --- Iowa 58; Nebr. 58; (experimental) 33, 70.

KINOSTERNIDAE: Musk and Mud Turtles

Kinosternon flavescens (Agassiz, 1857)

Eimeria ludotestudinus --- Iowa 65; *E. mitrarium* --- Iowa 65; *Mantonella hammondi* --- Iowa 65.

Kinosternon sonoriense (Le Conte, 1853)

Myxidium chelonarum --- Jalisco, Mexico 35.

Kinosternon subrubrum (Lacépède, 1788)

Entamoeba sp. --- 7; *Haemogregarina pseudemydis* --- La. 2; *H. stepanowi* --- La. 1; Tenn. 13 (?); *Haemogregarina* sp. --- Tex. 67; *Hexamita* sp. (?) --- 7; *Trepomonas* sp. (?) --- 7; *Trichomonas* sp. (?) 7.

Sternotherus carinatus (Gray, 1856)

Haemogregarina sp. --- Tex. 67.

Sternotherus minor (Agassiz, 1857)

Haemogregarina stepanowi --- Tenn. 13.

Sternotherus ororatus (Latreille, 1801)

Haemogregarina stepanowi --- Ill. 42; *Myxidium chelonarum* --- Ala. 35; N. C. 35.

EMYDIDAE: Semiaquatic Pond and Marsh Turtles

Chrysemys concinna (LeConte, 1830)

Endolimax clevelandi --- 27; *Entamoeba* sp. --- 27; *Haemogregarina stepanowi* --- Ill. 42; Tenn. 13; *Haemogregarina* sp. --- Tex. 67; *Haemoproteus metchnikovi* --- Ill. 42; *Myxidium chelonarum* --- Ala. 35; *Octomastix parvus* (?) --- 27; *Trimitus* sp. (?) --- 27.

Chrysemys floridana (LeConte, 1830)

Haemogregarina pseudemydis --- La. 2; *Myxidium chelonarum* --- N. C. 35; *Pirhemocyton chelonarum* --- La. 2.

Chrysemys nelsoni (Carr, 1938)

Myxidium chelonarum --- Fla. 35.

Chrysemys picta (Schneider, 1783)

Eimeria chrysemydis --- Iowa 8, 65; *E. delagei* --- Iowa 8, 65; *E. graptemydos* --- Iowa 65; *E. mitrarium* --- Iowa 8, 65; *E. pseudogeographica* --- Iowa 65; *E. tetradacrutata* --- Iowa 65; *Endolimax clevelandi* --- 27, 60; *Entamoeba invadens* --- Quebec, Canada 45; (experimental) 23; *E. terrapinae* --- 68; *E. testudines* --- 60; *Entamoeba* sp. --- 60; *Haemogregarina stepanowi* --- 58; Tenn. 13; *Haemogregarina* sp. --- Nebr. 44; *Haemoproteus metchnikovi* --- Mich. 10, 11; Wisc. 10; *Mantonella hammondi* --- Iowa 65; *Myxidium chelonarum* --- N. C. 35; *Trypanosoma chrysemydis* --- Iowa 58; Ontario, Canada 69; (experimental) 33.

Chrysemys scripta (Schoepff, 1792)

Eimeria pseudemydis --- Belise 39; *E. scriptae* --- Mississippi River (?) 59; *Entamoeba invadens* --- (experimental) 23; *E. terrapinae* --- 60; *Haemogregarina pseudemydis* --- La. 2; *H. stepanowi* --- Ill. 42; La. 1; Tenn. 13; *Haemogregarina* sp. --- Tex. 67; *Haemoproteus metchinkovi* --- Ill. 42; La. 10; Md. (Baltimore Seafood Market) 30; Tex. 67; *Myxidium chelonarum* --- Ala. 35; N. C. 35; S. C. 35; *Pirhemocyton chelonarum* --- La. 2

Clemmys insculpta (LeConte, 1830)

Eimeria megalostiedai --- Iowa 64.

Deirochelys reticularia (Latreille, 1802)

Myxidium chelonarum --- Fla. 35.

Emydoidea blandingii (Holbrook, 1838)

Haemogregarina stepanowi --- 58; *Haemogregarina* sp. --- Nebr. 44.

Graptemys barbouri Carr and Marchand, 1942

Eimeria --- (?) 65.

Graptemys geographica (LeSueur, 1817)

Eimeria delagei --- Iowa 65; *E. graptemydos* --- Iowa 65; *E. juniataensis* --- Pa. 53; *E. mitrarium* --- Iowa 65; *Eimeria* sp. --- Iowa 65; *Haemoproteus metchnikovi* --- Wisc. 10; *Mantonella hammondi* --- Iowa 65; *Trypanosoma chrysemydis* --- Ontario, Canada 70.

Graptemys kohnii (Baur, 1890)

Haemogregarina pseudemydis --- La. 2.

Graptemys pseudogeographica (Gray, 1831)

Eimeria delagei --- Iowa 65; *E. graptemydos* --- Iowa 65; *E. mitrarium* --- Iowa 65; *E. pseudogeographica* --- Iowa 65; *Mantonella hammondi* --- Iowa 65; *Myxidium chelonarum* --- 35.

Graptemys pulchra Baur, 1893

Myxidium chelonarum --- Ala. 35.

Terrapene carolina (Linnaeus, 1758)

Eimeria carri --- Ala. 17; Fla. 17; *Entamoeba testudinis* --- 37; *Entamoeba* sp. --- 7; *Haemogregarina pseudemydis* --- La. 2; *H. stepanowi* --- La. 1; *Hexamita* sp. (?) --- 7; *Pirhemocyton chelonarum* --- La. 2; *Trepomonas* sp. (?) --- 7; *Trichomonas* sp. (?) --- 7.

TESTUDINIDAE: Tortoises

Gopherus polyphemus (Daudin, 1803)

Eimeria paynei --- Ga. 16; *Nyctotherus* sp. --- Fla. 15.

CHELONIIDAE: Marine Turtles

Caretta caretta (Linnaeus, 1758)

Entamoeba invadens --- accidental fatal infection at Zoologischer Garten, Saarbrücken, Germany 20.

Chelonia mydas (Linnaeus, 1758)

Entamoeba invadens --- accidental fatal infection at Zoologischer Garten, Saarbrücken, Germany 20; *Trypanosoma testudinis* (?) --- 32.

TRIONYCHIDAE: Soft-shelled turtles

Trionyx ferox (Schneider, 1783)

Trypanosoma chrysemydis --- (experimental) 33.

Trionyx muticus LeSueur, 1827

Haemogregarina sp. --- Tex. 67; *Trypanosoma chrysemydis* --- (experimental) 33.

Trionyx spiniferus LeSueur, 1827

Eimeria amydae --- Iowa 57; *E. dericksoni* --- Iowa 57, 66; *E. mascoutini* --- Iowa 65, 66; *E. vesicostieda* --- Iowa 66: *Haemogregarina pseudemydis* --- La. 2; *H. stepanowi* --- Tenn. 13; *Haemogregarina* sp. --- Tex. 67; *Haemoproteus metchnikovi* --- Tex. 67; *Mantonella hammondi* --- Iowa 65; *Myxidium americanum* --- Ill. 36.

Literature Cited

1. Acholonu, A. D.
1966. Occurrence of *Haemogregarina* (Protozoa) in Louisiana turtles. *J. Protozool. 13*(suppl.):20.

2. ______________
1974. *Haemogregarina pseudemydis* n. sp. (Apicomplexa: Haemogregarinidae) and *Pirhemocyton chelonarum* n. sp. in turtles from Louisiana. *J. Protozool. 21*(5):659-664.

3. Barret, H. P. and N. M. Smith.
1924. The cultivation of an *Entamoeba* from the turtle, *Chelydra serpentina*. *Am. J. Hyg. 4*:155-159.

4. Bénex, J.
1972. Structure antigénique et taxonomie des amibes du genre *Entamoeba*. *Compt. Rend. Acad. Sci., Paris 275*:675-677.

5. Corliss, J. O.
1961. The ciliated protozoa: characterization, classification, and guide to the literature. *Pergamon Press, London.* 310 p.

6. Danilewsky, B.
1885. Die Hämatozoon der Kaltblüter. *Arch. Mikrosk. Anat. 24:* 588-598.

7. Das Gupta, B. M.
1935. The occurrence of a *Trepomonas* sp. in the caecum of turtles. *J. Parasitol. 21*:125-126.

8. Deeds, O. J. and T. L. Jahn.
1939. Coccidian infections of western painted turtles of the Okoboji region. *Trans. Am. Microsc. Soc. 58*:249-253.

9. DeGuisti, D. L.
1970. Additional studies on the life cycle of *Haemoproteus metchnikovi* from the turtle, *Chrysemys picta marginata. J. Parasitol 56*(suppl.):70-71.

10. ______________ and P. J. Batten.
1951. Notes on *Haemoproteus metchnikovi* in turtles from Wisconsin, Michigan, and Louisiana. *J. Parasitol. 37*(suppl.): 12.

11. ______________, C. R. Sterling and D. Dobrzechowski.
1973. Transmission of the chelonian haemoproteid *Haemoproteus metchnikovi* by a tabanid fly *Chrysops callidus. Nature 242*(5392):50-51.

12. Desser, S. S.
1973. A description of intraerythrocytic schizonts and gametocytes of a haemogregarine of the snapping turtle *Chelydra serpentina. Canadian J. Zool. 51*(4):431-432.

13. Edney, J. M.
1949. *Haemogregarina stepanowi* Danilewsky (1885) in middle Tennessee turtles. *J. Tennessee Acad. Sci. 24*:220-222.

14. Ernst, C. H. and R. W. Barbour.
1972. Turtles of the United States. *Univ. Press Kentucky, Lexington, Kentucky.* 347 p.

15. ____________ and J. N. Nichols.
1974. Intestinal ciliates of tortoises. *British J. Herpetol. 5*:450-451.

16. Ernst, J. V., G. T. Fincher and T. B. Stewart.
1971. *Eimeria paynei* sp. n. (Protozoa: Eimeriidae) from the gopher tortoise, *Gopherus polyphemus. Proc. Helminthol. Soc. Washington 38*:223-224.

17. ____________ and D. J. Forrester.
1973. *Eimeria carri* sp. n. (Protozoa: Eimeriidae) from the box turtle, *Terrapene carolina. J. Parasitol. 59*:635-636.

18. ____________, T. B. Stewart, J. R. Sampson and G. T. Fincher.
1969. *Eimeria chelydrae* n. sp. (Protozoa: Eimeriidae) from the snapping turtle, *Chelydra serpentina*. *Bull. Wildlife Dis. Assoc. 5*:410-411.

19. Fallis, A. M.
1965. Protozoan life cycles. *Am. Zool. 5*:85-94.

20. Frank, W., W. Sachsee and K. H. Winkelstrater.
1976. Aussergewöhnliche Todesfälle durch Amöbians bie einer Brückensechse (*Sphenodon punctatus*), bie jungen Suppenschildkröten (*Chelonia mydas*) und bie einer Unechten Karettschildkröte (*Caretta caretta*). II. Amöbiasis bei *Chelonia mydas* und *Caretta caretta*. *Salamandra 12*:120-126.

21. Garnham, P. C. C.
1966. Malaria parasites and other Haemosporidia. *Blackwell Press, Oxford, England.*

22. ________________, R. G. Bird, and D. L. DeGuisti.
1967. Electron microscopy of *Haemoproteus metchnikovi* of turtles. *Trans. Royal Soc. Trop. Med. Hyg. 61*:11.

23. Geiman, Q. M.
1937. Cross-infection experiments with three species of amoebae from reptiles. *J. Parasitol. 23*:557.

24. ____________ and H. L. Ratcliffe.
1936. Morphology and life-cycle of an amoeba producing amoebiasis in reptiles. *Parasitology 28*:208-228.

25. ____________ and R. Wichterman.
1937. Intestinal protozoa from Galapagos tortoises (with descriptions of three new species). *J. Parasitol. 23*:331-347.

26. Goodrich, J. P. and T. L. Jahn.
1943. Epizoic Suctoria (Protozoa) from turtles. *Trans. Am. Microsc. Soc. 62*:245-253.

27. Gutierrez-Ballesteros, E., and D. H. Wenrich.
1950. *Endolimax clevelandi*, n. sp., from turtles. *J. Parasitol. 36*:489-493.

28. Hahn, C. W.
1909. The stages of *Haemogregarina stepanowi* Danilewsky found in the blood of turtles, with special reference to changes in the nucleus. *Arch. Protistenk. 17*:307-376.

29. Hartman, M.
1910. Über eine neue Darmamöbe, *Entamoeba testudinis* n. sp. *Mem. Inst. Oswaldo Cruz 2*:3-10.

30. Hewitt, R. L.
1940. *Haemoproteus metchnikovi* (Simond, 1901) from the yellow-bellied terrapin (*Pseudemys elegans*). *J. Parasitol. 26:* 273-278.

31. Honigberg, B. M., W.Balamuth, E.C. Bovee, J.O. Corliss, M. Gojdics, R.P. Hall, R.R. Kudo, N. D. Levine, A. R. Loeblich, Jr., J. Weiser, and D. H. Wenrich.
1964. A revised classification of the phylum Protoza. *J. Protozool. 11*:7-20.

32. Hunt, T. T.
1957. Notes on diseases and mortality in Testudines. *Herpetologica 13*:19-23.

33. Jefferson, N. H.
1966. The biology of *Trypanosoma chrysemydis* Roudabush and Coatney. *Diss. Abstr. 26*(10):6248.

34. Johnson, C. A.
1969a. *Myxidium chelonarum* n. sp. (Cnidospora: Myxidiidae) from various North American turtles. *Assoc. S. E. Biol. Bull. 16*:56.

35. ____________
1969b. A redescription of *Myxidium chelonarum* Johnson, 1969, (Cnidospora: Myxidiidae) from various North American turtles. *J. Protozool. 16*:700-702.

36. Kudo, R. R.
1919. Studies on Myxosporidia. A synopsis of genera and species. *Illinois Biol. Monogr. 5*:1-265.

37. __________
1950. Protozoology. 3rd. ed. *Charles C. Thomas Publ., Springfield, Illinois.* 778 p.

38. Labbe, A.
1893. *Coccidium delagei*, coccidie nouvelle parasite des tortues d'eu douce. *Arch. Zool. Exper. Gen. 1*:267-280.

39. Lainson, R.
1968. Parasitological studies in British Honduras. IV. Some coccidial parasites of reptiles. *Ann. Trop. Med. Parasitol. 62*:260-266.

40. LaVern, A. and F. Mesnil.
1902. Sur quelques Protozoaires parasites d'une Tortue d'Asie (*Samonia reevesii*). *Compt. Rend. Acad. Sci., Paris 135:* 608-614.

41. Levine, N. D. and G. R. Campbell.
1971. A check-list of the species of the genus *Haemoproteus* (Apicomplexa, Plasmodidiidae). *J. Protozool. 18*:475-484.

42. Marquardt, W. C.
1966. Haemogragarines and *Haemoproteus* in some reptiles in southern Illinois. *J. Parasitol. 52*:823-824.

43. Marzinowsky, E.
1927. Du développement de l'*Haemogregarina stepanovi*. *Ann. Parasitol. Hum. Comp. 5*:140-142.

44. McAuliffe, J. R.
1977. An hypothesis explaining variations of hemogregarine parasitemia in different aquatic turtle species. *J. Parasitol. 63*:580-581.

45. Meerovitch, E.
1958. A new host of *Entamoeba invadens* Rodhain, 1934. *Canadian J. Zool. 36*:423-427.

46. Mitchell, L. D.
1967. *Myxidium macrocheili* n. sp. (Cnidospora: Myxidiidae) from the largescale sucker *Catostomus macrocheilus* Girard, and a synopsis of the *Myxidium* of North American freshwater vertebrates. *J. Protozool. 14*:415-424.

47. Neal, R. A.
1966. Experimental studies on *Entamoeba* with reference to speciation. pp. 1-51. *In* Dawes, B. (ed.). Advances in Parasitology. Vol. 4. *Academic Press, New York.*

48. Paterson, W. B. and S. S. Desser.
1976. Observations on *Haemogregarina balli* sp. n. from the common snapping turtle, *Chelydra serpentina. J. Protozool. 23*:294-301.

49. Pellerdy, L. P.
1965. Coccidia and Coccidiosis. *Akadémiai. Kiadó, Budapest,* 657 p.

50. Plimmer, H. G.
1912. On the blood-parasites found in animals in the Zoological Gardens during the four years 1908-1911. *Proc. Zool. Soc. London 1912*:406-419.

51. ____________
1913. Report on the deaths which occurred in the Zoological Gardens during 1912 together with the blood parasites found during the year. *Proc. Zool. Soc. London 1913:*141-149.

52. ____________
1916. Report on the deaths which occurred in the Zoological Gardens during 1915 together with a list of the blood parasites found during the year. *Proc. Zool. Soc. London 1916*:77-86.

53. Pluto, T. G. and H. Rothenbacher.
1976. *Eimeria juniataensis* sp. n. (Protozoa: Eimeriidae) from the map turtle, *Graptemys geographica*, in Pennsylvania. *J. Parasitol. 62*:207-208.

54. Reeves, R. E. and J. M. Bishchoff.
1968. Classification of *Entamoeba* species by means of electrophoretic properties of amebal enzymes. *J. Parasitol. 54*:594-600.

55. Reichenow, E.
1910. *Haemogregarina stepanowi.* Die Entwicklungsgeschichte einer Hämogregarine. *Arch. Protistenk 20*:251-350.

56. Rodhain, J.
1934. *Entamoeba invadens* n. sp. Parasite de serpents. *Compt. Rend. Acad. Sci., Paris 117*:1195-1199.

57. Roudabush, R. L.
1937. Some coccidia of reptiles found in North America. *J. Parasitol. 23*:354-359.

58. ______________ and G. R. Coatney.
1937. On some blood protozoa of reptiles and amphibians. *Trans. Am. Microsc. Soc., 56*:291-297.

59. Sampson, J. R. and J. V. Ernst.
1969. *Eimeria scriptae* n. sp. (Sporozoa: Eimeriidae) from the red-eared turtle *Pseudemys scripta elegans*. *J. Protozool. 16*:444-445.

60. Sanders, E. P. and L. R. Cleveland.
1930. The morphology and life-cycle of *Entamoeba terrapinae* sp. n., from the terrapin, *Chrysemys elegans*. *Arch. Protist. 70*:267-272.

61. Simond, P. L.
1901. Contribution à l'étude des hématozoaires endoglobulaires des reptiles. *Ann. Inst. Pasteur, Paris 15*:319-351.

62. Steck, F.
1963. Die Amoebendysenterie der Reptilien. Aetiologie, Epidemiologie, Diagnostik und Bekampfung. *Acta Tropica 20*:115-142.

63. Taliaferro, W. H. and F. O. Holmes.
1924. *Endamoeba barreti* n. sp. from the turtle, *Chelydra serpentina*; a description of the amoeba from the vertebrate host and from Barret and Smith's cultures. *Am. J. Hyg. 4*:160-168.

64. Wacha, R. S. and J. L. Christiansen.
1974. *Eimeria megalostiedai* sp. n. (Protozoa: Sporozoa) from the wood turtle, *Clemmys insculpta*, in Iowa. *Proc. Helminthol. Soc. Washington 41*:35-37.

65. ______________________________
1976. Coccidian parasites from Iowa turtles: systematics and prevalence. *J. Protozool. 23*:57-63.

66. ______________________________
1977. Additional notes on the coccidian parasites of the soft-shelled turtle, *Trionyx spiniferus* LeSueur, in Iowa, with a description of *Eimeria vesicostieda* sp. n. *J. Protozool. 24*:357-359.

67. Wang, C. C. and S. H. Hopkins.
1965. *Haemogregarina* and *Haemoproteus* (Protozoa, Sporozoa) in blood of Texas freshwater turtles. *J. Parasitol. 51*:682-683.

68. Wenyon, C. M.
1926. Protozoology, a manual for medical men, veterinarians and zoologists. 2 vols. *Wm. Wood and Co., New York* 1,563 p.

69. Woo, P. T. K.
1967. Studies on a trypanomsome in the painted turtle (*Chrysemys picta marginata* Agassiz) in southern Ontario, Canada. *J. Protozool. 14*(suppl.):16.

70. ____________
1969. Trypanosomes in amphibians and reptiles in southern Ontario. *Canadian J. Zool. 47*:981-988.

71. Zaman, V.
1972. Structure and movement of *Entamoeba*. *Ann. Trop. Med. Parasitol. 66*:329-333.

Department of Biology, George Mason University, Fairfax, Virginia 22030

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ARE LEATHERBACK TURTLES, *DERMOCHELYS CORIACEA*, COMMON ALONG THE MIDDLE ATLANTIC COAST?

Carl H. Ernst and Martin J. Gilroy

ABSTRACT

Evidence from sighting and stranding records indicates that leatherback turtles, *Dermochelys coriacea*, are common along the Middle Atlantic states during summer and early fall, and that they utilize inshore waters during their migrations rather than long open sea routes.

INTRODUCTION

The pelagic leatherback turtle, *Dermochelys coriacea*, is the largest turtle, and, although its nesting beaches are mostly confined to tropical areas, adults regularly migrate to cold, northern waters. Along the Atlantic Coast of North America, leatherbacks range from the Florida Keys (Ernst and Barbour, 1972) to Labrador (Threlfall, 1978). There are numerous summer records from eastern Canada and New England (Squires, 1954; Moulton, 1963; Bleakney, 1965; Zullo and Bleakney, 1966; Miller, 1968; Threlfall, 1978). Apparently they follow drifting jellyfishes (their major food) northward. There is also evidence that they can physiologically maintain a warm body temperature and are well adapted to cold northern waters (Pritchard, 1969; Frair, Ackman and Mrosovsky, 1972). These northward migrations aid them in avoiding competition with the other species of marine turtles, which are basically tropical.

It has been generally thought that leatherbacks make long open ocean journeys to reach New England and eastern Canada, perhaps directly northward from Florida or Cape Hatteras, and that they are rare along the Middle Atlantic coast.

DISCUSSION

On 8 June, 1978 the junior author found the remains of a leatherback on a beach in Ocean County, New Jersey. The turtle was lying plastron-up with the carapace buried in the sand. It was in an advanced state of decomposition, and had probably been there since early spring; representing the earliest record for the area.

At first it was thought that such a stranding was a rare event. However, as we reviewed the obscure literature and made inquiries, it became apparent that leatherback strandings and sightings occur frequently in late summer and early autumn from Virginia to New Jersey.

McCauley (1945), Reed (1957), and Jones (1968) give records for Virginia, and Hardy (1969) summerizes Virginia and Maryland records from

Chesapeake Bay. Ford (1879) discusses specimens from Delaware, and Mitchell (1812), DeKay (1842), Ford (1879), Arndt (1975) and Stein, Eames and Parris (1977) provide other records from New Jersey. In addition to these, the Scientific Event Alert Network (SEAN), of the National Museum of Natural History, Smithsonian Institution, Washington, D.C. also had unpublished records of two New Jersey and one Delaware strandings. Data for all of the above records are presented in Table 1.

These records show that many, if not all, leatherbacks do not take the direct open water routes, but instead remain close to the shore during their migrations, and that adults are seasonally common along the Middle Atlantic states.

We wish to thank Ms. Shirley L. Maina for allowing us to publish the stranding records of the Scientific Event Alert Network.

Literature Cited

Arndt, R. G.
1975. Meet our turtles. *Delaware Conservationist* 19:11-14.

Bleakney, J.S.
1965. Reports of marine turtles from New England and eastern Canada. *Canadian Field-Natur.* 79:120-128.

DeKay, J. E.
1842. Zoology of New York. Part III. Reptiles and Amphibia. *W. & A. White & J. Visscher, Albany, N.Y.* 415 p.

Ernst, C. H. and R. W. Barbour.
1972. Turtles of the United States. *Univ. Press Kentucky, Lexington.* 347 p.

Ford, J.
1879. The leather turtle. *Amer. Natur.* 13:633-637.

Frair, W., R. G. Ackman, and N. Mrosovksy.
1972. Body temperature of *Dermochelys coriacea*: warm turtle from cold water. *Science, N.Y.* 177:791-793.

Jones, D.
1968. Occurrence of the leatherback turtle on Virginia's S.E.coast. *Virginia Herpetol. Soc. Bull.* (58):8.

McCauley, R. H., Jr.
1945. The reptiles of Maryland and District of Columbia. Privately printed. *Hagerstown, Md.* 194 p.

Miller, M.D.
1968. An additional observation of the leatherback turtle off Newfoundland. *Canadian Field-Natur.* 82:226.

Mitchill, S.L.
1812. A description of a great tortoise, or *Testudo coriacea*, taken in the Atlantic Ocean, near New-York, in the autumn of 1811. In a letter to John LeConte, Esq. pp 191-195. In: S.L. Mitchill and E. Miller. *The Medical Repository. Original Essays and Intelligence.* 3rd hexade, volume 3, New York.

TABLE 1. Locality records for leatherback turtles, *Dermochelys coriacea*, from the Middle Atlantic states.

Locality	Date	Carapace Length (cm)	Weight (kg)	Source
Virginia:				
1. Paramore Isl., Accomac Co.	----	----	----	McCauley, 1945
2. 11.3 km S. Sand Bridge, Princess Anne Co.	20 Aug.	144	±193	Jones, 1968
3. Gloucester Pt., Gloucester Co.	----	----	----	Ford, 1879
4. 3.2 km S.E. Great Wicomico Light House, near Fairport, Northumberland Co.	May or June	----	318	Reed, 1957
Maryland:				
1. Between Little Cove Pt., Calvert Co. and Barren Isl., Dorchester Co.	3 June	----	500	Hardy, 1969(a)
2. Little Cove Pt., Calvert Co.	14 Sept.	----	----	Hardy, 1969
3. Dares Beach, Calvert Co.	24 June	----	----	Hardy, 1969
4. Hooper Island, Dorchester Co.	15 July	----	±284	Hardy, 1969
Delaware:				
1. Delaware Bay	1 June	----	----	Ford, 1879
2. Delaware Bay	----	----	416	Ford, 1879
3. Bennett's Pier, E. of Milford, Sussex Co.	1 Aug.	137	----	SEAN
New Jersey:				
1. Off Sandy Hook, Monmouth Co.	28 Sept.	173	363	Mitchill, 1812
2. Sandy Hook, Monmouth Co.	----	Large	----	DeKay, 1842
3. Nr. Atlantic City, Atlantic Co.	Summer	----	----	Ford, 1879
4. Beach Haven, Ocean Co. (2)	Summer	----	----	Ford, 1879
5. Bayside, Cumberland Co.	18 Aug.	----	227	Arndt, 1975
6. 2.5 km. S. Park Office, Island Beach St. Pk., Ocean Co.	26 Oct.	180	360-480	Stein, et al., 1977
7. 3 km. S. Park Office, Island Beach St. Pk., Ocean Co.	29 Sept.	157	315-360	Stein, et al., 1977
8. Point Pleasant Beach, Ocean Co.	28 Oct.	165	315-405	Stein, et al., 1977
9. Seaside Pk. Borough, Ocean Co.	27 Oct.	136	360-405	Stein, et al., 1977
10. Sea Girt Borough, Monmouth Co.	24 Aug.	----	----	Stein, et al., 1977
11. Sighted off Beach Haven, Ocean Co.(b)	13 Sept.	----	----	Stein, et al., 1977
12. 13 km. S. Park Entrance, Island Beach St. Pk., Ocean Co.	8 June	170	±360	Gilroy
13. N. end. Brigantine Isl., Atlantic Co.	15 Oct.	138	----	SEAN
14. Whale Beach, Strathmere, Cape May Co.	30 Sept.	150	----	SEAN

a. Hardy (1969) discusses several other specimens with localities listed only as "Chesapeake Bay".

b. Stein et al. (1977) mention five other sightings within 10 km of the beach, but give no localities.

Moulton, J.M.
1963. The recapture of a marked leatherback turtle in Casco Bay, Maine. *Copeia* 1963:434-435.

Pritchard, P.C.H.
1969. Sea turtles of the Guianas. *Bull. Florida St. Mus.* 13:85-140.

Reed, C. F.
1957. Contributions to the herpetofauna of Virginia, 2: The reptiles and amphibians of Northern Neck. *J. Washington Acad. Sci.* 47:21-23.

Squires, H. J.
1954. Records of marine turtles in the Newfoundland area. *Copeia* 1954:68.

Stein, R. J., W. K. Eames, and D. C. Parris.
1977. Recent occurrences of beached dead leatherback turtles (*Dermochelys coriacea coriacea)* along the New Jersey Coast. *Sci. Notes, New Jersey St. Mus.* (15):1-6.

Threlfall, W.
1978. First record of the Atlantic leatherback turtle (*Dermochelys coriacea*) from Labrador. *Canadian Field-Natur.* 92:287.

Zullo, V. A., and J. S. Bleakney.
1966. The cirriped *Stomatolepas elegans* (Costa) on leatherback turtles from Nova Scotia waters. *Canadian Field-Natur.* 80:162-165.

Department of Biology, George Mason University, Fairfax, Virginia 22030

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MORELET'S CROCODILE *(Crocodylus moreleti* DUMERIL AND DUMERIL), IN THE REGION OF LOS TUXTLAS, VERACRUZ, MEXICO

Until a few years ago it was possible to find *Crocodylus moreleti* easily, in the more copious rivers, such as the Rio papaloapan and the Rio Coatzacoalcos, and in smaller rivers and lakes which irrigate the region of Los Tuxtlas. At the present time, the two species of crocodiles reported in Veracruz, *C. moreleti* and *C. acutus* (Smith and Taylor, 1950), are almost extinct in most areas. The uncontrolled exploitation carried out during the last several decades (Casas Andreu, 1970), and the clandestine hunting and fishing of crocodile and turtle, with the lack of effective legislation to protect them in this State, has not allowed for population growth. The same has been reported elsewhere in Mexico (Alvarez del Toro, 1972). The few medium sized individuals occasionally seen in some rivers and lakes, are rements of which in another time, were large populations. At present, in the Region of Los Tuxtlas, and all the low plains comprised in the Rio Papaloapan basin, is found only one species, *Crocodylus moreleti*. All specimens examined from this region were *C. moreleti*; not a single animal referable to *C. acutus* was seen.

Crocodylus moreleti, prefers quiet water, small or dead water areas formed by rivers without pertubance for its growth and reproduction. They prefer not to live in deep miry places, with emergence vegetation. In the river Cuetzalapan, (Campbell, 1972), Catemaco Municipe, Yugualtajapan, Coscoapan, and also in the Rio Playa Vicente of the Municipe of Isla, are occasionally found individuals which may reach a meter in length. These areas, however, cannot, at present, be considered viable colonies.

This note reports two localities where, it is still possible to find viable populations of *C. moreleti* in its natural habitat. One area is a valuable hatchery, which should be protected if *C. moreleti* is to survive.

Locality 1 - Swamps of Tesechoacán

Tesechoacán, Municipe of Isla, Veracruz; between Tesechoacán and El Ñape (old road from Tesechoacán-Loma Bonita), approximately 60 km SW Santiago Tuxtla, Veracruz; elevation: 18 m above sea level.

This "swamp" area is formed by a Rio Playa Vicente and Rio de Tesechoacán overflow. It includes localities known as "Laguna de Lagartos", "Laguna de Guerrero", and "Laguna de Tesechoacán". During the rainy season, it is enlarged by ten km or more; on the southern side, the shores are conserved by high pasture; in the central areas and along the other shores, is found abundant vegetation. Almost the whole area is composed of movable sand with little deep water. This area harbors a considerable Morelet's population, both adult and young. During the rainy season, it is possible to observe many young specimens on the low shores, and on the roads; the adults are more wary and stay faraway. Ten specimens 2.50 to 3.00 m long, were caught in September, 1977; smaller specimens are being kept at the Estación de Biología Tropical. This area is almost inaccessible, and for this reason alone, the population has survived.

Locality 2 - Laguna Escondida

Colony with the same name; 3 km NW Catemaco-Montepío road; bordering the Nature Reserve of Estación de Biología Tropical "Los Tuxtlas", Veracruz; elevation: 160 m above sea level.

This lake is approximately 1,100 m in length and is very deep. It is fed by the Rio Cárdenas, and due to its volcanic origin, broken land surrounded by rainforest and having few plain shores, is also a very inaccessible place. Its drain contributes to the Rio Máquina formation, which arrives at the sea at Montepío.

Between the middle of October and the beginning of November 1976, near the area where the Lake leads to the Rio Máquina, five adult crocodiles were located, however, positive identifications were not possible. In December, 1976, one adult crocodile was captured by villagers, which was *C. moreleti*, and measured 100 cm snout-vent length, 220 cm total length and had a ventral expansion of 42 cm.

Literature Cited

Alvarez del Toro, M.
1972. Los reptiles de Chiapas; Inst. de Hist. Nat. del Edo. *Tuxtla Gutierrez, Chis. Mexico,*

Campbell, H. W.
1972. News and notes. Preliminary report: status investigations of Morelet's crocodile in Mexico. *Zoologica, Scient. Contrib. of the New York Zool. Soc.*

Casas Andreu, G. and M. Guzmán A.
1970. Estado actual de las investigaciones sobre «cocodrilos» Mexicanos (Leyes que protegen al recurso). *Com. Nal. Cons. de Pesca, Inst. Nal. de Inv. Biol. Pesq. Serie Divulgación* (3):15-20.

Smith, H. M. and E. H. Taylor.
1950. An annotated checklist and key to the reptiles of Mexico exclusive of the snakes. *Bull. U.S. Nat. Mus.* (199):210-211.

—Gonzalo Pérez Higareda, *Estacion de Biología Tropical "Los Tuxtlas", Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 94, San Andrés Tuxtla, Veracruz, México.*

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NOTES ON *Ambystoma tigrinum* FROM SONORA, MEXICO

When Lowe (1954) originally described *Ambystoma tigrinum stebbinsi* from the Huachuca mountains of southeastern Arizona, he stated that this race was to be expected in adjacent Sonora. Reed (1951) reported on preserved larvae of this species in the Museum of Zoology, University of Michigan, that had been collected in northeastern Sonora. Van Devender (1973) reported on *A. tigrinum stebbinsi* sympatric with *A. rosaceum* in Chihuahua. Although *Ambystoma tigrinum* has apparently been collected in northern Sonora since Lowe's (1954) prediction, little or no mention of this fact has been made in the literature.

Recently, three larval *Ambystoma tigrinum stebbinsi* were collected in the northwestern part of the Sierra de los Ajos, southeast of Cananea, Sonora. These specimens were taken 5 July 1977 at an elevation of ca. 2200 meters in small pools of a barely flowing creek. The narrow canyon through which the creek flowed contained riparian vegetation in the bottom and pine-oak forest on the hillsides, though pines were not common. Summer rains had only recently begun in these mountains. The larvae were abundant along a very limited stretch of the creek. Associated herpetofauna observed at this locality consisted of *Hyla arenicolor, Sceloporus jarrovi, S. virgatus, Urosaurus ornatus, Thamnophis c. cyrtopsis, Lampropeltis pyromelana woodini, Crotalus m. molossus, C. p. pricei,* and *C. willardi* ssp. (considered *C. w. willardi/silus* by Harris and Simmons, 1976).

The collected larvae were subsequently housed individually in the laboratory and were fed live tubifex worms.

When collected, the dorsal and lateral surfaces of the larvae were gray-black with pale yellow speckling. The ventral surfaces were cream-colored and lacked any markings. Two weeks prior to transformation (here defined as loss of external gills) the dorsal ground color became progressively darker (black) and yellow spots (versus speckles) became visible. The newly-transformed salamanders had a black ventrum and dorsum. The labial region was tinged with gray. External gills disappeared over a 72 - hour period on the average and snout-vent lengths at time of transformation were 52, 55, and 55 mm. Spot counts for dorsal and lateral body surfaces and tail were made two months and eight months after transformation following Gelbach's (1967) procedure. These data are shown in Table 1.

Table 1. Spot counts (body/tail) for sub-adult *Ambystoma tigrinum stebbinsi* from Sierra de los Ajos, Sonora.

Date of Transformation	Two Months After Transformation	Eight Months After Transformation
13 October	25/50	17/14
1 November	29/45	23/21
4 November	21/42	16/16

We tentatively assign these salamanders to *Ambystoma tigrinum stebbinsi*, while recognizing that our material differs somewhat from *A. t. stebbinsi* from Arizona (as illustrated by Lowe, 1955). Sonoran *A. t. stebbinsi* possess fewer and larger dorsolateral spots and have a less boldly patterned underside of the chin when compared with salamanders from the Huachuca mountains. *A. t. stebbinsi* from Arizona, Chihuahua, and Sonora (all known populations) are dark-ventered, as is *A. rosaceum* from Durango. However, the latter species possesses an "immaculate cream" ventrum in Chihuahua (Van Devender, 1973).

Recent examination of transformed salamanders in the Museum of Vertebrate Zoology collection reveals several specimens obtained by James D. Anderson in the vicinity of La Cuidad, Durango that are very similar to *A.t. stebbinsi* from Sonora (as illustrated in this paper) with respect to size and arrangement of dorsolateral spotting. The Durango material was considered by Anderson (1961) to be *A. rosaceum.*

The considerable amount of color and pattern variation exhibited by *Ambystoma tigrinum* and *A. rosaceum* suggests that further study is needed to clarify the taxonomy of *Ambystoma* in northwestern Mexico and southeastern Arizona.

We thank Dr. Antonio Landazuri Ortiz for issuing a Mexican scientific collecting permit and Dr. David B. Wake for permission to examine MVZ material.

Fig. 1. Sub-adult *Ambystoma tigrinum stebbinsi* eight months after transformation. Snout-vent length is 70 mm.

Fig. 2. Habitat of larval *Ambystoma tigrinum stebbinsi* at 2200 m, Sierra de los Ajos, Sonora.

Literature Cited

Anderson, J. D.
1961. The life history and systematics of *Ambystoma rosaceum*. *Copia 1964*: 371-377.

Gelbach, F. R.
1967. *Ambystoma tigrinum*. *Cat. Amer. Amphib. Rept. 52*: 1-4.

Harris, Herbert S., Jr., and Robert S. Simmons.
1976. The paleogeography and evolution of *Crotalus willardi*, with a formal description of a new subspecies from New Mexico, United States. *Bull. Md. Herp. Soc. 12*(1):1-22.

Lowe, C. H., Jr.
1954. A new salamander (genus *Ambystoma*) from Arizona. *Proc. Biol. Soc. Washington 67:*243-246.

________________.
1955. The salamanders of Arizona. *Trans. Kansas Acad. Sci. 58:* 237-251.

Reed, C. A.
1951. Larval ambystomid salamanders from southern Arizona and Sonora. *Chicago Acad. Sci., Nat. Hist. Misc. 79:*1-3.

Van Devender, T. R.
1973. Populations of *Ambystoma tigrinum* and *A. rosaceum* in Chihuahua, Mexico. *J. Arizona Acad. Sci. 8:*84.

—Robert W. Hansen, *Department of Biology, California State University, Fresno, California 93740* and Ronald L. Tremper, *Roeding Park Zoo, 890 West Belmont, Fresno, California 93728.*

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PREDATION BY BULLFROG TADPOLES *(Rana catesbeiana)* ON EGGS AND NEWLY HATCHED LARVAE OF THE PLAINS LEOPARD FROG *(Rana blairi)*

Feeding studies on tadpoles indicate that they are non-selective, consuming vegetation, detritus, carrion, and small animals associated with vegetation (Savage, 1962; Jenssen, 1967; Thrall, 1972). However, Noble (1929), Taylor (1954), and Heusser (1970) have made the unusual observation that tadpoles of several species (*Anotheca spinosa, Hoplophryne rogersi, Hyla brunnae, Hyla wilderi, Hyla marianae, Hyla lichenata, Rana temporaria*) fed on anuran eggs. Either eggs of sympatric species or eggs of the same species were eaten. Similar food habits have not been observed among U.S. anurans. It might be predicted, however, that tadpoles of the North American bullfrog (*Rana catesbeiana*) would consume anuran eggs because bullfrog tadpoles can take two or more years to metamorphose and are thus large and available in the spring when many anuran eggs are laid. In the spring of 1978 I attempted to test this hypothesis using eggs of the sympatric plains leopard frog, *Rana blairi*.

Ten tadpoles of *R. catesbeiana* and two egg masses of *R. blairi* were collected at the spillway of Lake Bloomington, McLean County, Illinois on 28 April. Shortly after capture the eggs were presented to the bullfrog tadpoles in the laboratory in plastic tubs (36 cm long X 28 cm wide X 13 cm high). All of the bullfrog tadpoles consumed the eggs of *R. blairi* with no hesitation. Three to four eggs were usually consumed by a given tadpole every few seconds. Some of the eggs of *R. blairi* hatched in the laboratory and these larvae also were offered to the bullfrog tadpoles. The larvae were also readily eaten. In some cases, however, the hatchling *R. blairi* were able to swim fast enough to avoid being devoured by the bullfrog tadpoles.

Heusser (1970) felt that egg eating by tadpoles of *R. temporaria* was a density dependent means of population regulation. Egg eating by tadpoles of *A. spinosa* was also interpreted by Duellman (1970) as a means of controlling population size. In contrast, Noble (1929) suggested that egg eating by larval anurans was simply due to the lack of any other available food. Such egg eating behavior may be particularly adaptive for tadpoles which live in similar restricted habitats. Tadpoles of *H. Rogersi* are found between leaves of wild banana or within the stems of bamboo while tadpoles of *H. brunnae*, *H. wilderi*, *H. marianae*, *H. lichenata*, and *A. spinosa* occur in bromeliads. The water in such cases is shallow and confining. Thus, competition for limited food supplies is probably high. The reason for egg eating among ranids such as the bullfrog may be somewhat different. Tadpoles of this species are usually found in ponds or other large bodies of water and thus the habitat is not spatially confining. It is likely, however, that food supplies are rather limited in early spring and this may explain why bullfrog tadpoles consume anuran eggs and young larvae which are readily available at that time.

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Literature Cited

Duellman, W. E.
1970. The hylid frogs of Middle America. *Monograph of the Museum of Natural History, The Univ. of Kansas, 1*:1-753.

Heusser, H.
1970. Laich-Fressen durch Kaulquappen als mogliche Ursache spezifischer Biotoppreferenzen und kurzer Laichzeiten bei europaischen Froschlurchen (Amphibia, Anuran). *Oecologia (Berl.) 4*:83-88.

Jenssen, T. A.
1967. Food habits of the green frog (*Rana clamitans*), before and during metamorphosis. *Copeia 1967*(1):214-218.3.

Noble, G. K.
1929. The adaptive modifications of the arboreal tadpoles of *Hoplophryne* and the torrent tadpoles of *Staurois*. *Bull. Amer. Mus. Nat. His., 58*:291-334.

Savage, R. M.
1962. The ecology and life history of the common frog (*Rana temporaria*). *Hafner Publ. Co., New York*, v + 221 pp.

Taylor, E. H.
1954. Frog-egg eating tadpoles of *Anotheca coronata* (*Stejneger*). (Salientia, Hylidae). *Kansas Univ. Sci. Bull., 36*:589-595.

Thrall, J. H.
1972. Food, feeding, and digestive physiology of the larval bullfrog, (*Rana catesbeiana* Shaw). *Ph.D. Thesis, Illinois State University*, xi + 176 pp.

—Diane Ehrlich, *Department of Biological Sciences, Illinois State University, Normal, Illinois 61761.*

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OBSERVATIONS ON *Gopherus polyphemus* IN WEST-CENTRAL GEORGIA

A break in the distribution of the gopher tortoise (*Gopherus polyphemus*), as it appears in a map by Auffenberg and Franz (1978), may not exist in reality. This gap in the outlying populations of this species in west central Georgia and east central Alabama is probably created by the presence of the Fort Benning military reservation. Activities there from 1940 to the present may have precluded collecting. [In July and August, 1944, while stationed at Fort Benning, I frequently observed a gopher tortoise in its habitat.]

Information presented here may confirm suspicions that the northerly outlying populations of the gopher tortoise in the vicinity of Columbus, GA., are contiguous, or nearly so. This part of the Chattahoochee River is easily picked out on maps of any scale by the large bends in the river. The occurrence of this species on the east bank of the river within the military reservation was a fact in 1944, if not today. Personal knowledge of the species' ability to cross rivers is lacking, but at low water the river is silted for a few yards from each shore and should prove no great barrier to a tortoise.

The area in which *Gopherus polyphemus* was observed is in that part of the reservation known popularly as the "frying pan area." It is within the triangle formed by Dixie Road, the extension of Sight-seeing Road toward the river, and the Chattahoochee River itself within sight of the activity on the airport runways at Lawson Field, about a mile (2 km) to the north. The area is within Chattahoochee County, GA. During late July and most of August, 1944, the site was occupied by two medical companies and at least one specimen of *Gopherus polyphemus*. The habitat area was bounded on the east by the 64th Infantry Woods, and to the southeast by the Bickford firing range. The river formed the southwestern boundary. Dixie Road formed the northern limit. Elevation above mean sea level varied from 220 to 230 feet with the river bank at about 200 feet above mean sea level. The soil was sandy and the primary drainage was southwesterly to the river by way of some deep erosion ditches. No amphibians were observed there, but a small specimen of the black swamp snake (*Seminatrix pygaea*) was caught and released in this declivity. On the marshy edge of the 64th Infantry Woods there was a small southern leopard frog (*Rana utricularia*) colony.

The site was undeveloped in 1944; there were few buildings and no paved roads south of Dixie Road. The only structures were some old (1917-1918) supply sheds, latrines, and wooden platforms for pyramidal tents. A small hill was shaded by a tall stand of redolent white pine which did wonders for the air.

On my latest visit, March 1969, only the concrete footings of the buildings remained. A major portion of the former Army medical company area is now under a macadamized motor vehicle park surrounded by chain-link fencing. Toward the river, I was able to discover undisturbed patches of the *Gopherus* habitat. The area frequented by the gopher tortoise (*circa* 1944) was a small gulley behind two parallel rows of pyramidal tents facing away from the gulley. *Gopherus* resided in what appeared to be a well-disguised culvert from an earlier drainage system.

Except for one notable item of diet, there were many similarities between what I had observed and what has been described in the literature (Ernst and Barbour, 1972). The presence of the tortoise came to general attention shortly after my first sightings of it near its burrow. Someone had discarded stale biscuts behind the tents. One day on return to the company area, there was an audible chomp, chomp, chomping coming from the gulley out back. *G. polyphemus* was making considerable headway through the batch of stale biscuts. It had occurred to me then, and it seems logical still, that this specimen was quite accustomed to the presence of human beings.

From the dark color of its carapace and the size, I assumed it was an old male. The straight line measurement from nuchal to anal plate was approximately 30 cm. Despite the presence of 200 medical soldiers, I never saw the tortoise being handled. This impressive old timer was respected by all; unfortunately no direct measurements were made. We left the area in September 1944 for Boston's Port of Embarkation.

Literature Cited

Auffenberg, Walter and Richard Franz.
1978. *Gopherus polyphemus. Cat. Amer. Amphib. Rept.* 215.1-215.2.

Ernst, Carl H., and Roger W. Barbour.
1972. Turtles of the United States. *University Press of Kentucky, Lexington.* 347 pp.

—Franklin J. Tobey, Jr., *Coordinator, Virginia Herpetological Society, P.O. Box # 1376 (VaHS), Leesburg, VA. 22075.*

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Morphology and Biology of Reptiles

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This book, the proceedings of a Linnean Society Symposium held in September 1975, contains articles by fourteen authorities from Europe and the USA, and reflects some of the most interesting trends in the study of reptiles, both living and extinct. Some of the contributions are in review form, while others describe original work that has been undertaken. Traditional areas of study are covered — such as palaeontology and systematics — as well as the newer areas of functional anatomy, histology, physiology and ecology.
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Index.

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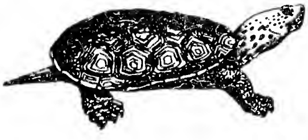

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JUNE 1979 VOLUME 15, NUMBER 2

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CONTENTS

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BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

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CHEMOSENSORY INVESTIGATION OF FISH MUCUS ODOR BY RATTLESNAKES

David Chiszar, Kent M. Scudder and Hobart M. Smith

Abstract

Rattlesnakes of three taxa (*C. v. viridis, S. c. edwardsi* and *S. c. tergeminus*) flicked their tongues at higher rates in an environment containing fish mucus odor than in a control environment. In several previous experiments rattlesnakes did not exhibit increased tongue flick rates (TFR) in the presence of rodent odors unless the snakes had an opportunity to strike a mouse just prior to the tests. The fact that fish mucus odor generates an unconditional elevation in TFR may mean that such odors are simply more potent than rodent odors such that snakes can detect them directly from the substrate whereas rodent odors are best detected only after they have been placed (in large quantities) into the vomeronasal organs concomitant to striking a mouse. Since rattlesnakes do not eat fish, the TFR increase seen during presentation of fish mucus odors may indicate: (1) facultative exploration of a novel stimulus, or (2) an atavism derived from *Agkistrodon*-ancestors.

In previous investigations we have exposed garter snakes to fish mucus odors and rattlesnakes to mouse odors (Chiszar, Scudder & Knight, 1976; see also Burghardt, 1967, 1969). Whereas the former responded with greatly elevated tongue flick rates (TFR), the latter showed no significant change in TFR consequent to the introduction of rodent odors. We concluded that garter snakes are able to detect and trail prey odors arising directly from the substrate while rattlesnakes must first strike a prey item before they become attentive to odor trails (Chiszar, Radcliffe & Scudder, 1977). In other words, something about striking acts as a trigger for rattlesnake chemosensory searching (Chiszar, Radcliffe & Smith, 1978; Scudder, Short & Chiszar, 1978; Scudder, in prep).

It is possible that fish mucus is inherently more odoriferous than mouse odors. Although we are currently unable to specify any biochemical dimensions along which these substances might differ, it is not unlikely that such things will soon be discovered (G.M. Burghardt, personal communication). In any case, recall that garter snakes were tested with fish mucus while rattlesnakes were tested with rodent odors. If these odors differ in strength, then it may be possible that rattlesnakes will detect and respond (with high TFR) to fish mucus even though such odors are presumably biologically irrelevant to them. The present study was designed to evaluate this possibility.

METHODS AND MATERIALS

Subjects and maintenance conditions. Sixteen rattlesnakes were observed in this experiment (six prairie rattlesnakes, *Crotalus viridis viridis*, captured locally, were all at least 3 years old and were experimentally naive but had resided in the lab for 3 to 7 months prior to this study; four massasaugas, *Sistrurus catenatus edwardsi*, captured in southeastern Colorado, were all at least 2.5 years old and were experimentally naive but had resided in the lab for 2 to 14 months prior to the study; and six additional massasaugas, *Sistrurus catenatus tergeminus*, born in the Dallas zoo, were 3 years old and were experimentally naive but had resided in the lab for 12 months prior to the study). All *C. v. viridis* were housed in a wooden terrarium (180 X 62.5 X 80 cm) containing rocks, sand, water and a heat lamp (250 W, mounted at the center of the ceiling, illuminated between 0700 and 2000 hr) which created a temperature of 38° C on the sand immediately below and a gradient which dropped to 26° C in the left- and right-most areas of the cage floor. All *S. c. tergeminus* were housed in an identical terrarium. The four *S.c. edwardsi* were housed in a smaller terrarium (66.2 X 38.7 X 36.2 cm) containing rocks, sand, water, and a 40-W incandescent bulb (mounted at the upper left of the rear wall, illuminated between 0700 and 2000 hr) which kept the cage at 26 ± 1° C. All snakes accepted food readily under these conditions (one or two mice per week at 1400 hr).

Apparatus and Procedure. A glass cage (59cm long X 30cm wide X 39cm high) was the main piece of apparatus. The cage was clean, dry and contained a paper floor covering. Each snake was placed into this cage twice, each time for 20 min. During one trial (i.e., the control trial) the floor covering was clean; during the other trial (i.e., the experimental trial) the floor covering had been rubbed three times with a live bluegill sunfish (*Lepomis macrochirus*) and thereby invested with an unquantified amount of mucus. Half of the snakes received the control trial first and half of the snakes received the experimental trial first. The two trials were separated by one week and snakes were fed within one hour after each trial. Hence, the animals were under 7 days of food deprivation at the time of control and experimental trials. While snakes were in the apparatus all tongue flicks were recorded with the aid of hand-held counters.

RESULTS

Figure 1 presents the mean TFR (per min) emitted by each taxon of rattlesnake across the two 20 min trials. These data were subjected to nonparametric (Chi Square) and parametric (ANOVA) analyses with essentially the same outcomes. Tongue flick rate was higher in experimental than control trials ($X^2 = 9.00$, df = 1, $P < .01$; $F = 17.07$, df = 1/13, $P < .01$), and this effect did not differ significantly between taxa ($X^2 = .95$, df = 1, $P > .05$; $F = 3.13$, df = 2/13, $P > .05$). Another view of the data is shown in Table 1 where it can be seen that the control vs. experimental difference was generally strongest during the first two 5-min blocks of the test sessions (see especially data for *C. v. viridis* and *S. c. edwardsi*).

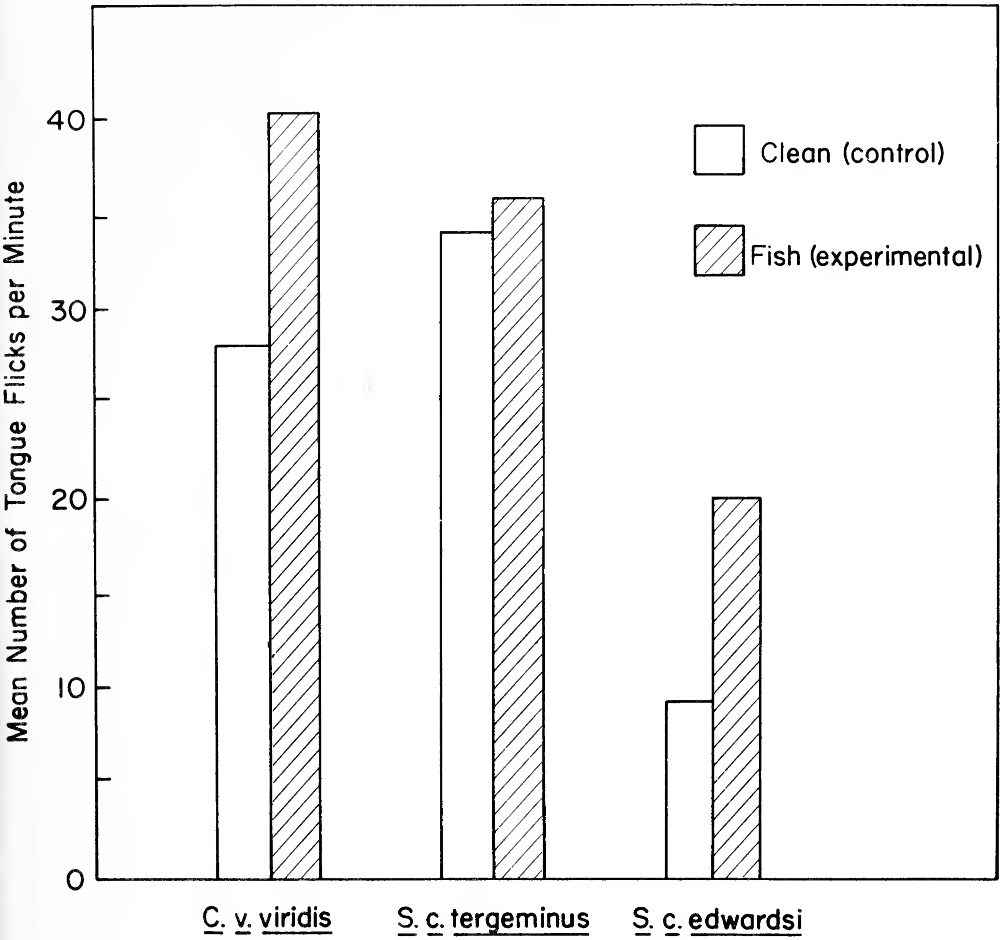

Fig. 1. Mean number of tongue flicks emitted per minute by three taxa of rattlesnakes during 20-min exposures to a test apparatus containing clean floor covering and floor covering that had been coated with fish mucus.

DISCUSSION

Our earlier data (e.g., Chiszar, Scudder, & Knight, 1976) could have been accounted for by suggesting that rattlesnakes have less sensitive vomeronasal tissues than garter snakes. If that were so, we can readily understand why the former might require the Jacobson's organ stimulation that accompanies striking whereas the latter can perceive prey odors directly from the substrate. The present data leave no doubt, however, that rattlesnakes can detect fish mucus under the same conditions that were used to study garter snake responsivity to such odors. Hence, it

Table 1

Mean TFR (per min) by Each Taxon during Four Successive 5-min Blocks
Under Control and Experimental Conditions

Successive 5-min Periods

	Crotalus v. viridis				*Sistrurus c. tergeminus*				*Sistrurus c. edwardsi*			
	1	2	3	4	1	2	3	4	1	2	3	4
Clean (control)	37.9	23.2	28.2	23.2	33.3	31.6	29.6	42.4	18.8	6.7	5.5	7.6
Fish (experimental)	53.5	52.0	28.9	31.0	27.7	39.2	30.7	47.2	27.0	23.2	16.8	13.0

no longer seems possible to argue that these taxa differ in terms of our operational measures of vomeronasal sensitivity. Therefore, we can not explain the difference in their response to prey odors by hypothesizing a more basic difference in vomeronasal structure and/or function.

We can argue that fish odors are somehow stronger than rodent odors. The fact that rattlesnakes specialize in the latter prey has therefore required some technique for "keying in" on such odors, and this is exactly what the strike-induced chemosensory searching phenomenon accomplishes. But, if rattlesnakes and garter snakes are tested with the same odor (fish mucus), both respond strongly and no qualitative or quantitative differences in responsiveness are visible (compare present results with data in Chiszar, Scudder, & Knight, 1976).

Now we might wonder why rattlesnakes respond at all to fish mucus. Rattlesnakes are not known to eat fish or other mucus bearing organisms in nature, and accounts of such behavior in captivity are rare. Furthermore, rattlesnakes do not show "curiosity" about all odors to which they are exposed. For example, they exhibited little or no TFR increase in the presence of perfume (Scudder, in prep.). Accordingly, the present results may not reflect general curiosity activated by strong odors.

We initially suspected that rattlesnakes would respond strongly to prey-derived odors and to predator-derived odors (Chiszar, Scudder, Knight & Smith, 1978), and that they would respond less strongly or not at all to biologically irrelevant odors. Their response to fish mucus odor might imply that such odor is not biologically irrelevant to rattlesnakes or that there is something special about such odor (i.e., a catnip type phenomenon). Another possibility might arise if we consider the hypothesis that rattlesnakes are descendent from a moccasin-type ancestor (Gloyd, 1940, p. 249). Contemporary moccasins prey upon mucus bearing organisms, and they respond much like garter snakes in tests involving presentation of fish mucus (Chiszar, Simonsen, Radcliffe & Smith, under review). Assuming that the common ancestor also behaved in this way, we can infer that rattlesnakes may have retained such responsiveness as an atavistic trait. Since rattlesnakes do not eat fish, we must also suggest that lingual responsiveness to fish odor was somehow separable from actual ingestion, the former being retained while the latter was lost.

A final idea is that predation on mucus bearing organisms may not have been totally lost by rattlesnakes; rather, it may be overshadowed by a strong preference for rodents. Perhaps rattlesnakes can be trained to take fish! This would be worth trying in order to explore the full range of rattlesnake predatory potential and in order to confirm the above speculations regarding rattlesnake evolution.

We gratefully acknowledge the financial support of the M.M. Schmidt Foundation.

Literature Cited

Burghardt, G. M.
1967. Chemical cue preference of inexperienced snakes: Comparative aspects. *Science, 157,* 718-721.

______________.
1969. Comparative prey-attack studies in newborn snakes of the genus *Thamnophis*. *Behavior, 33,* 77-114.

Chiszar, D., Radcliffe, C.W. & Scudder, K.M.
1977. Analysis of the behavioral sequence emitted by rattlesnakes during feeding episodes. I. Striking and chemosensory searching. *Behavioral Biology, 21,* 418-425.

______________ Smith, H.M.
1978. Chemosensory searching for wounded prey by rattlesnakes is released by striking: A replication report. *Herpetological Review, 9,* 54-56.

______________ Scudder, K. & Knight, L.
1976. Rate of tongue flicking by garter snakes (*Thamnophis radix haydeni*) and rattlesnakes (*Crotalus v. viridis, Sistrurus catenatus tergeminus,* and *Sistrurus catenatus edwardsi*) during prolonged exposure to food odors. *Behavioral Biology, 18,* 273-283.

______________ & Smith, H.M.
1978. Exploratory behavior in prairie rattlesnakes (*Crotalus viridis*) and water moccasins (*Agkistrodon piscivorus*). *Psychological Record, 28,* 363-368.

______________ Simonsen, L., Radcliffe, C. & Smith, H.M.
Rate of tongue flicking by water moccasins (*Agkistrodon piscivorus*) during prolonged exposure to various food odors; and, strike-induced chemosensory searching in the cantil (*Agkistrodon bilineatus*). Under review.

Gloyd, H. K.
1940. The rattlesnakes, genera Sistrurus and Crotalus: A study in zoogeography and evolution. *Chicago: The Chicago Academy of Sciences*, special publication number four.

Scudder, K. M.
(in prep.) Mechanisms mediating the sequential aspects of predatory episodes in Crotalid snakes. Ph.D. dissertation.

_____________, Short, J. S. & Chiszar, D.
1978. Mechanisms activating chemosensory searching in rattlesnakes during predatory episodes. Paper presented at meeting of the Animal Behavior Society, Seattle, Washington.

Department of Environmental, Population and Organismic Biology,
University of Colorado, Boulder, Colorado 80309

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HAWAIIAN LIZARDS -
THEIR PAST, PRESENT AND FUTURE

Richard E. Jones

The waters of the Pacific Ocean cover more than seven million square miles of the earth's surface. Scattered about this fluid expanse, the volcanic, oceanic islands of Polynesia stand as oases for terrestrial life. The distribution of these islands forms a huge triangle covering almost a fourth of the Pacific Ocean. At the western point of the triangle is New Zealand, to the east is Easter Island, and to the north, above the equator and near the Tropic of Cancer, are the Hawaiian Islands.

Before human occupation, the Polynesian Islands were relatively barren, volcanic formations surrounded by the turquoise and green waters of coral reefs. Any living terrestrial organism (or its ancestors) present on a given island came there by active or passive dispersal. To reach the Hawaiian Islands, organisms had to disperse over vast reaches of ocean, this archipelago being the most isolated in the world. Two thousand miles to the east lies the American Continent, with no intervening landfalls. Alaska, to the north, is only slightly closer. To the south and southwest are numerous stepping-stone islands to the Indo-Australian area, the closest being Johnston Island, 450 miles away. This is a small coral atoll, and the nearest large island group, the Marquesas, is 2,200 miles distant.

The prevailing ocean and wind currents to Hawaii are from the east, but these steady currents are interrupted periodically by massive, cyclonic disturbances from the west and southwest. Many Hawaiian organisms apparently drifted on debris or were carried by wind or other organisms on the wings of these counter-currents. Evidence of this is that most of the Hawaiian flora have Indo-Pacific orgins, and a majority of the insects and land snails have Pacific origins. An exception to this pattern are the Hawaiian birds, which are mostly of North-American origin. Birds, being strong fliers, can traverse the vast reaches of ocean to the east without much help from strong currents (Oliver and Shaw, 1953).

Several birds and many molluscs and insects of Hawaii are found only in the Hawaiian Archipelago (i.e., are endemic). Two circumstances may help explain this high degree of endemism. First, the single or few individuals lucky enough to find land produced distinctive gene pools, the so-called "founder effect". Second, the period of genetic isolation of these organisms has been long enough to favor evolution of new forms (genetic drift). Other species not only are found in Hawaii but in other places as well. For example, the power of flight of some migratory birds has favored their wide dispersal in the Pacific region. There are three marine turtles and one marine seasnake found in Hawaiian waters. These are capable of swimming long distances, and reach Hawaii under their own power. However, the lizards of Hawaii are another matter. None are endemic, yet is is difficult to imagine them dispersing in sea water or even on floating debris. Therefore, these reptiles must have reached the Hawaiian Islands with the help of man. But, how did man arrive? Most archeological and anthropoligical evidence favors the following scheme:

About 3,000 years ago, early inhabitants of New Guinea sailed eastward to the islands of Tonga and Samoa, using Fiji as a staging area. The settlers of Tonga appear to have been the first Polynesians. Soon after, Polynesians settled in the Marquesas in eastern Polynesia. An attestment to the navigational skills and daring of these sailors in their large voyaging canoes is their colonization of Easter Island, 2,400 miles from the Marquesas, in 400 A.D. Soon, Polynesian culture reached Tahiti and other Society Islands. Around 500 A.D., final thrusts of the double-hulled voyaging canoes carried Polynesians to land falls in New Zealand and Hawaii, the latter journey covering 2,200 miles. Hawaiian tradition recalls many a return journey to the Marquesas Islands and Tahiti. On journey to Hawaii, the large 60-foot canoes carried provisions for the journey and for life on the new islands. Taro root, bananas, bread-fruit, coconuts, pandanas fruit, sugar cane, pigs and fowl were common provisions. In all probability, lizards and lizard eggs were hidden in the cargo, and this is the way these Hawaiian terrestrial reptiles reached their new home. As Snyder (1917) states after his visit to the Hawaiian Islands, "Wherever large canoes were seen lying on the beach (a number of them were carefully examined) geckos were found concealed among the mats covering them. Eggs were found also in the canoes. It would be quite impossible at the present time to provision or launch a large canoe without including both adult geckos and their eggs."

The lizards present in Hawaii before 1900, and probably before the islands were "discovered" by Captain Cook in 1778, were brought there by early Polynesians (Oliver and Shaw, 1953). They eventually may have reached Hawaii by natural means, but man certainly speeded up their dispersal. These lizards include the Snake-eyed Skink (*Cryptoblepharis boutoni*), Moth Skink (*Lipinia noctua*), and Azure-tailed Skink (*Emoia cyanura*). Also present were four members of the family Gekkonidae, the Mourning Gecko (*Lepidodactylus lugubris*), Tree Gecko (*Hemiphyllodactylus typus*), Stump-toed Gecko (*Gehyra multilata*), and Fox Gecko (*Hemidactylus garnoti*). All of these geckos are found in many other areas in the western and southwestern Pacific, having origins in Asia and East Indies.

Distribution of the Hawaiian lizard fauna is presented in Fig. 1. The Mourning Gecko has been found on all the major Hawaiian Islands except Niihau and Kahoolawe. It is a gregarious species found in open non-forested areas, often on buildings and other man-made structures. The Tree Gecko is the least common gecko in the islands, being reported only from Hawaii, Kauai, and Oahu. It is a wary, arboreal species and prefers forested areas. The Stump-toed Gecko is present on all the larger islands except Niihau. It is found on rocks, buildings, and trees in dry and wet areas. The Fox Gecko is also common, except on Kahoolawe, in dry or wet areas. Like the tree gecko, it prefers forested areas; it is more solitary than the other species (Oliver and Shaw, 1953; Smith and Kohler, 1978).

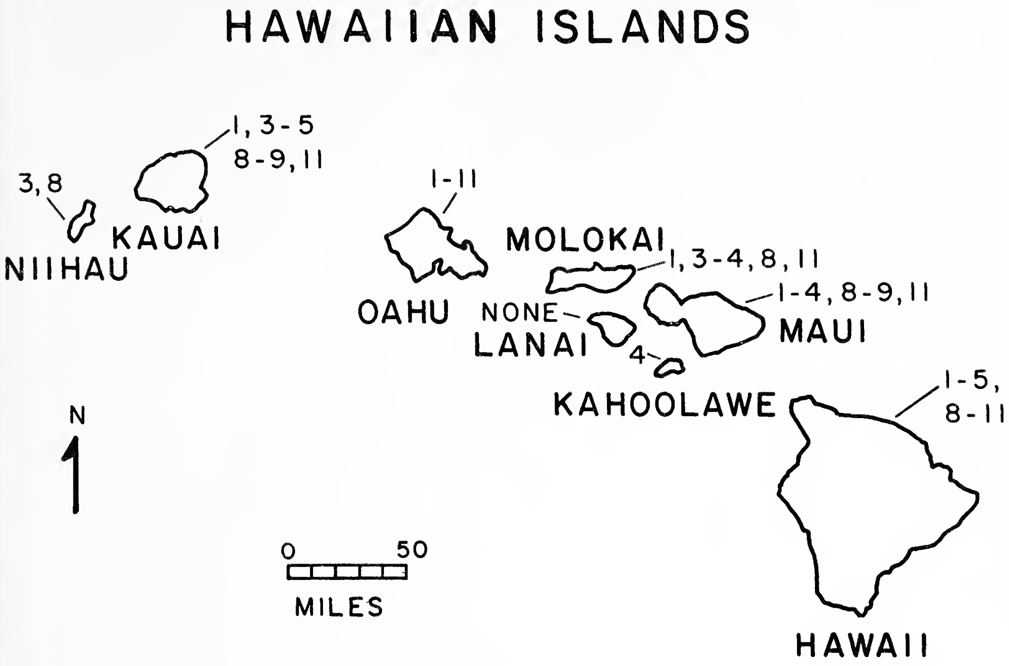

Fig. 1. Last reported distribution of the 11 lizard species occurring in the Hawaiian Islands. (from Oliver and Shaw, 1953; Hunsaker and Breese, 1967; Smith and Kohler, 1978; R. Jones, personal observations). Gekkonidae: 1) *L. lugubris*, 2) *H. frenatus*, 3) *H. garnoti*. 4) *G. mutilata*. 5) *H. typus*. Iguanidae: 6) *A. carolinemsis*, 7) *P. cornutum*. Scincidae: 8) *C. boutoni*, 9) *L. noctua*, 10) *L. metallicum*, 11) *E. cyanura*. NOTE: present distribution of species 9 may now be limited to Oahu. It is difficult to know if the absence of a species on a given island is due to lack of dispersal or poor collecting effort. No information is available for the privately-owned island of Lanai, although K. Fitzgerald (personal communication) recently (1979) collected *H. frenatus* and *L. lugubris* on this island.

It is one thing for a gecko to reach a volcanic island, and another to establish itself as a breeding population, but several aspects of the biology of geckos, although not unique to this family, favored their success as colonizers. Most geckos are crepuscular or nocturnal, coming out only at dusk or night to feed on insects and retreating to crevices under bark or rocks in the daytime. They are splendidly adapted for this nocturnal life. For example, they have cat-like vertical pupils exhibiting serrations which produce a series of small openings when the pupil is closed. Images from light passing through these openings are superimposed on the retina. This, along with the fact that their retinas possess only rods and no cones, makes their vision in low light intensities very acute.

The nocturnal habits of geckos mean, among other things, that any potential predators resident on the islands had a hard time locating them. But, how do geckos locate each other? One answer is that most geckos are very vocal. For example, Mourning Geckos greet each other and interact socially with a series of clicks. They squeek when frightened and, in the words of Loveridge (1945), "The usual cry when hunting at night is a shrill, cricket-like sound, so high pitched that not all human ears can pick up". The inner ear of geckos (see Wever, 1974) has a complex arrangement of sensory cells that allows them to sense high frequency sounds (greater than 10,000 cycles per second). Most lizards can only detect sound up to a few hundred cycles per second.

Even if a predator succeeds in locating a gecko, it often will gain only a tail for its efforts. In most geckos, the tail releases if it is pulled or pinched, and then it wiggles violently on the ground. Meanwhile, the previous owner sneaks off to a crevice. A new tail, fatter and less decorated with scales than the first, appears soon after. Hatchling geckos also have this ability. Snyder (1917), speaking of the Fox Gecko, says "An egg, accidentally dropped and broken, freed a young gecko, which immediately disappeared to new cover, leaving the tail wriggling among the pieces of shell". The skin of the Stump-toed Gecko, being loose and fragile, provides it with another means of escape. It peels off when the animal is grabbed, and a predator would be left holding the bag; new skin replaces that lost in a few days.

Aspects of gecko reproduction also favor ease of colonization. Each female has two ovaries, and in most species the ovaries each produce one egg per cycle. (see Jones *et. al.*, 1978) Thus, the clutch size is two. Pairs of eggs are produced periodically all year long, at least in some species. Thus, the geckos have high fecundity and can build up a population rapidly. Another apsect of reproduction favoring colonization is the egg shell of geckos. Once the eggs are ovulated, each enters an oviduct and acquires a sticky, calcareous covering. These shelled eggs can easily be seen through the translucent, ventral skin of a gravid female. When the eggs are laid, they are soft and sticky and adhere to any surface. Soon after, they harden. Pairs of gecko eggs are commonly found in shady areas under logs, boards, rocks, leaves, building crevices and even clothing. An exception are the eggs of the Fox Gecko, which are not sticky. Females of this species tend to lay their eggs in clusters. The hard, calcareous shell means that the eggs are more protected against desiccation than are soft eggs of other lizard species. Also their sticky nature at laying makes it likely that any provisions loaded on a Polynesian voyaging canoe would have carried gecko eggs.

A final aspect of reproduction favoring colonization is that two of the five Hawaiian geckos reproduce parthenogenetically; i.e. only females exist. These are the Mourning Gecko and the Fox Gecko. How do we know that they are all-female? Certain evidence (Kluge and Eckardt, 1969; Eckardt and Whimster, 1971; Cuellar and Kluge, 1972) has shown that a great majority of individuals collected are female. The very rare male is usually sterile. The ovulated eggs, which in bisexual vertebrates are haploid (1N) before fertilization, are either diploid (2N), as in the Mourning Gecko, or are triploid (3N), as in the Fox Gecko. In addition, skin transplants between individuals of a parthenogenetic species are not rejected as they are in bisexual geckos. This implies that individuals of parthenogenetic geckos are genetically very similar if not identical.

An unpublished study of Mourning Geckos by Margaret Falanruw provides an interesting sidelight to this story. Ms. Falanruw has discovered that some female Mourning Geckos court and "mount" other females, as do males of bisexual geckos. An individual gecko may assume a male role at one time and be female at another time. Whether age or breeding condition governs sexual role is conjecture at this time. Crews (1975) has evidence that male courtship behavior in at least some bisexual lizards is essential for ovarian growth in females. Perhaps, in a similar manner, "pseudomale" behavior has been retained in these all-female species to ensure ovarian cyclicity in other females.

It is clear that being all-female would favor dispersal and colonization, although two bisexual geckos also succeeded in colonizing the islands. Only one founder female would be needed, or at least two if pseudomale behavior is necessary for reproduction. It is noteworthy that the only snake in the Hawaiian Islands (the Brahminy Blind Snake, *Typhlops braminus*) is parthenogenetic. In 1930, this snake was transported to Oahu from the Phillippines in the potted soil of palm trees used to landscape the Kamehameha Boys School, and it has subsequently spread to the island of Hawaii (Oliver and Shaw, 1953, Hunsaker and Breese, 1967).

Another reason for the gecko success story in Hawaii is that they are adapted to live in human habitations. Besides liking crevices of buildings for escape, they gather in the evening to feed on insects attracted to lights. Geckos can climb anything, even glass (the dirtier the better). Some part of their fingers or toes have discs bearing a series of plates. It was thought at one time that these plates enabled the geckos to climb by suction. Geckos, however, slip on wet surfaces. As Loveridge (1945) has said, "Indeed, it seems probable that a water pistol is likely to prove the best weapon for securing a gecko alive and uninjured by causing it to fall to the ground". But a moist surface should improve, not reduce, suction. It turns out that the plates of gecko feet possess hundreds of microscopic, hair-like processes which insert like tiny toes in each slight flaw in the climbing surface.

Besides the blind snake, other reptiles have been introduced by man in seemingly random fashions to the Hawaiian Islands since 1900 (Oliver and Shaw, 1953; Hunsaker and Breese, 1967). In 1917, the Metallic Skink (*Leiolopisma metallicum*) came to the islands in shipments of wood or plants from Australia. It is now very common in Oahu and Hawaii (Hunsaker and Breese, 1967). The chinese Soft-shelled Turtle (*Trionyx sinensis*) was brought to Kauai around 1947 by Orientals interested in culturing them for food as is done in their homelands (Oliver and Shaw, 1953). The Cuban Anole (*Anolis carolinenis porcatus*) is established in Oahu (Hunsaker and Breese, 1967). This population was derived from animals that were either released or that escaped as pets. More recently, the Texas Horned Lizard (*Phrynosoma cornutum*) can be found in dry regions of Oahu, another population derived from pet imports (Hunsaker and Breese, 1967).

A recent arrival is the House Gecko (*Hemidactylus frenatus*). This species was first reported in Oahu in 1951, and is now common in Oahu, Hawaii and Maui (Shaw and Breese, 1961). The House Gecko is native to tropical Asia and islands of the Pacific and Indian Ocean, and has been introduced to Tropical Africa, Mexico, and Panama. How it got to the Hawaiian Islands is anybody's guess, but it is now the most common gecko in Honolulu. This is a large, nocturnal species that is quite vocal. A walk through downtown Honolulu will treat a listening observer to a chorus of their calls, a series of six or seven loud chirps. This species is very aggressive, and appears to be displacing several other geckos from their previously occupied habitats. In 1953, Oliver and Shaw reported the Mourning Gecko to be the most common gecko in Oahu. In contrast, I collected geckos around buildings in Honolulu in the summer of 1977, and most of these were House Geckos. Only when I collected on the outskirts of Honolulu did I find large numbers of Mourning Geckos. So, the House Gecko seems to be displacing the Mourning Gecko in cities. How does this occur? K. Frogner (1967), in a thesis written at the University of Hawaii, suggests some answers. First, House Geckos replaced Mourning Geckos from favorable crevices in his experimental pens by being more aggressive. Second, House Geckos can eat insects up to nine mm in width, but Mourning Geckos do not eat insects greater than three mm in width. Finally, Frogner found that House Geckos eat juvenile Mourning Geckos, but Mourning Geckos cannot reciprocate because hatchling House Geckos are too large.

In general, the origins of the skinks in Hawaii are similar to those of the geckos, and most of the skinks present in Hawaii before 1900 were probably stowaways with the geckos on Polynesian canoes. Both the skinks and geckos prefer either beach habitats or situations related to human habitation. One can imagine both types of lizards foraging near a beached canoe in Tahiti, boarding it to search for insects attracted by the stored goods, and becoming part of a long and eventually fruitful voyage to Hawaii. Time will tell what the next colonizing lizard will be, and how it reaches Hawaii. Whatever the species of the traveller, it will find successful establishment on the Hawaiian Islands more difficult than did its predecessors.

One can speculate on success of future reptilian introductions. For example, if there are refugia dry enough for *Phrynosoma cornutum*, lizards of the genus *Cnemidophorus*, common to deserts of the southwest U.S., could survive. Lizard species of the genera *Ameiva* and *Ophisaurus* could flourish in the forests and grasslands. Chosen carefully, Hawaiian lizard species could be tripled or quadrupled. But, the gecko population is near saturation. Very large geckos, such as the Tokay (*Gekko gecko*), would have a great time in the islands because it could eliminate all others in a hurry. It is seven inches long and has a very large head, big enough to eat the other geckos with ease. Smaller geckos of the genera *Gonatodes* and *Sphaerodactylus* may survive if they arrive and their niches do not overlap considerably with those of geckos already present.

Should man purposefully introduce more lizards to Hawaii? As Smith and Kohler (1978) stated in a recent paper on introduction of reptiles, "Monitored introduction of exotic species that are regarded as unlikely to displace native species should be encouraged. Introduction of endemics into areas where they do not now occur should not be permitted; introductions of specimens from one part of a species' range into another are equally objectionable". We need to know more of the biology of lizards now present in Hawaii, and of those to be introduced. Careful monitoring of introductions may avoid the fate of the Moth Skink in the Islands. At present, this viviparous skink is found only in a small area on the northern coast of Oahu, whereas it used to be common on Oahu as well as Hawaii, Kauai, and Maui (Hunsaker and Breese, 1967). Most biologists feel that the introduction of the Metallic Skink is responsible for the near-extinction of the Moth Skink (Oliver and Shaw, 1953; Hunsaker and Breese, 1967). The status of present Hawaiian lizard populations as new species arrive will be well worth watching.

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Literature Cited

Crews, D.
1975. Psychobiology of reptilian reproduction. *Science 189:*1059-1065.

Cuellar, O., and A. G. Kluge.
1972. Natural parthenogenesis in the gekkonid lizard *Lepidodacylus lugubris*. *J. Genet. 6:*14-28.

Eckardt, M. J., and I. W. Whimster.
1971. Skin homografts in the all-female gekkonid lizard *Hemidactylus garnoti*. *Copeia 7:* 152-154.

Frogner, K. J.
1967. Some aspects of the interaction between the gecko species *Hemidactylus frenatus* and *Lepidodactylus lugubris* in Hawaii. M.S. thesis, Univ. Hawaii.

Hunsaker, D. II, and P. Breese.
1967. Herpetofauna of the Hawaiian Islands. *Pac. Sci. 21:* 423-428.

Jones, R.E., K. T. Fitzgerald, and D. Duvall.
1978. Quantitative analysis of the ovarian cycle of the lizard, *Lepidodoctylus lugubris*. *Gen. Comp Endocrinol. 35:* 70-76.

Kluge, A. G., and M. J. Eckardt.
1969. *Hemidactylus garnoti* Dumeril and Bebron, a triploid all-female species of gekkoid lizard. *Copeia 1969:* 651-664.

Loveridge, A.
1946. Reptiles of the Pacific World. *MacMillan Co., N.Y.* 259 pp.

Oliver, J., and C. Shaw.
1946. The amphibians and reptiles of the Hawaiian Islands. *Zoologica 38:* 65-95.

Shaw, C., and P. Breese.
1951. An addition to the herpetofauna of Hawaii. *Herpetologica 7:* 68.

Smith, H. M., and A. J. Kohler.
1978. A survey of herpetological introductions in the United States and Canada. *Trans. Kans. Acad. Sci. 80:* 1-24.

Snyder, J. O.
1917. Notes on Hawaiian lizards. *Proc. U.S. Nat. Mus. 54:* 19-25.

Wever, E. G.
1974. The lizard ear. Gekkoniade. *J. Morphol. 143:* 121-166.

Additional Bibliography On Hawaiian Lizards

Bryan, W. A.
1915. Natural history of Hawaii. *Hawaiian Gazette Co., Ltd., Honolulu.* 596 pp.

Fisher, H.
1948. Locality records of Pacific Island reptiles and amphibians. *Copeia 1948:* 69.

Fowler, H. W.
1914. Notes on Hawaiian geckos. *Copeia 1914:* 4.

Hunsaker, D.
1966. Population expansion of the house gecko, *Hemidactylus frenatus. Phill. J. Sci. 95:* 1-10.

Kluge, A. G.
1968. Phylogenetic relationships of the gekkonid lizard genera *Lepidoctylus* (Fitzinger), *Hemiphyllodactylus* (Bleeker) and *Pseudogecko* (Taylor). *Phill. J. Sci. 95:* 246-331.

LaRivers, I.
1948. Some Hawaiian ecological notes. *Wasmann Collector 7:* 85-110.

Loveridge, A.
1939. A new skink (*Leiolopisma hawaiiensis*) from Honolulu. *Proc. Biol. Soc. Wash. 52:* 1-2.

McCann, C.
1953. Distribution of the gekkonidae in the Pacific area. *Proc. 7th Pac. Sci. Cong. 4:* 27-38.

McGregor, R. G.
1904. Notes on Hawaiian reptiles from the island of Maui. *Proc. U. S. Nat. Mus. 28:* 115-118.

Perkins. R. C. L.
1903. Fauna Hawaiiensis, being the land-fauna of the Hawaiian Islands (or the Zoology of the Sandwich (Hawaiian) Isles). *Cambridge Univ. Press, Vol. 1, pt. 4, Vertebrata,* pp. 365-466.

Quay, W. B.
1974. Notes on the winter reproductive biology of the gecko, *Peropus mutilatus*, on Kauai, Hawaiian Islands. *Copeia 1974:* 254.

Smith, H. M., and C. Grant.
1961. The mourning gecko in the Americas. *Herpetologica 17:* 68.

Stejneger, L.
1899. The land reptiles of the Hawaiian Islands. *Proc. U.S. Nat. Mus. 21:* 783-813.

Tinker, S.
1941. Animals of Hawaii, a natural history of the amphibians, reptiles and mammals living in the Hawaiian Islands. *Tongg Pupl Co., Honolulu.* 190 pp.

Laboratory of Comparative Reproduction, Department of Environmental, Population, and Organismic Biology, University of Colorado, Boulder Colorado 80309.

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THE GIANT LAND TORTOISE OF ALDABRA,
GEOCHELONE GIGANTEA

Jay C. Shaffer and Carl H. Ernst

Abstract

The status of the Aldabra tortoise, *Geochelone gigantea*, population is discussed in view of daily habits, past decline and future possibilities.

Mention the Galapagos and one thinks immediately of the legendary giant tortoises for which these islands are famous; yet today these splendid reptiles are pitifully few in number, most island races being extinct or nearly so. While valiant conservation efforts are underway to replenish their numbers we find a scene of remarkable contrast nearly half a world away in the western Indian Ocean. Here, on the Atoll of Aldabra exists a population enormous by Galapagos standards --- over 150,000 tortoises (Bourn and Coe, 1978). The Aldabra tortoise, *Geochelone gigantea*, is a close relative of the Galapagos species, *Geochelone elephantopus*, and is itself only a remnant of a once widespread population that extended from Mauritius and Madagascar north to the Seychelles.

Over two centuries ago giant tortoises thrived on many islands in the western Indian Ocean from Aldabra east to Rodriquez and north to the Seychelles. This was not to last. Writing in 1915, Lord Rothschild reported that the tortoises faced extinction on Reunion about 1750, on Mauritius in 1780, and on Rodriquez in 1800. By 1840 they had disappeared from all three islands. What happened over 200 years ago is an all too familiar story today. The realm of the tortoise was overrun by an expanding human population. The supreme competitor greatly altered the best habitat leaving only marginal areas for the tortoises, and introduced domestic animals which either competed for food (as did goats), or ate their eggs and hatchlings (as did rats and dogs). Perhaps worst of all, the enormous tortoises (19-120 kg) themselves proved to be deliciously edible. "Steak free for the taking," and unable to flee, hide, or defend themselves effectively the tortoises faced devastation. Not only were they consumed locally, but thousands at a time were taken by sailors for their ship stores. Being able to survive long periods without food or water, they made ideal provisions and were often stored upside down in the holds of ships for as long as six months.

How is it then that while decimated elsewhere the tortoises have managed to survive, and in fact thrive, on Aldabra?

As to why the tortoise survives there at all we need to know something of the atoll itself. Lonely, nearly uninhabited, Aldabra atoll is located approximately 640 km east of Tanzania and 420 km northwest of Madagascar. Roughly pear shaped, it is 35 km long east to west, and at most about 12 km as wide. A large shallow lagoon occupies the center and channels connecting it to the sea divide the atoll into four main islands of very unequal size. Its 138 km^2 of land area supports an unusual array of plants and animals, endemics making up to 18% of the higher land plants, 23% of the insects, and about 50% of the land birds. The atoll is well known for its spectacular population of boobies, frigate birds, and land crabs. Aside from the tortoise there are only three other land reptiles, two geckos (*Phelsuma abbotti, Hemidactylus mercatorius*) and a skink (*Ablepharus boutonii*).

The diversity of fauna and flora is unusually high for a coral atoll and is due in part to the relative nearness to major land masses, and also to the fact that though lacking hills Aldabra has been uplifted by about 8 meters and so its biota is well protected from occasional typhoons that could innundate lower lying islands.

One of the most unique and fortunate aspects of Aldabra is that it offers so little to human enterprise. Almost devoid of soil and fresh water the terrain in most places exhibits a degree of ruggedness that has to be seen to be believed. Here travel is nearly impossible. Called "champignon" after the mushroom-shaped rocks formed where fluctuating water levels have worn away the bases of limestone blocks, this terrain resembles torn chunks of enormously magnified sponge cake, sharp edged, and so hard a properly directed hammer blow can set it ringing like a bell.

Finally, and of critical importance, Aldabra lacks commercially exploitable phosphate deposits and so has escaped the ruinous surface strip mining to which many of its neighbors have fallen prey. In consequence, Aldabra is probably the only large atoll in the world lacking a permanent human settlement. Were Aldabra more hospitable to man it is unlikely that any of its tortoises would survive outside of zoos.

And what of natural enemies? Here the tortoises' way of sleeping is revealing. Wherever they happen to be when nightfall overtakes them, they simply stretch out their long necks, lay their head on the earth, and close their eyelids, perfectly content and perfectly vulnerable. Clearly, the atoll harbors no natural predators of consequence, at least for the adults. By contrast, the first several years of life must be dangerous ones and probably most of the tiny softer-bodied juveniles fall prey to crabs and predatory birds. Crows, Ibises, and frigate birds, and large land crabs are abundant on Aldabra. Especially impressive is the enormous coconut crab, specimens of which may reach a length of 33 cm. The powerful claws of this fearsome crab can puncture tin cans and have been seen to snap apart the hard shells of fully grown dead tortoises. Juvenile tortoises stay hidden - so effectively in fact that for a time scientists on Aldabra, finding only adults, speculated in jest that the tortoises, like so many amoebae, reproduced by dividing in half!

Individuals which manage to survive those first crucial years enjoy a life free of many of the hazards that would confront them elsewhere in the world, for large carnivores, speeding cars, and guns are unknown. Yet, the rugged, uncompromising terrain and the blistering hot tropical sun pose their own hazards. Time and again one finds animals with punctured or fractured shells. Others are less fortunate. A bleached shell amid a jumble of champignon gives testimony to an animal that, perhaps

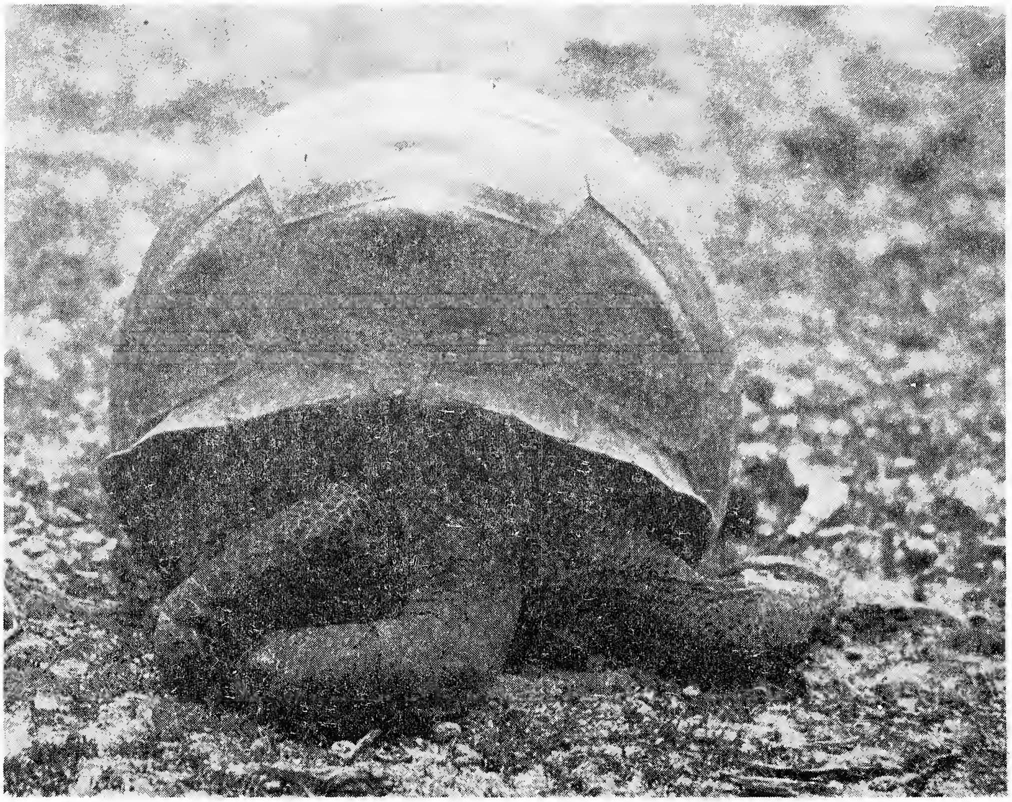

Fig. 1. Aldabra tortoise sleeping in open on overcast day.

in trying to reach some tasty green morsel, became wedged in the rocks, and unable to extricate itself, died there, baked to death by the sun.

A prolonged death by starvation awaits any tortoise unlucky enough to blunder into one of the numerous deep pits that pocket the Aldabran limestone. The vase majority of thesepits occur in areas far too rugged for tortoises to traverse, but many of those that are found in the relatively flat places where tortoises abound have a scattering of bones at the bottom and sometimes one or more living tortoises awaiting certain starvation.

A more immediate threat to the tortoises is the life-giving sun itself. Aldabra is less than 10° south of the equator and the fierce midday sun is always high in the sky. Tortoises that find themselves in the scrub forest have no problem and may carry on active feeding throughout the day, as will those under cloud cover. Elsewhere some way of avoiding themidday heat is essential and tortoises take advantage of whatever their surroundings offer. One often finds them wallowing in mud flats, or cooling off in the numerous fresh water and saline pools.

Fig. 2. Tortoises seeking shade in early morning.

Along the southeast coast, sun and an open terrain combine to produce what must surely be the most remarkable sight on this unique atoll. Here prevailing landward winds and pounding surf on a rocky coast have produced a long narrow strip of perched beach along the coast. The *Sporobolus* grass covering much of this beach is favored by the tortoises and, though fresh water is essentially absent, in the very few places where minimal shade is available tortoises abound. Here as elsewhere, tortoises spend the night strewn about like so many boulders wherever they happen to be feeding at nightfall. At dawn they simply lift their heads and resume feeding. On a clear day the heat will be uncomfortable by half an hour after sunrise and the tortoises, while continuing their browsing for a time, all begin to orient toward the nearest shade trees. Then, suddenly the migration is on. A migration in minature, but spectacular indeed as hundreds of tortoises converge on a small cluster of *Guettarda* trees. Nearer to the trees the tracks of countless past marches form long parallel furrows; furrow upon furrow, with no untouched sand between. If a cloud covers the sun all movement may cease and the animals draw in their heads. When the cloud passes, out come their heads, and the march resumes.

Fig. 3. Aldabra tortoises concentrated under dead *Guettarda* tree.

By midmorning each tree may shelter over a hundred tortoises. Here they spend the day in deep cool shade provided by the dense green canopy of these low spreading trees -- cool oasis amid blistering hot desolation. These same trees may serve as havens over and over again for an individual tortoise, thus forming fixed sites along its home range.

For sheer concentration of tortoises one dead *Guettarda* observed must surely hold the record. Like other *Guettardas* of the dune, this too is sculptured by prevailing onshore winds and grows landward from its trunk in an arc that daily shelters well over a hundred tortoises. The meager shade of this leafless relic harbors a spectacular concentration of tortoises, three deep at the center and looking like a minature Volkswagen graveyard. As the day progresses the whole pile of tortoises shifts with the sun to remain in the bare-bones shadow of the tree.

In late afternoon the fierce sunlight has diminished and the cluster begins to dissolve as a swarm of tortoises lumbers forth to feed in the remaining hours before darkness. At dusk they stretch out their heads onto the sand and rest till morning. They also sometimes feed by moonlight.

Aside from these few trees, shade is provided by driftwood logs tossed onto the elevated beach by previous storms. Here competition for shade is extreme and tortoises line up like hogs at a feeding trough, if only to keep their heads shaded and cool.

Another factor aiding the survival of these magnificent beasts is their ability as herbivores to both graze and browse. In the drier open areas they are grazers, feeding primarily on sedges, grasses, and small herbs which form the distinctive "tortoise turf" plant community. Usually over half of the tortoises observed eating will be feeding on this turf. So minute and low-growing are these plants that the tortoises inevitably ingest soil as they feed. This allows much erosion to occur. Dry conditions and heavy grazing prevents formation of a continuous plant cover and in many places much dry earth is exposed. Along much of the coastal dunes *Sporobolus* grass is dominant to the exclusion of other grasses and sedges and is the favorite food of tortoises there.

In the wooded and scrub areas, the large reptiles browse on many types of woody plants. A number of species are readily eaten, and some of these show a conspicuous browse line about a yard above the ground, or as high as the tortoise can stretch their necks. While many woody plants are eaten, many apparently unpalatable species are ignored. Al-

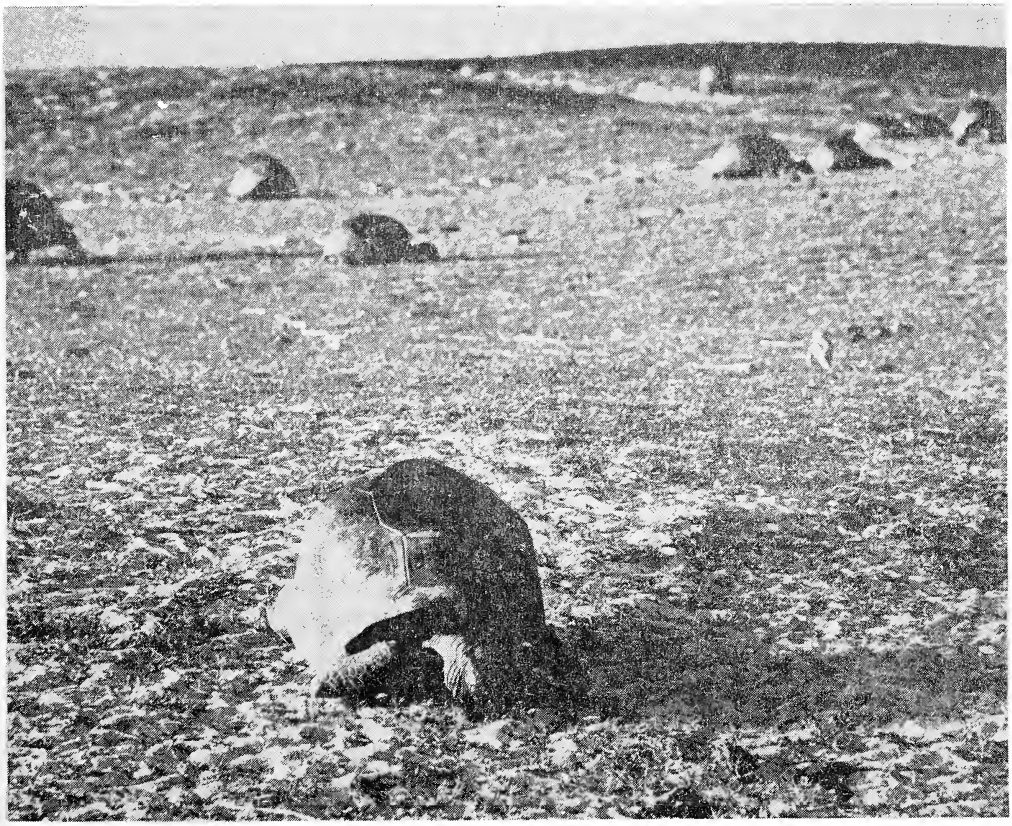

Fig. 4. *G. gigantea* grazing on 'tortoise turf'.

though they can not reach the branches of the screw pine (*Pandanus*), these are readily eaten if they are cut down, as are also dry coconut fronds. Tortoises have considerable influence on regeneration of the browse plants and the saplings of *Ficus* and *Flacourtia* are especially stunted by repeated feeding.

Although primarily vegatarians, the tortoises eat many other foods if the opportunity arises including feces and the decaying flesh of dead land crabs and other tortoises. They are probably attracted to these by the stench, and possibly these foods provide additional sources of water. There also seems to be a predilection for red-colored foods.

Drinking water is generally scarce on the atoll, though in places pools are abundant. During the wet season rain puddles provide drinking water. When free water is unavailable, tortoises probably supply most of their water through metabolism.

The onset of the rainy season in late October or November triggers reproductive activity in the adults and the emergence of the young from the nests. Aldabra tortoises are one of the few vocal turtles and male mating grunts and bellows can be heard for considerable distances during the long mating season extending from February to May. Most copulatory attempts observed were unsuccessful, as has also been noted by Grubb (1971).

Fig. 5. Tortoise drinking from algae-covered pond.

Nesting occurs from June into September, the coolest, driest months. Such a long period of time between mating and nesting (possibly six months) is rather unusual in turtles other than marine species. The female digs and covers the nest, which may be as deep as 40 cm and as wide as 30 cm, entirely with her hindfeet. The usual clutch is about 12 (4-28) almost round (49.5 x 48.5 mm), white to cream colored eggs. The young hatch and emerge from the nest shortly after the heavy October rains begin. Gaymer (1968) has noted that breeding seems most successful where the eggs are laid in guano deposits, possibly due to its moisture content as opposed to the dryer soil. Recently the reproductive habits have been studied in more detail by Grubb (1971), Frazier (1972), Swingland (1977), and Swingland and Coe (1978).

On Aldabra today one observes only the thinnest slice of time in a tortoise history extending back many thousands of years. Indeed, fossil tortoise bones at several sites on the atoll point to a long period of habitation. Turning to the literature we can extend our slice of time but slightly into the past, yet far enough to raise some surprising question. To quote Lord Rothschild (1915): "This tortoise has a very great though melancholy interest above the rest. . .in being the only one of which a few individuals still linger in a wild state. The few still living in South Island, Aldabra, owe their existence to the fact that there never has been a permanent settlement on Aldabra, and more especially to the dense scrub and mangrove fringe on the island." Why "the few still living" at that time? Were even the Aldabra tortoises nearly extinct over 60 years ago? Plainly Rothschild thought so, as did others. It was not until the 1960s that they were clearly shown to be abundant on Aldabra. What had happened? Was the decline real or had no one looked in the right places? Over much of Aldabra the terrain is too rough for tortoises to exist, but in the platin area of south Aldabra one can not possibly avoid tortoises - they are everywhere, about 20 per hectare (Bourn and Coe, 1978).

The decline reported by Rothschild (1915) was apparently real and caused by human exploitation of these animals for food. With the advent of new canning techniques and refrigerated units, by which enough food for an entire trip could be stored on ships, the demand for tortoise "steaks" no longer existed, and once again they were unmolested. Even though they are rather slow reproducers, they have had enough time to repopulate the atoll.

Today, another question arises. Could it be that the population is still growing and gradually destroying its food reserves so that another great decline or crash is inevitable? Bourn and Coe (1978) reported that tortoise biomass estimates are far in excess of those for other natural tropical ecosystems with similar rainfall, and that in some habitats the population exceeds the stable carrying capacity. Also, with increased population size there is less opportunity to find the necessary shade from the broiling tropical sun. Are more tortoises now dying of heat stroke?

Although they are slow to mature sexually, 17 to 23 years, the tortoises may live to 90 years on Aldabra, thus having a long reproductive span. Swingland (1977) reported that the low density populations are from relatively less food limited environments. They mature earlier and produce larger clutches of larger eggs. These eggs, in turn, hatch out larger young which survive better. The opposite is true of tortoises from highly populated areas. Possibly this strategy will eventually limit population growth.

It is almost certain that the doings of the tortoises will receive close scrutiny from now on (see the papers by Bourn, Frazier, Gaymer, Grubb, Honegger and Swingland). In the late 1960s the threatened construction of an Anglo-American air base focused world attention on Aldabra, and the British Royal Society - the world's oldest and most distinguished scientific body - sent forth an expedition, of which the senior author (working as an entomologist) was a member, to learn as much as possible of the Aldabran ecology - tortoises included - before the anticipated destruction of that ecosystem should become fact. Worldwide protests by conservationists coupled with devaluation of the British pound sterling led to abandonment of the air base project, yet the expedition continued with new members and through additional phases, and eventually a permanent research station was established there. What ever the fate of the tortoises, scientists will be watching and learning, hopefully without threats of air bases and other modern forms of 'progress'.

Literature Cited

Bourn, D. M.
1976a. The giant tortoise population of Aldabra (Cryptodira: Testudinidae). Part 1: Preliminary results. *Zoologica Africana* 11: 275-284.

__________. 1976b. Giant tortoises do almost too well on island reserve. *Smithsonian* 7: 82-86, 88, 90-91.

__________. 1977. Reproductive study of giant tortoises on Aldabra. *J. Zool., London* 182: 27-38.

__________ and M. Coe.
1978. The size, structure and distribution of the giant tortoise population of Aldabra. *Phil. Trans. Royal Soc. London* B. 282: 137-175.

Frazier, J. G.
1972. Behavioural and ecological observations on the giant tortoise of Aldabra atoll. Unpublished Ph.D. diss., Oxford Univ.

Gaymer, R.
1968. The Indian Ocean giant tortoise *Testudo gigantea* on Aldabra. *J. Zool., London* 154: 341-363.

__________. 1973. A marking method for giant tortoises, and field trials on Aldabra. *J. Zool., London* 169: 393-401.

Grubb, P.
1971. The growth, ecology and population structure of giant tortoises on Aldabra. *Phil. Trans. Royal Soc. London.* B. 260: 327-372.

Honegger, R.
1967. Beobachtungen an den Riesenschildkröten (*Testudo gigantea* Schweigger) der Inseln im Indischen Ozean. *Salamandra* 3: 101-121.

Rothschild W.
1915. On the gigantic land tortoises of the Seychelles and Aldabra-Madagascar group with some notes on certain forms of the Mascarene group. *Novit. Zool.* 22: 418-442.

Swingland, I. R.
1977. Reproductive effort and life history strategy of the Aldabran giant tortoise. *Nature, London* 269: 402-404.

_______________ and M. Coe.
1978. The natural regulation of giant tortoise populations on Aldabra Atoll. Reproduction. *J. Zool., London* 186: 285-309.

Department of Biology, George Mason University, Fairfax, Virginia 22030

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MISCELLANEOUS DISTRIBUTIONAL RECORDS FOR MARYLAND AMPHIBIANS AND REPTILES

According to Harris (1975), seven of the amphibians and reptiles listed below represent new county and/or physiographic records for the state of Maryland. Specimens of six of the species discussed here have been deposited in the herpetological collections of the Natural History Society of Maryland (NHSM) and Towson State University (TSU).

Eurycea b. bislineata (A 4775 NHSM). A specimen of this salamander was recently received through R. Czarnowsky, and was collected along a small creek at the north end of Big Mill Pond (elevation 6.0 m) in extreme south-central Worcester County on 13 April 1977 by D. Hurst. The present record is approximately 42 km south-southeast of the only other known lower Eastern Shore, Maryland locality, about which some confusion exists as to the site of actual collection. Data regarding this initial record (USNM 141312-4; three specimens) are "about 17 miles" (27 km) NE Nanticoke, Wicomico County, on Md. Route 249, collected on 30 March 1949 by R. Mansueti (F.I. McCullough, pers. comm.). As there does not appear to be a Route 249 in Wicomico County, the data are probably best interpreted as Route 349 (for which Route 249 may be a lapsus), which trends in an east-northeast direction from Nanticoke to Salisbury. Such an interpretation yields a collection site roughly 4.0 miles (6.4 km) west of Salisbury's city limits.

Eurycea l. longicauda (TSU 1860). A series of five juvenile specimens (range 32-40 mm SVL; mean 35.4 mm SVL) was collected on Race Road (AOR) (elevation 60 m), Anne Arundel County, between 2100 and 2400 hrs on 4 May 1977 by A. O'Connell and R. Sinners. This is the first record of this salamander on the coastal plain of Maryland. The locality, however, is in close proximity to the Fall Line, being roughly 5.0 km from the zone of contact between coastal plain and piedmont.

Bufo a. americanus (TSU 1740). A single American toad was collected by J. F. Cover and others in a water-filled depression off All Faith Church Road, 1.3 km S JCT All Faith Church Road and Golden Beach Road, St. Mary's County, on 4 March 1977. An additional series of six specimens (TSU 1719) was obtained nearby one week later (11 March) in a pond along Md. Route 6, 1.6 km E JCT Md. Route 6 and All Faith Church Road. Both localities are the first for the county and lie in the coastal plain at an elevation of 13 m.

Rana sylvatica (TSU 1739). A series of four wood frogs was collected with the same locality data and date of collection as TSU 1740 above. These are also the first specimens from St. Mary's County.

Sceloporus undulatus hyacinthinus. In an article overlooked by Harris (1975), this species was recorded by Mansueti (1958) from the Cranesville (Pine) Swamp in extreme west-central Garrett County (elevation 775 m). It represents the only reported occurrence of this lizard on Maryland's Alleghany Plateau, an area comprising ca. 1950 sq km (Garrett County and extreme western Allegany County). J. A. Fowler, who is listed by the late Mansueti as a field companion, has tentatively indicated (pers. comm.) that to his knowledge no specimens were deposited in collections. Five other species recorded by Mansueti (1958) are of additional interest in that most represent rarely collected forms on the Plateau; all are of significance as records for the Cranesville Swamp, as this area has been one of the most frequented by local naturalists.

Rana catesbeiana. While perhaps generally distributed throughout the Alleghany Plateau, this is only the second reported locality.

Terrapene c. carolina. This turtle is decidedly uncommon on the Plateau, in distinct contrast to the remainder of the state. Harris (1975) plotted three other localities for Garrett County.

Thamnophis s. sauritus. Only one other mapped locality is available for the Alleghany Plateau (Harris, 1975). This is based on a sight record by J. E. Cooper, who found the species along the edge of the large pond (5.25 ha) at New Germany State Park, New Germany, Garrett County, sometime during 1948 (J. E. Cooper, pers. comm.). A third locality for Garrett County has been supplied by A.W. Norden (pers. comm.), who found an individual at a drained pond on the property of Bear Creek Rearing Station (trout hatchery), Engle Mill, during the early 1970s. The snake was not retained.

Agkistrodon contortrix mokasen. This species is regarded as uncommon on the Alleghany Plateau of Maryland (McCauley, 1945; Franz, 1968). Four records were plotted by Harris (1975).

Crotalus horridus. While generally distributed throughout the Plateau (Harris, 1975) and reported 5.0 km to the southeast by Franz (1972), no other records are available for the Swamp.

Eumeces laticeps (R 2335 NHSM). An uncatalogued juvenile (55 mm SVL; tail broken) was recently discovered in the collection of R. Franz. It was obtained by Franz at McKay's Farm, Taylorsville, Carroll County, on 6 November 1965 at an elevation of approximately 240 m. Details regarding its collection are not available, although the record should be considered reliable (R. Franz, pers. comm.). This is the first documentation of this lizard in the interior of Maryland's piedmont. Previously published localities for Maryland's Piedmont and Appalachian Provinces (Fowler, 1946; Meanley, 1951; Harris, 1975) suggest a northerly dispersal from the coastal plain via the Potomac River Valley.

Diadophis p. punctatus x *edwardsi* (TSU 1636). An example of this intergrading subspecies (Conant, 1946) was collected by the writer from under the bark of a dead pine along Wango Road, 1.3 km S JCT Wango Road and Md. Route 350, Wicomico County, on 30 April 1977 (elevation 13 m). The specimen is apparently the first record for the county and the last for the state's 23 counties.

I thank John E. Cooper, James A. Fowler, Richard Franz, Frances I. McCullough and Arnold W. Norden for providing information relevant to this note.

Literature Cited

Conant, Roger.
1946. Intergradation among ring-necked snakes from southern New Jersey and the Del-Mar-Va Peninsula. *Bull. Chicago Acad. Sci.* *7*(10):473-482.

Fowler, J.A.
1946. A new locality record for *Eumeces laticeps* (Schneider) in Maryland. *Proc. Biol. Soc. Washington* *59*(33):165.

Franz, Richard.
1968. A copperhead from Garrett County, Maryland. *Bull. Maryland Herp. Soc.* *4*(3):61.

______________.
1972. Maryland herpetology. 72-0006. Timber rattlesnake. *Bull. Maryland Herp. Soc.* *8*(3):82.

Harris, Herbert S., Jr.
1975. Distributional survey (Amphibia/Reptilia): Maryland and the District of Columbia. *Bull. Maryland Herp. Soc.* *11*(3):73-167.

Mansueti, Romeo.
1958. The Cranesville Pine Swamp. *Atlantic Nat.* *13*(2):72-84.

McCauley, Robert H., Jr.
1945. The reptiles of Maryland and the District of Columbia. Published by the author, Hagerstown, Md., 194 pp., illus.

Meanley, Brooke.
1951. *Eumeces laticeps* (Schneider) in the Alleghanian Zone of Maryland. *Proc. Biol. Soc. Washington* *64*(8):59-60.

—Robert Miller, *Museum of Zoology, Towson State University, Towson, Maryland 21204.*

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AN INSTANCE OF A DESERT IGUANA PREYED UPON BY A LOGGERHEAD SHRIKE

In compiling an annotated bibliography of the desert iguana, *Dipsosaurus dorsalis*, I was not able to discover any published observations of shrikes as predators. Funk (1965) reported *Dipsosaurus* preyed upon by sidewinders (*Crotalus cerastes laterorepens*). Van Denburgh (1922) reported the prairie falcon as a predator. An actual instance of predation by a shrike on a lizard was provided by Pickwell (1947, pl. 59) who included a photograph of a *Uta stansburiana hesperis* (Northern brown shouldered lizard) pinned to a willow stem by a California shrike. Montanucci (1965) reported the shrike as a known predator of the San Joaquin Valley leopard lizard, *Gambelia silus*, in western Fresno County, California.

During a Mira Costa College field trip to sand dunes just east of Palm Desert, Riverside County, California, on 9 April 1978, several members of the class and I observed one adult and a number of juvenile desert iguanas, *Dipsosaurus dorsalis dorsalis*. They were particularly noticed by turning over dead bushes of Russian thistle, *Salsola kali*. Two students, Sam Unotoa and James Rosier, were diligently searching the widely spaced creosote bushes (*Larrea divaricata*) when at 1330 they spotted a juvenile desert iguana running on the sand dunes for shelter. There then suddenly appeared a loggerhead shrike, *Lanius ludovicianus sonoriensis*, which flew in pursuit of the lizard and swiftly captured the lizard in its beak. The bird then flew to a nearby creosote bush. Sam Unotoa observed that there were two shrikes, actually juveniles, perched in the same creosote bush. James Rosier rushed over to the shrike and then noticed that the bird could not fly too well, possibly from the weight of the lizard, and then caught the shrike with his hands. The bird with the *Dipsosaurus* in its mouth was then displayed to other members of the class. At the time of class observation only the lizard's tail was visible jutting out of the bird's mouth. I tried to dislodge the lizard by pulling on the tail. The lizard was too well enlodged and my efforts resulted in the tail breaking off. The bird with its prey was then released in an adjacent creosote bush. In addition to the two juvenile shrikes, an adult shrike was also observed in the area, possibly a parent of the two juveniles. The list of predators of desert iguanas should include shrikes.

Literature Cited

Funk, R. S.
1965. Food of *Crotalus cerastes lateroropens* in Yuma County, Arizona. *Herpetologica 21*: 15-17.

Montanucci, R. R.
1965. Observations on the San Joaquin leopard lizard, *Crotaphytus wislizenii silus* Stejneger. *Herpetologica 21*(4):270-283.

Pickwell, G. B.
1947. Amphibians and reptiles of the Pacific states. *Stanford, California: Stanford Univ. Press*, xiv, 1-23 p., 64 pls.

Van Denburgh, J.
1922. The reptiles of western North America. Vol. 1 - Lizards. *California Acad. Sci., Occas. Pap.* (10): 611 pp., 128 plates

---Benjamin H. Banta, *San Diego Natural History Museum, P. O. Box 1390, San Diego, California 92112.*

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SAUROPHAGY IN *Cnemidophorus hyperythrus beldingi* STEJNEGER

Bostic (1966) provided a detailed analysis of stomach contents of *Cnemidophorus hyperythrus beldingi* from San Diego County, California, and Baja California Norte, Mexico. The results indicated that arthropods, primarily Isoptera and Araneae, constituted the main energy source.

It was interesting, therefore, to discover a hatchling *Uta stansburiana hesperis* Richardson in the stomach of an adult male *C.h. beldingi* obtained along Nate Harrison Grade in Pauma Valley, San Diego County, California, on 11 July 1970. The *C. h. beldingi* (SDNHM 59409) has a snout-vent length of 63 mm and was captured in a pitfall trap located at 1350 feet elevation. The snout-vent length of the slightly digested *U. s. hesperis* is 22 mm.

Literature Cited

Bostic, D. L.
1966. Food and feeding behavior of the teiid lizard, *Cnemidophorus hyperythrus beldingi*. *Herpetologica* 22(1):23-31.

—James Berrian and Benjamin H. Banta, *Department of Herpetology, San Diego Natural History Museum, P.O. Box 1390, San Diego, California 92112.*

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News & Notes

EARTHWATCH
BULLETIN

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AMATEURS TO HELP SOLVE CARIBBEAN PUZZLE

Belmont, MA -- Amateur biologists, herpetologists and SCUBA divers will be helping scientists solve an intriguing puzzle about the animal life in the Caribbean. Participants will join J. David Hardy, Associate Curator of Maryland's Natural History Society, on the tiny island of Tobago. Despite its isolation from South America, the island supports many mainland species not found on other nearby islands. By surveying and collecting terrestrial and marine animals, the research team will try to find out where these animals came from and how they got to Tobago. Participants will live in beach-front cottages on the beautiful Man O' War Bay, where they will be in close proximity to the many rivers and mountainous areas which support a fantastic array of wildlife. Each participant's share of the costs is $700 and is tax-deductible.

This expedition is one of the many research projects in wildlife ecology EARTHWATCH is sponsoring in 1979. EARTHWATCH is a non-profit organization located in Belmont, MA which gives amateurs the opportunity to join research projects all over the world, working with professionals and sharing the excitement of field research. Participants range in age from 16 to 75, and represent a wide variety of occupations, but they all share the enthusiasm and the desire to work and learn in the field.

For more information, contact EARTHWATCH, Box 127 M, 10 Juniper Rd. Belmont, MA. ; (617) 489-3030

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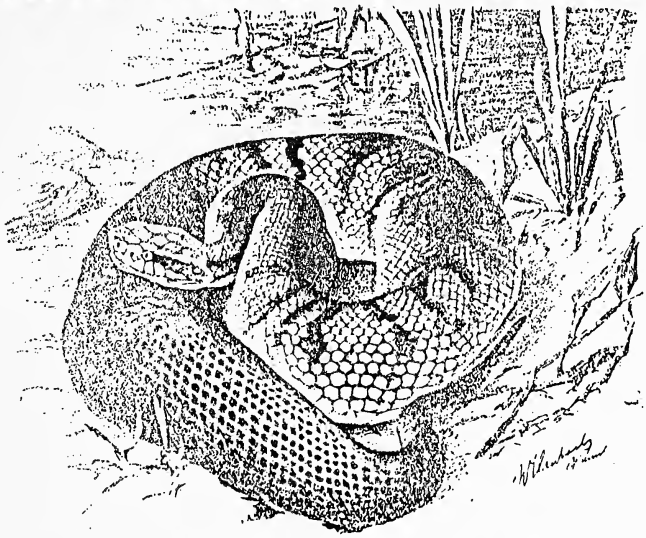
Handbook of Snakes



VOLUME 3: BIBLIOGRAPHY

about 200 pages, with new introduction, portrait; 6 x 9 inches

ALBERT HAZEN WRIGHT and Anna Allen Wright's *Handbook of Snakes of the United States and Canada* was first issued by Cornell University Press in 1957. The accompanying bibliography, which gives full citations for the literature references abbreviated in volumes 1 and 2, was not issued until 1962 and published privately by the Wrights themselves. The continuing demand for the *Handbook* caused Cornell to reissue it several times since but the bibliography, which is essential to the full use of those volumes, has been unavailable for nearly a decade and yet it is absolutely necessary for any comprehensive library on North American reptiles.

The bibliography is a detailed list of 3500 references arranged in several sections. There is a general list given chronologically and divided into named periods; a list of literature according to life zones and ecological classifications; and finally a geographic listing by state and province. The extensive bibliography on pitvipers in Klauber's *Rattlesnakes* overlaps only slightly with the Wrights' list so that together these two works provide the most complete bibliography of the snakes of North America.

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A pricelist of other Society publications can be obtained on request from Dr. Taylor.

1979 REPTILE SYMPOSIUM IN KNOXVILLE

The Third Annual Reptile Symposium on Captive Propagation and Husbandry will be hosted by the Knoxville Zoological Park on August 10-11, 1979. Arrangements are being made for papers and presentations by many leading herpetologists. Registration is $40.00 per person, with special group and single day rates. This symposium will immediately precede the SSAR Conference to be hosted by the University of Tennessee in Knoxville.

For further information, contact Howard Lawler, Department of Herpetology, Knoxville Zoological Park, P. O. Box 6040, Knoxville, Tennessee 37914.

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HOST: Knoxville Zoological Park Department of Herpetology.

DATES: August 10-11, 1979, immediately preceding 1979 SSAR Conference in Knoxville.

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*Will you need transportation from the Holiday Inn to the Knoxville Zoo on August 11?

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The Society also publishes a Newsletter on a somewhat irregular basis. These are distributed to the membership free of charge. Also published are Maryland Herpetofauna Leaflets and these are available at \$.05/page.

Information for Authors

All correspondence should be addressed to the Executive Editor. Manuscripts being submitted for publication should be typewritten (double spaced) on good quality 8½ x 11 inch paper, with adequate margins. Submit original and first carbon, retaining the second carbon. Indicate where illustrations or photographs are to appear in text. Cite all literature used at end in alphabetical order by author.

Major papers are those over 5 pages (double spaced, elite type) and must include an abstract. The authors name should be centered under the title, and the address is to follow the Literature Cited. Minor papers are those papers with fewer than 5 pages. Author's name is to be placed at end of paper (see recent issue). For additional information see *Style Manual for Biological Journals* (1964), American Institute of Biological Sciences, 3900 Wisconsin Avenue, N.W., Washington, D.C. 20016. Price is \$6.00.

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The Maryland Herpetological Society
Department of Herpetology
Natural History Society of Maryland, Inc.
2643 North Charles Street
Baltimore, Maryland 21218


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BULLETIN OF THE Maryland Herpetological Society

DEPARTMENT OF HERPETOLOGY

THE NATURAL HISTORY SOCIETY OF MARYLAND, INC.

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SEPTEMBER 1979 VOLUME 15, NUMBER 3

BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

Volume 15 Number 3 September 1979

CONTENTS

COMMENTS & LETTERS RECEIVED

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The third Wednesday of each month, 8:15 p.m. at the Natural History Society of Maryland (except May-August, third Saturday of each month, 8:00 a.m.). The Department of Herpetology meets informally on all other Wednesday evenings at the NHSM at 8:00 p.m.

BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

VOLUME 15 30 SEPTEMBER 1979 NUMBER 3

SOME DIETARY AND ECOLOGICAL CONSIDERATIONS OF THE COMMON SNAPPING TURTLE IN DELAWARE

Peter F. Townsend

ABSTRACT

The literature on the feeding habits of the Common Snapping Turtle, *Chelydra serpentina serpentina,* was reviewed. Their diet was found to consist of approximately 80% animal matter and 20% vegetable matter. These proportions vary with habitat, the most carnivorous turtles occurring in lentic ecosystems. Gamefish and water fowl each constitute under 1% of volume of a snapper's diet. Because of their minimal impact on gamefish and fowl, and due to the survival pressure caused by turtle trappers, conservation measures are not recommended in Delaware waters.

Lotic, lentic, and estuarine ecosystems, in addition to abundant deciduous and coniferous forests, make Delaware capable of supporting a wide diversity of herpetofauna. Included are some fourteen species of anurans, eleven of salamanders, and thirty-six of reptilés, including nine species of turtles (Conant, 1947). The common snapping turtle, *Chelydra serpentina serpentina,* is the largest of Delaware's semi-aquatic turtles, both in size and in number (Arndt, 1975). Fossil evidence of *C. serpentina* in the Chesapeake and Delaware bay areas dates back to the Pleistocene epoch, 10,000 years B.C. (Schwartz, 1967). The turtles exploit all types of fresh water communities, and also range into slightly brackish water, as in the Odessa Tidal creeks and Bombay Hook Wildlife refuges (Conant, 1947; Schwartz, 1967). Contrary to reports by turtle trappers, the alligator snapping turtle, *Macroclemys temmincke*, has never been observed in Delaware. Its northernmost limit on the eastern seaboard is southern Georgia (Conant, 1976).

A diversified diet enables the snapping turtle to exploit a variety of niches, although it prefers lentic habitats with many obstructions to serve as cover (Froese & Burghardt, 1975; Froese, 1978; Lagler, 1943: Punzo, 1973). Surface (1908) was the first to report on the stomach contents of snapping turtles. The analysis of ingested materials has since been correlated with type of habitat, and, all findings have been essentially the same (Coulter, 1957; Gibbons & Tinkle, 1969; Lagler, 1943; Pell, 1940; Penn, 1950; Punzo, 1973). Generally, fish comprise 39% of a snapping turtle's diet, ranging from a high of 69% in lakes to a low of 18% in swamps. Crayfish constitute only 8% of volume of food ingested, but it is the most frequently eaten invertebrate, occurring in 37% of all stomachs analyzed, and it often surpasses the volume of fish ingested by turtles taken from a lotic ecosystem (Penn, 1950). Mammals comprise 7% of a turtle's diet by volume. In general water fowl constitute 2% of the volume, although this figure has a wide range, depending on what study is read. Plants comprise 20-30% of the volume. This percentage varies with the nature of the habitat where the snapping turtles occur. Ten per cent of the volume is usually unidentifiable matter. Correlation of food and habitat is summarized in Table 1.

Table 1. Correlation of stomach contents and habitat (from Pell (1940) and Maurice (1943)).

	Percent Volume					
Habitat	Fish	Plants	Crayfish	Mammals	Birds	Unknown
Lakes	69	13	10	3	0	5
Ponds	42	35	6	3	0	14
Streams	32	36	11	12	2	7
Swamps	18	59	4	9	2	8
Total	38	37	8	7	1	7

These results can be interpreted to mean that a snapping turtle's feeding habits are determined by the flora and fauna immediately available (Gibbons & Tinkle, 1969; Lagler, 1943; Maurice, 1943). Lagler, (1943) observed that when the usual prey organisms are not abundant, snappers will occasionally become cannibalistic.

There seems to be some confusion in the literature as to whether carrion or fresh meat is preferred by snapping turtles. Pell (1940) and Schwartz (1967) cited a preference for carrion. Lagler (1943), Arndt (1975), Conant (1947), and Maurice (1943) state explicity that there is a preference for fresh bait. Lagler (1943) added that carrion older than six days was avoided by the turtles. My own observations and the reports of trappers interviewed indicate that snapping turtles show a marked preference for meat less than 24 hours old.

The ecological impact of predators on gamefish and water fowl has raised some questions as to whether snapping turtle populations should be controlled. Stomach content analyses have shown an average of 0.8 gamefish per turtle (Hammer, 1943; Lagler, 1943; Maurice, 1943; Pell, 1940; Punzo, 1973), an almost negligible effect on gamefish population. Furthermore, certainly part of the fish was eaten as carrion, minimizing even more the predatory effect on fish.

The impact on water fowl is somewhat more significant. Coulter (1957) estimated that, at a density of 2 ducks/HA., snapping turtle predation can remove an estimated 13% of the duckling population over a sampling period of 25 days with an average of 60 turtles per/HA (Froese & Burghardt, 1975; Mayor, 1975). At periods of low water, there is an increase in duckling predation (Coulter, 1957). The body weight of the turtle is often directly proportional to the number of adult fowl taken (Spellett, 1973). The average frequency of water fowl taken is 3 birds/turtle. Coulter (1957) also reports that surface feeding ducks were taken twice as often as diving ducks. This would tend to affect duck population mostly from the Silver marsh, Delaware City marsh area, and all inland tidal creeks where the puddle duck populations are most dense. Mammalian prey is virtually limited to muskrats or an occasional mouse that ventures across a farm pond. Although mammalian flesh contributes 7% to a snapper's diet, the effect on the muskrat population is minimal. Areas with a high density of turtles show no perceptive decrease in the average number of muskrats trapped.

Snapping turtles fall prey mostly to man, although predation of other mammals on the nests is heavy; Norway rats and raccoons prey on newly laid eggs, and can eliminate 45% of the population (Arndt, 1975; Hammer, 1969).

The suitable habitats for turtles in Delaware are not being eliminated by progress or pollution, as is the case in many other parts of the country. Due to the large demand for snapping turtle meat in the Philadelphia and Baltimore fish markets, man is the most voracious predator of the snapper. Nevertheless, the population in Delaware is still in equilibrium. In accordance with other studies (Coulter, 1957; Lagler, 1943; Mayor, 1975; Maurice, 1943; Punzo, 1973; Spellett, 1973), population conservation in areas with high densities of gamefish and water fowl is not recommended. Hopefully, if environmental selection pressures stay as they are, the snapping turtle will remain as one of Delaware's natural assets.

Literature Cited

Arndt, R.G.
1975. Turtles of Delaware. *Delaware Conservation Magazine, 19*(1):10-15.

Conant, R.
1947. VI. Reptiles and amphibians in Delaware, pp. 23-25. *In*: Delaware, a history of the first state. *Lewis Historical Publishing Co., Inc., New York.*

__________.
1975. A field guide to reptiles and amphibians of eastern and central North America. *Houghton Mifflin Co., Boston,* xviii + 429 pp.

Coulter, M. W.
1957. Predation by snapping turtles upon aquatic birds in Maine marshes. *J. Wildlife Management, 21*(1):17-21.

Froese, A.D. and B. M. Burghardt.
1975. A dense natural population of common snapping turtles (*Chelydra serpentina serpentina*). *Herpetologica, 31*(2):205-208.

Froese, A.D.
1978. Habitat preference of the common snapping turtle (*Chelydra serpentina serpentina*). *J. Herpetology, 12*(1):53-53.

Gibbons, W. S. and D. W. Tinkle.
1969. Reproductive variation between turtle populations in a single geographical area. *Ecology, 50*:340-341.

Hammer, A. D.
1969. Parameters of a marsh snapping turtle population, La Creek Refuge, S. Dakota. *J. Wildlife Management, 33*(4):995-1005.

Lagler, K. F.
1943. Food habits and economic relations of the turtles of Michigan with special reference to fish management. *Am. Midl. Nat., 29*(2):257-312.

Mayor, P.D.
1975. Density of snapping turtles (*Chelydra serpentina*) in western West Virginia. *Herpetologica, 31*:332.

Maurice, A. M.
1943. Food habits of the common snapping turtle in Connecticut. *J. Wildlife Management, 7*(3):278-282.

Pell, S. M.
1940. Notes on the food habits of the common snapping turtle. *Copia, 1940*(2):131.

Penn, G. H.
1950. Utilization of crawfish by cold-blooded vertebrates in eastern U.S. *Am. Midl. Nat. 44*:643-658.

Punzo, F.
1973. Studies of the feeding behavior, diet, nesting habitat, and temperature relations of *Chelydra serpentina osleola. J. Herpetology, 9*(2):207-210.

Schwartz, F. J.
1967. Maryland turtles. *Uni. Maryland Nat. Resources Inst. Educ. Ser.* (79):1-38.

Spellett, J. J.
1973. Ecological relations of water fowl and snapping turtle populations. *Dis. Abstracts, 34B*(1):178.

Surface, H. A.
1908. First report on the economic features of the turtles in Pennsylvania. *Pa. Dept. Agriculture, Div. Zool., Zool. Bull., 6*(4&5):186-195.

Department of Environmental Population and Organismic Biology,
University of Colorado, Boulder, Colorado 80309
Present address: *1211 Stoney Run Drive, Wilmington, Delaware 19803*

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THE LESSER AFRICAN ROCK PYTHON

Tracy J. Miller and Hobart M. Smith

During the past year at least six specimens and possibly more of a strange python have been imported into the United States from Jonathan E. Leakey in Nakuru, Kenya, East Africa. Three of them came into the possession of the first author in January 1979, and considerable information on others has been kindly provided by their owners. All are very similar in appearance, and also basically similar to *Python sebae* (Gmelin), but they also differ from the latter species in numerous ways, involving structure, color, pattern and biology. We are convinced that they represent not a variant of *sebae* but a distinct entity. Geographical origin of the specimens is the vicinity of Mwingi, Kenya. The specimens were taken within the known range of *sebae* and therefore represent a species sympatric with *sebae*.

Determination of the identity of this species has defied our every effort. It is certainly not referable to *Python anchietae* Bocage or *P. regius* (Shaw), the only species other than *P. sebae* presently known to occur in Africa. Fitzsimons (1962: 94) and Stimson (1969: 31) have provided excellent synonymies for *sebae*. Its synonyms (i.e., *Coluber speciosus* Bonnaterre, 1789; *Boa hieroglyphica* Schneider, 1801; *Python houttuyni* Daudin, 1803; *Python natalensis* Smith, 1840; *Heleionomus variegatus* Gray, 1842; *Python liberiensis* Hallowell, 1845) were either proposed early, in ignorance of Gmelin's earlier name, or in the case of the 1842 and 1845 names, on the basis of material clearly referable to *sebae* and not to the present species. Gray's *variegatus* (later synonymized by himself with the name he was then accepting for the African rock python, namely *natalensis*) from unknown locality, and Hallowell's *liberiensis* are both eliminated from consideration by possession of large scales in the frontal and prefrontal area.

Pitman's *Python jubalis* of 1936, from the Juba River, is a *nomen nudum* (Stimson, *loc. cit.*) and may well have been applied to this species. Pitman's recent review of the snakes of Uganda (1974: 67) mentioned only that *jubalis* is a *nomen nudum* in accordance with Loveridge's (1957: 248) appraisal. Therefore, even if the name was applied to the present species, it is not nomenclaturally occupied. See further remarks under Range.

Thus it is apparent that no name is available for the taxon represented by the present specimens and that we regard as distinct. We accordingly here propose a name for it, although we keenly regret the uncertainty of the entire range of the species. We also recognize the possibility that what we interpret as a distinct species may prove to be a result of some genetic anomaly, such as polyploidy, although since males are represented it is at least not a case of parthenogenetic polyploidy. The apparent constancy or near-consistency of a large number of presumably distinctive characteristics in the reasonably large total sample, and the failure of the numerous *sebae* we have seen to conform with them in any way, convince us that a valid taxonomic entity is entailed. We name it

Python saxuloides sp. nov.

Holotype. Univ. Colorado Museum (UCM) 51932, female, presumably subadult, from the vicinity of Mwingi, Kenya. Obtained from Jonathan E. Leakey. Paratypes. Two, UCM 51933-4, female and male respectively, both presumed subadults; source same as for holotype. All specimens at present alive.

Diagnosis-Definition. A moderate-sized species, apparent maximum total length about 4-5 m, reaching sexual maturity at apparently 2-2.5 m; similar otherwise to *Python sebae* (which reaches at least 7 and perhaps 8 m, and becomes sexually mature at about 3-3.5m) except: scales posterior to anterior prefrontal area small, subequal in size, 3-6 between anterior supraoculars, 6-7 between posterior supraoculars, 9-11 between upper postoculars; scales around eyes relatively nearly uniform in size, supraoculars and preoculars not greatly larger than suboculars; interorbital distance about 80% orbitorostral distance, over 70% distance between rostral and rictus oris; eyes nearly vertical in dorsal view; iris black, pupil scarcely distinguishable; 3 supralabials contacting circumorbitals; subocular dark triangle (as of *sebae*) reduced to a small round dot, smaller than eye, surrounded by a white area extending from preocular area below the orbitonasal line diagonally to lip and backward to rictus oris; postorbital dark line narrower than eye-diameter, ending just above and curving behind rictus oris; yellow supraocular-temporal line broader than eye, continuous posteriorly with ground color behind rictus oris, originating in anterior prefrontal area; loreal dark area continuous anteromedially across dorsal surface of snout, involving internasals and anterior prefrontals, on lip extending between a dark vertical bar on suture between 1st and 2nd supralabials and another on 7th supralabial; posterior edge of loreal dark zone essentially convex; no subnasal light line; throat moderately black-flecked throughout, no blotches on infralabial area; a nearly continuous dark line connecting dorsolateral series of dark spots but enclosing a series of light spots extending throughout length of body; dark spots in median series reduced to dark crossbars, each only somewhat expanded medially, or not at all, and irregularly fused with dorsolateral line; therefore a median series of light blotches but little narrowed at midline; lateral vertical bars separated from each other by 2-4 times their own length, posteriorly fused with dorsolateral dark line, often expanded and enclosing a central light spot at point of junction, not prominently dark- and light-edged posteriorly, fading anteriorly, but more or less uniform, narrow; dorsal caudal light stripe confined to base of tail, broken irregularly over rest of tail; ventral surface of tail with a median light stripe. Temperament usually mild, body relatively slender.

Description of holotype. Median head scales uniformly small, 6 between anterior pair and 7 between posterior pair of supraoculars, 11 between upper postoculars; circumorbitals subequal in size, suboculars relatively large but supraoculars and preoculars not greatly larger; total circumorbitals 10, 11; preoculars 2, 3; postoculars 4, 4; suboculars

2, 2; supraoculars 2,2; supralabials 14-14, infralabials 19-19; rostral pitted on both sides; 1st and 2nd supralabials pitted; infralabials with pits 2-4, 13-16 on one side, 2-4, 12-15 on other; scale rows 64-84-50; ventrals 278; caudals 72. Total length 160 cm, tail 19 cm; width of head at midorbital level, 20 mm; rictus oris to tip of snout (straight line) 45 mm; midorbit to tip of snout (straight line) 25 mm.

Ground color of body light, yellowish olive green, more whitish toward belly; dark markings chocolate brown, edged with blackish brown; dorsal and dorsolateral dark zone covering about 40 medial scale rows; lateral vertical bars separate from dorsal dark zone on anterior three-fifths of body, mostly fused to it posteriorly, with no exceptions in anterior and posterior quarters of body, some variation medially; anterior part of dorsal dark zone composed of eight crossbars, little fused longitudinally, somewhat irregular in shape, with little enclosure of light spots; following these 8 bars, dark markings continuously fused and enclosing a rather regular dorsolateral series of light spots on each side, and a central series of larger light spots; enclosed dorsolateral light spots closely coinciding in position with lateral dark bars. Belly and throat whitish, profusely dark-flecked; flecks under throat smaller. On tail, dorsolateral dark lines fused irregularly across middorsal light line, this latter discontinuous over most of tail length; lateral caudal dark bars extending onto ventral surface of tail but not fused there, leaving a continuous longitudinal medial white line.

Tip of snout light between a dark line on each side along suture between 1st and 2nd supralabials; central dark arrowhead on head with a small postparietal light spot and continuous with a pair of nuchal dark blotches largely enclosing a Y-shaped light central spot; iris black, pupil scarcely visible. Pattern otherwise as in Diagnosis-Definition. Very docile, mild-tempered, body relatively slender (15 cm maximum circumference).

Variation. The two paratypes are essentially identical with the holotype in color and pattern, except that in 51934 the light blotches enclosed between the dorsolateral dark zones tend to be vertebral in position, narrow and elongate, and all the dark markings are darker, virtually black. Respectively (nos. 51933-4) they have the following scale counts and measurements: total scales around eye 9-10, 11-12; preoculars 2-2, 2-3; postoculars 3-4, 5-5; supraoculars and suboculars 2-2, 2-2; scales between anterior supraoculars 3 and 5, between posterior supraoculars 6 and 7, between dorsal postoculars 9 and 11; 3 supralabials contacting circumorbitals on both sides of both; supralabials 14-14, 14-14; infralabials 20-19, 20-19; scale rows 69-89-52, 64-86-55; total length 160, 162 cm; tail 19.5, 18 cm; intermidorbital width 20, 18 mm; rictus oris to rostral, 45, 43 mm (straight line); midorbit to rostral 25, 23 mm (straight line). One paratype mild-tempered; the other vicious, both slender-bodied (15 and 14.5 cm maximum circumference, respectively).

Comparisons. *Python sebae* is obviously the most closely similar, and presumably the most closely related species, to *saxuloides*. It differs in many ways, however, from the latter species (*saxuloides* character-states in parentheses): (1) minimum scales between supraoculars 2 (3); (2) supraoculars and preoculars much larger than--x 4-5 times--other circumorbital scales (x 2-3 times); (3) only 2 supralabials contacting circumorbitals (always 3); (4) subocular dark triangle often contacting orbit, much larger than eye, separated on each side by a narrow light line from loreal and postocular dark marks (smaller than eye, not contacting orbit, surrounded on all sides by a much larger light area); (5) postorbital dark mark broader than eye diameter (narrower); (6) supraocular-temporal light line not extending broadly onto lateral gular region, but narrowly continuous between large dark blotches with light ventral color (widened in lateral gular area, not partially/ blocked by dark blotches); (7) supraocular-rostral light line originating at tip of snout (in anterior prefrontal area); (8) loreal dark area separated from median dark arrow on top of head by supraocular-rostral light line (united); (9) a prominent diagonal subnasal light line (absent); (10) loreal dark area confined at lip between 2nd and anterior edge of 4th supralabial (much wider, rostral to anterior edge of 6th supralabial); (11) rear edge of loreal dark area diagonally straight or concave (convex); (12) throat and under side of head white, unmarked, except for large lineate blotches on infralabial area, sharply distinct from profusely black-flecked ventral surfaces posterior to throat (throat and underside of head black-flecked much like rest of ventral surface of body, but no blotchlike marks on infralabial area); (13) a continuous dorsal caudal light stripe (discontinuous, absent except at base of tail); (14) subcaudal surface irregularly mottled, no continuous light line (dark markings largely confined to sides, leaving a nearly straight, continuous subcaudal light line); (15) light edging of dark marks on body in bold relief against dark ground color as well as dark marks (light edging poorly defined, ground color but slightly darker); (16) dorsolateral dark line or zone enclosing a very few, scattered light spots (enclosing numerous light spots, almost full length of body); (17) light spaces enclosed between dorsolateral dark lines or zones large, often continuous, commonly narrowed centrally and expanded anteroposteriorly in paravertebral area, much more extensive than dark areas between dorsolateral dark zones (small, highly irregular but much less extensive than dark areas, not expanded); (18) iris brownish, pupil readily distinguishable (black, pupil scarcely distinguishable); (19) eyes obliquely positioned as seen in dorsal view, much exposed (nearly vertical, only apex exposed); (20) intermidorbital distance narrow, about two-thirds distance from midorbit to snout, less than 40% distance from rictus oris to tip of snout (broader, about three-quarters or more of distance from midorbit to tip of snout, more than 40% distance from rictus oris to tip of snout); (21) heavy-bodied (slender-bodied); (22) sexual maturity reached at about 300-350 cm, although maximum perhaps near 700 cm (200-250 and 450-500 cm); (23) invariably vicious, with rare exception of a few raised in captivity from hatchlings (only 1 in 6 vicious).

No structural differences, other than size of median head scales, position of eyes, slenderness, relation of circumorbitals and supralabials, and interorbital proportions, as noted above, are apparent in comparison with data in Fitzsimons (1962), Pitman (1974) and elsewhere. Perhaps not even those differences are fully distinctive, as Fitzsimons and numerous others have noted that although a pair of frontals is the rule, they "may be broken up into smaller shields". We suggest that on the contrary, the differences we have observed in this and other structural characters in *saxuloides* (including three specimens not included in the type-series) and in illustrations and numerous specimens examined of *sebae* are actually species-specific, and that the "variation" noted by others is a product of failure to distinguish the two species. The extremely large number of pattern and color differences, even though some are perhaps subject to some intraspecific variation not evident in our modest samples, is impressive collectively and, more importantly, in their constancy throughout our series of 6 *saxuloides* and numerous *sebae*, including many published illustrations.

Although it is unduly presumptuous to assume that all of the differences apparent in the small series available to us are infallibly constant, it would be difficult not to regard these differences, in their number and constancy, as alone indicative of taxonomically distinct populations. Clinching evidence however comes from the combination of those distinctions with an apparent remarkable disparity in maximum size and in size at sexual maturity. It appears that the specimens we regard as representing a distinct taxon here named *saxuloides* are past the peak of rapid growth and near sexual maturity at 160 cm total length--a size at which *sebae* is still growing rapidly and far from sexually mature. When first received in this country by Mr. Jerry Tresser of Reptile Collectors, Inc., the specimens measured 110-120 cm total length, and were no doubt 1-2 years old. At their present length they are 2-3 years old, and in another year could be expected to reach 190-200 cm. This growth rate is distinctly slower than that of *sebae*, although our specimens have been fed liberally at least during 1979 (minimally from July to December, 1978), suggesting the slowing rate of growth expected with approach to sexual maturity. In contrast, a hatchling *sebae* obtained by the first author at the same time as the *saxuloides* types has quadrupled its length in the same span of time and is still growing rapidly. Furthermore, the rate of moulting has dropped in the types of *saxuloides* from 3-wk to 6-wk intervals, whereas the rate in the *sebae* has remained the same, at about 4-wk intervals. This is a disparity also that is expected only in association with approach to sexual maturity.

We are also impressed with the marked difference between *sebae* and *saxuloides* in temperament, as our experience and that of our colleagues reveals a virtually invariable viciousness in *sebae*, whereas 5 of our 6 observed *saxuloides* are very docile.

Range. The "biological" evidence combined with structural (including pattern and color) evidence provides a convincing case for the conclusion we have reached that two species are involved. Mr. Jonathan E. Leakey reports finding *saxuloides* in the vicinity of Mwingi, Kenya, a "very dry and torrid area, where Savannah Monitors and burrowing snakes, such as sand boas are also found. *Python sebae* have been collected in the same area." The proposal by Pitman of the nomenclaturally unoccupied *jubalis* for some distinct relative of *sebae* occurring in the vicinity of the Juba River in Somalia and Ethiopia suggests the possibility that his form is the same as *saxuloides*. However, many photographs of so-called "African Rock Pythons" exist in the literature, and some clearly depict *saxuloides*, not *sebae*, adding significantly to the knowledge of both. An example is pl. 3 in Parker and Grandison (1977), showing a specimen apparently of about the same size as our type-specimens; no locality is cited. A somewhat larger specimen is illustrated in the pl. facing p.

104 in Isemonger (1962). Another seemingly of about the same size as ours is illustrated on p. 105 of Kondo et al. (1972). A ten-foot specimen is shown on pl. 2 (p. 163) of Sweeney's review of the snakes of Nyasaland (1961). Lanworn (1972) gives (p. 19) a photograph in color of a *saxuloides* that appears to be of about the same size as the types, as well as two of 3 specimens of *sebae* (pp. 60-61, 113). The largest specimen we have found illustrated is shown in Fitzsimons (1930: opp. p. 62, lower fig.); no size is given but the snake is said to contain a half-grown leopard, and appears to be perhaps 12-14 ft. in length. These photographs reinforce the impression that *saxuloides* is distinctly more slender-bodied than *sebae*, although the difference is difficult to quantify satisfactorily. The species is thus one that has long been accessible ---it simply has not heretofore been recognized as distinct from *sebae*. No doubt several examples of true *saxuloides* exist at present in zoos and museum collections all over the world, all masquerading as *sebae*. The abundance of references to it in the literature makes it unlikely that the species has a very restricted range, particularly since the species is illustrated explicitly as a part of the fauna of at least South Africa and Nyasaland (now Malawi). The other evidence suggesting its presence in Kenya, Uganda, Somaliland and Ethiopia contributes to an emerging picture of a wide-ranging species occurring throughout most of the eastern part of Africa, at least from Cape to Horn and therefore extensively sympatric with *sebae*, of which it may properly be regarded as a cryptic associate.

Remarks. The photographs published elsewhere also indicate that *saxuloides* reaches a moderately large size, perhaps to the 12-14 foot range. Our own observations on growth rate substantiate the supposition that it does not grow as rapidly or reach as large a size as *sebae*, and that it reaches sexual maturity at a smaller size.

It may be noted that existence of a sympatric cryptic species pair of moderate to large pythonids, as we here postulate for Africa, finds a precedent in the complex of species of *Eunectes* in South America (at least of *deschauenseeii*, *barbouri* and *m. murinus* near the mouth of the Amazon), as analyzed by Dunn and Conant (1936), although the extent of sympatry we postulate is far greater.

We are persuaded to name and describe the present species despite uncertainty of its range in order to bring attention to the problem, in the hopes that additional information thus adduced may provide the desired conclusivity. These conspicuous snakes are of sufficiently broad interest that concerted attention to such a major and basic taxonomic problem is fully justified.

The name *saxuloides* is derived from the Latin *saxulum*, meaning "little rock", combined with the suffix *-oides*, meaning "like" or "similar to". We use the word as an adjective, in allusion to the general impression that the species to which we apply it is essentially, or is like, a small rock python. We suggest the English vernacular "Lesser African Rock Python" for it.

Acknowledgments

We are much indebted to Jonathan E. Leakey for providing the specimens of *saxuloides* as well as giving the collection data for them.

We would like to thank Jerry Tresser of Reptile Collectors, Inc. for his invaluable assistance in directing the collection data of the specimens to us, as well as his most generous offer to provide us with additional specimens of *saxuloides* so that a breeding program can be initiated, and more data from these snakes can be obtained.

We would also like to thank Sheffield Edwards, Jr. who helped in recognizing *saxuloides* as being distinct from *sebae*, directed the material to us, permitted us to study and report it, and helped in preparation of our description; to Stan Chiras for data on several live *Python sebae*, and for directing a breeding program for the specimens; to Lawrence Rouch, III for providing data on his specimen of *saxuloides* and on one live *sebae*; to Rick Haeffner for providing a live specimen of *sebae*; to Dr. Richard E. Jones for provision of housing and encouragement in the study of the material; to Steve Sardello for help in providing housing for the specimens; and to Ralph Black for his patient forbearance in obtaining the photographs reproduced herewith.

Special thanks to Trooper Walsh for his encouragement, support and friendship without which this project could have never been undertaken.

Fig. 1. Left, holotype of *Python saxuloides*; right a *Python sebae* of approximately same size (obtained as a hatchling at same time as the *saxuloides*, still growing rapidly).

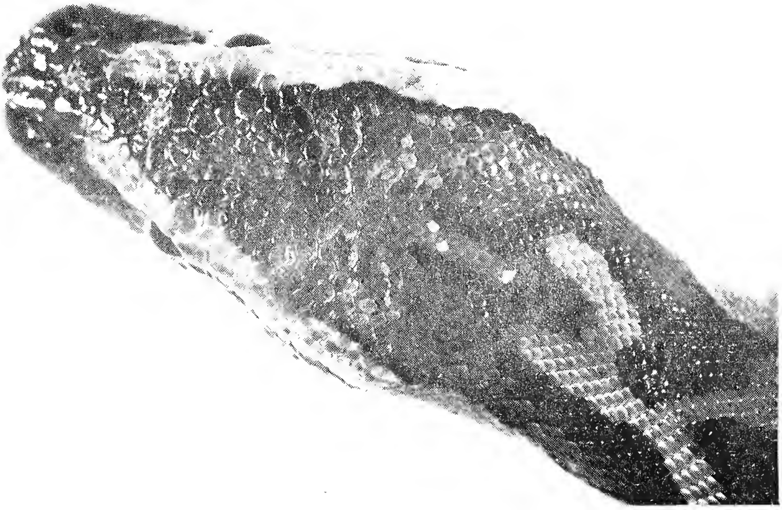

Fig. 2. Top of head, *Python saxuloides*, holotype.

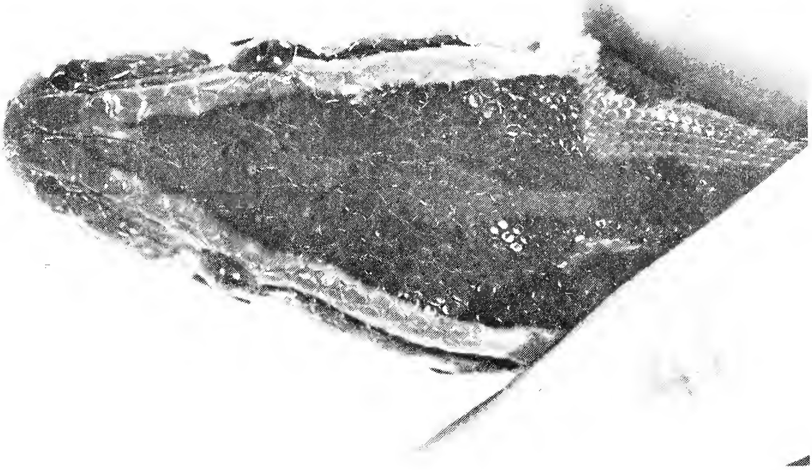

Fig. 3. Top of head, *Python sebae*.

Fig. 4. Side of head, *Python saxuloides*, holotype.

Fig. 5. Side of head, *Python sebae*.

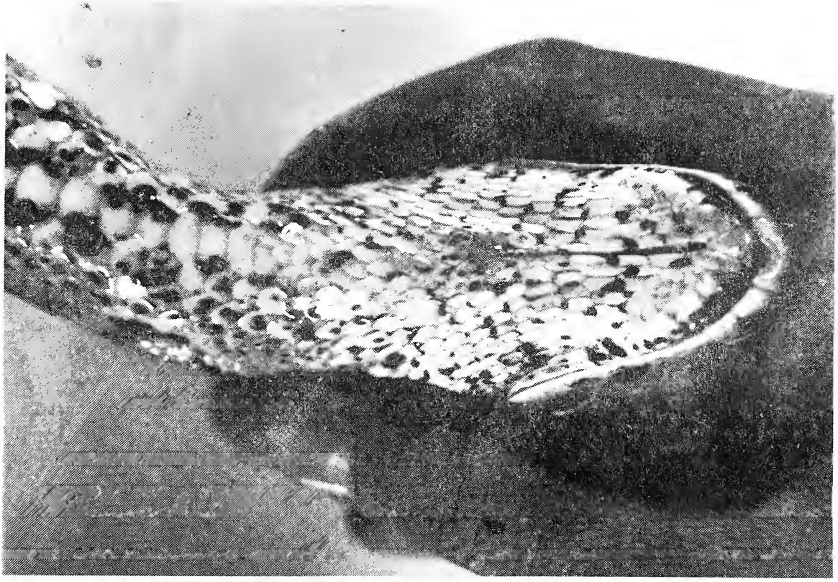

Fig. 6. Underside of head, *Python saxuloides*, holotype.

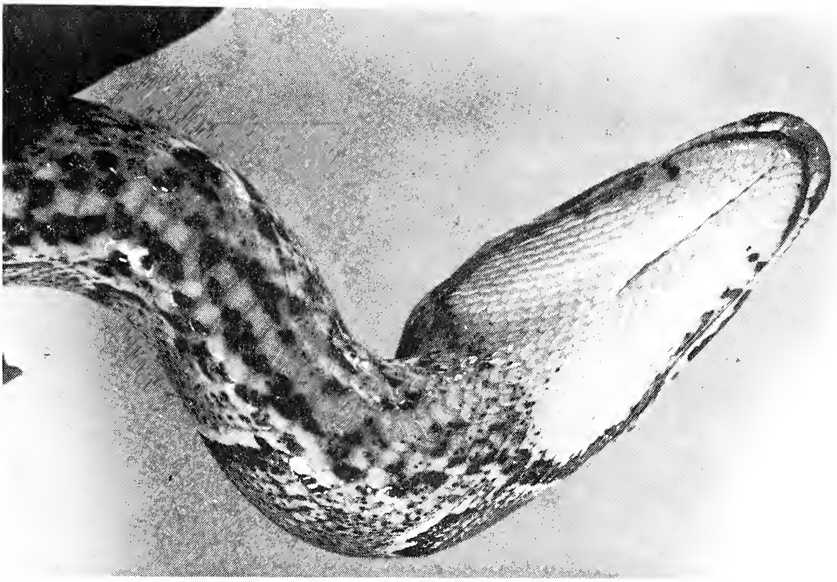

Fig. 7. Underside of head, *Python sebae*.

Fig. 8. Dorsal surface of tail, *Python saxuloides*, holotype.

Fig. 9. Dorsal surface of tail, *Python sebae*.

Fig. 10. Subcaudal surface, *Python saxuloides*, holotype.

Fig. 11. Subcaudal surface, *Python sebae*.

Literature Cited

Dunn, Emmett R. and Roger Conant.
1936. Notes on anacondas with descriptions of two new species. *Proc. Acad. Nat. Sci. Philadelphia, 88*: 503-506.

Fitzsimons, F. W.
1930. Pythons and their ways. *London, Harrap.* 155 pp., ill.

Fitzsimons, Vivian F. M.
1962. Snakes of southern Africa. *London, Macdonald.* 423 pp., 78 maps, 106 figs., 74 pls. (col.), frontis. (col.).

Isemonger, A. M.
1962. Snakes of Africa: southern, central and east. *Cape Town, Nelson.* viii, 236 pp., ill., partly col.

Kondo, Herbert, Richard G. Zweifel et al.
1972. Reptiles. Illustrated Encycl. Anima. Kingd., 9: 1-144, ill. (col.).

Lanworn, R.A.
1972. The book of reptiles. *London, Hamlyn.* 127 pp., ill. (partly color).

Loveridge, Arthur.
1957. Check list of the reptiles and amphibians of east Africa (Uganda; Kenya; Tanganyika; Zanzibar). *Bull. Mus. Comp. Zool., 117* (2): 151-372, i-xxxvi.

Parker, H. W. and A. G. C. Grandison.
1977. Snakes--a natural history. *Ithaca, N.Y., Cornell Univ. Press.* iv, 108 pp., 29 figs., 16 col. pls.

Pitman, Charles R. S.
1936. A guide to the snakes of Uganda. Part III. *Uganda J., 3*: 211-229.

______________.
1974. A guide to the snakes of Uganda. Revised edition. *London, Wheldon and Wesley.* xxii, 289 pp., 54 pls. (partly col.).

Stimson, Andrew F.
1969. Liste der rezenten Amphibien und Reptilien. Boidae (subfam. Boinae, Bolyeriinae, Loxoceminae et Pythoninae). *Das Tierreich,* 89: i-xi, 1-49.

Sweeney, R. C. H.
1961. Snakes of Nyasaland. *Zomba, Nyasaland, Govt. Printer.* xi, 199 pp., 42 figs., map, 2 pls.

Department of Environmental, Population and Organismic Biology, University of Colorado, Boulder, Colorado 80309

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The authors are knowingly violating several precepts of highest standards for taxonomic publication in presenting this account. The editors, Society and journal referees should not be held responsible in any way for those violations, which have been clearly pointed out to the authors, who in turn have defended their exceptions to standard policy on the basis of circumstantial exigency. In deference to the authors' defense and in the interest of the possibly resultant clarification of exigencies that may be generally accepted to justify exceptions such as this, the account is here published as submitted.

Author Defense

The foremost violation of custom is the designation of a living specimen as holotype; indeed, the entire type-series consists of living specimens. To be sure, the authors intend that all of the type-series ultimately be given to respected public museums, but obviously that intent could be thwarted by any of dozens of possible events. Not until the specimens are preserved and finally housed can their destiny be acceptably assured. However, these animals are extremely valuable per se, quite aside from being types; they each cost $250 and their value has increased steadily. They could well be valued at $500 each. No museum has funds for purchase of such expensive specimens, even types.

The purposes of museum accession of types are to document the accuracy of published accounts and to permit other workers not only the assurance of verification but also the opportunity to explore possible areas significant in taxonomic appraisal not exploited originally. In past eras when descriptions were usually brief, and even at the present time when dealing with taxa evaluated by characters predominantly subjective in both validity and measurement (as is true of most amphibians, for example), types are vital for name fixation. Snakes, however, can be very objectively portrayed, so that thorough description and illustration of types greatly minimizes the real value of the convention of immediate and ready type-accessibility. We think we have acceptably served the real purposes that have led to that convention, by the alternative route of detailed portrayal of a species particularly amenable to such treatment. We fully agree that ideally ready accessibility of types should be immediately assured, but in this particular case, that does not permit such assurance, we are serving the same basic purposes of good taxonomy at an acceptably practical level by providing detailed descriptions and illustrations. The established nomenclatural protocol permits erection of a neotype in case the living type is accidentally destroyed or lost.

It should be pointed out that circumstances have been accepted occasionally even in the recent past as justifying proposal of new species with living types. Dunn and Conant so named *Eunectes barbouri* and *E. deschauenseei*, both based on a single specimen of only "probable" provenance from the island of Marajo. *Nessiteras rhombopteryx* Rine was named even without a captured living specimen. None of these authors, all eminent scientists, would regard their violations of highest standards as desirable; they simply made the best possible of limiting circumstances.

The authors feel that establishment of a breeding colony of *saxuloides*, in order to obtain important reproductive data from adults and growth data from neonates, is of a higher priority than sacrificing specimens for museum collections. Due to the low number of specimens available to us at the present time we feel it would be unwise to diminish our breeding colony any further.

Since we think that other specimens exist in museums and in collections of live animals, a survey of such repositories would obviously be desirable. We do not have the financial resources to visit likely museums, however, nor would curators welcome the prospect of shipping bulky material for our inspection. We furthermore do not regard additional material as vital to our simple objective of pointing out the existence of a cryptic species hitherto confounded with *Python sebae*.

In like manner we readily admit that much more study of the problem will be required, both in the field and in the laboratory, to establish firmly the taxonomic status of the sample we hypothesize represents an hitherto unrecognized and unnamed species. We are certainly not in a position to carry out such studies, but there is every reason to provide others who can with the impetus to pursue it. Certainly in the ideal situation a full study of the biology as well as external morphology and variation is desired by every systematist, in proposal of any new species, but seldom is that possible. The present case is even more exceptional in the large size of organism, remoteness from most centers of herpetological study, and extensive apparent range. It is about as far from our personal potential for full solution as it is possible to get. To expect that all answers pertinent to the "species" (as we interpret it) be answered at the outset is to expect the impossible. Status, phylogeny, ecological relations and biology are large problems on which many people over many years must work to provide answers.

In the meantime there is no reason to withhold announcement of our interpretation of the animals in question, or of our nomenclatural conclusions. Nothing stimulates further work like revival or proposal of a name for a given supposed taxon.

Statistical analyses of the data available to us would add nothing to the validity of our conclusions, particularly because of the small sample size of *saxuloides* (even though large enough to provide subjective confidence of validity), and also because of the small size of the sample available to us for scale counts of *sebae*. The differences are extensively in pattern, which cannot be readily tested statistically, but for which large numbers of literature-reported specimens, mostly of *sebae*, were available. Those numbers cannot be determined, but certainly amount to over a hundred *sebae* and perhaps a dozen *saxuloides*.

We thus regard our account as here presented the very best that circumstances permit, and that it is fully adequate to justify the conclusions given.

T.J.M. and H.M.S.

A LARGE COPPERHEAD, *Agkistrodon c. mokasen*, FROM MARYLAND

On 3 August 1978 a large copperhead, *Agkistrodon c. mokasen*, was found dead on Dublin Road near the Wellington Wildlife Management Area, Princess Anne, Somerset County, Maryland. It was found by personnel of the Maryland Wildlife Administration. The specimen measured 46.5 inches in length. It is presently in the possession of the Maryland Wildlife Administration.

---Steve Dawson, *Maryland Wildlife Administration, Tawes State Office Building, Annapolis, Maryland 21401.*

Received 27 August 1979
Accepted 30 August 1979

A NEW COUNTY RECORD FOR THE WOOD FROG, *Rana sylvatica sylvatica*, IN MARYLAND

The wood frog, *Rana sylvatica sylvatica* Le Conte, has been reported from every county in Maryland except St. Mary's on the Western Shore and Dorchester on the Eastern Shore (Harris, 1975). Despite these absences and only a few recorded localities in Talbot, Caroline and Wicomico Counties, which surround Dorchester, the wood frog has generally been assumed to occur statewide (Harris, 1975). We discovered both egg masses and tadpoles of this species during a spring 1979 herpetological survey in the vicinity of the Vienna Steam Electric Station, Dorchester County (Johnson and Van Deusen, 1979). This locality constitutes a county record for the wood frog.

On 2 March 1979, we found egg masses of this frog in a series of temporary ponds occupying a joint railroad and power line right-of-way. The area lies just east of Maryland Route 331 about 0.5 mi north of the junction of U. S. Route 50 in Vienna. These ephemeral pools were about 1-1.5 feet deep. Dead leaves, grasses and twigs formed the bottom substrate and provided attachment sites. Most ponds were 4-6 feet long and 1-2 feet wide. The surrounding vegetative community was old-field with panic and quack grasses, broomsedge, goldenrod, chickweed and white clover dominating. The fields are maintained in early succession by annual or biennial mowing. The distinctive egg masses: 2½ - 4 inches in diameter, globose in shape, ½ - 2 inches below the water surface, with obvious and spherical outer envelopes (Wright and Wright, 1949) - in the appropriate habitat and this early in the spring confirm the identity of this species.

During subsequent site visits (19 April and 2 May), wood frog tadpoles were seen in these same pools as well as in several nearby temporary pools in cut-over woods. The greenish to black iridescence with gold and orange spots and cream-colored line along the upper jaw (Wright, 1914) are unmistakable characteristics of tadpoles of the wood frog.

Although no adult specimens of the wood frog have been found to date in our Vienna field studies, the finding of both egg masses and tadpoles of this species constitutes a new county record for *Rana sylvatica sylvatica* in Maryland.

We would like to acknowledge support of the Maryland Power Plant Siting Program, Detailed Site Evaluation Section to Dr. Robert G. Otto, Chesapeake Bay Institute.

Literature Cited

Harris, H. S., Jr.
1975. Distributional survey (Amphibia and Reptilia): Maryland and the District of Columbia. *Bull. Md. Herp. Soc.* *11*(3):73-167.

Johnson, R. H. and M. Van Deusen.
1979. Herpetological survey of the proposed expansion site for the Vienna Steam Electric Station, Vienna, Dorchester County, Maryland. *Chesapeake Bay Institute, The Johns Hopkins University*. Spec. Rept. 76, Ref. 79-7.

Wright, A. H.
1914. North American Anura, life-histories of the Anura of Ithaca, New York. *Carnegie Inst. of Washington, Washington, D. C.*, 98 pp.

_____________ and A. A. Wright.
1949. Handbook of frogs and toads of the United States and Canada. *Comstock Publ. Co., Ithaca, N.Y.*, 3 ed., xii + 640 pp.

--Marie Van Deusen, *Chesapeake Bay Institute, The Johns Hopkins University, Baltimore, Maryland 21218* and Robert H. Johnson, *Department of Pathobiology, The Johns Hopkins University, 615 N. Wolfe Street, Baltimore, Maryland 21205.*

Received 12 September 1979
Accepted 21 September 1979

COMMENTS & LETTERS RECEIVED

THE MYSTERY OF LOCH NESS

The search for the Loch Ness Monster continues. Even with all the modern technology employed, scientists have not yet been able to obtain a positive identification. The unusual nature of the loch makes the investigation quite a technical challenge. Aside from the technical difficulties, the investigators are faced with another type of hindrance due to people's lack of support for the project. The negative attitude that Loch Ness is some kind of hoax is not constructive. Over the past years, there have been 10,000 known reported sightings at Loch Ness, 3,000 of which have been recorded. Although a large number of these can be attributed to hoaxes, misinterpretations of common objects, and optical illusions, it seems highly unlikely that none of them are legitimate. Mackal (1976) states, "an average of 10 valid sightings per year is probably a solid figure representing observations over the past decades. Even this lower figure supports the view that a stable population of animals well adapted to Loch Ness is present." At this point in time, it seems to be no longer a question of whether a creature exists in Loch Ness, but rather, what the identity of this elusive organism is. "The guesses of monster advocates encompass a wide range of aquatic animals: plesiosaurs, long necked seals, giant annellid worms, giant eels, and embolomere amphibians" (Zug, 1978). The term "monster" connotes a negative stigma which does not lend itself to scientific advancement. In 1975, Robert Rines and Sir Peter Scott named the infamous animal *Nessiteras rhombopteryx* which means "Ness wonder with diamond shaped fins." Acceptance of *Nessiteras*' existence is a constructive contribution to the search. The Loch Ness provides enough of a problem in the investigation without having a non-supportive audience.

The Loch Ness is an extremely unusual environment. "It is the northernmost freshwater lake in the string of lochs extending from the Firth of Lorn on the west coast of Scotland to the Moray Firth on the east " (Zug, 1978). Approximately 10,000 years ago, Loch Ness filled with salt water when the last glacial sheet receded. Over the years, the water in the loch gradually changed from salt to fresh. The loch is fairly deep with a mean depth of about 433 feet as well as having two deeper basins which range anywhere from 700 to 900 feet deep. The water is cold, although the depth of the loch prevents it from ever freezing. The low water temperature slows the rate of decay. This factor combined with the depth of the water prevents corpses from becoming buoyant enough to float. Aside from seeming a bit gruesome, this fact decreases the chance of obtaining a *Nessiteras* specimen for closer study. The concentration of peat particles is so great that there is often no clear demarcation of the bottom of the loch. This high density of organic material not only makes for low light penetration, but is also a major source of difficulty in obtaining observational data. The investigators have had trouble getting clear pictures due to the agitation of surrounding particles by active organisms, particles settling on the camera equipment, or to other technical complications with their equipment. "The temperature stratification, the narrow, linear shape of the loch, and the direction of the prevailing winds produce opposing currents within the loch. The surface movement is not great, but the waves of the thermocline (approximately 100 feet below the surface) are 15 to 20 feet high," (Zug, 1978). One last bit of interesting data about the Loch Ness is that in recent sonar scans for bones, stone circles similar to Stonehenge were found on the bottom of the lake as well as several unidentified objects. The mystery of the Loch Ness is heightened by this peculiar habitat which is not making observations of *Nessiteras* easy.

The lack of support for investigators of the Loch Ness mystery is not justified. Although the attitude is not consciously malicious, its effect is harmful nonetheless. For example, a few sightings have been credited to practical jokers. These tricksters find it amusing to test the competency of the investigators. However, the more illegitimate cases that are proved to exist, the less likely are people to believe the really credible observations. Ultimately, the task of the researchers is made that much more difficult because people are reluctant to contribute funds to a project that seems to be more of a hoax than a serious scientific endeavor. Also, the lack of support for the project makes it harder to get competent investigators to work on the mystery. Even though concrete evidence in the form of sonar diagrams and underwater photographs confirms the existence of a large unidentified inhabitant of the Loch Ness, a largely skeptical public attitude still exists.

Although the presence of *Nessiteras* has been fairly well established, a positive identification has not been obtained. Sonar diagrams and underwater photography indicate the following characteristics: 1) a size range of about 20 to 30 feet 2) a central body thickening 3) an approximate weight of 2500 pounds 4) the presence of a front pair of appendages assumed to be flipperlike and 5) the presence of a long, powerful, laterally flattened tail. The investigation continues with plans of setting up a year round strobe-cinecamera-sonar-minicomputer system. Ultimately, the scientists would like to obtain a specimen of *Nessiteras rhombopteryx*, probably the only type of evidence that will convince some people of this creature's existence. Hopefully, the increased credibility of the evidence will increase public support and decrease the negative stigma associated with the investigators of this phenomenon.

Literature Cited

Mackal, Roy P.
1976. The monsters of Loch Ness. *Chicago, Swallow Press*, 232 pp., ill.

Scott, Peter and Robert Rines.
1975. Naming the Loch Ness monster. *Nature*, 104(1697): pp. 25-40.

Zug, George.
1978. Once more into the Loch. pp. 154-169. *In:* Yearbook of Science and the Future. *Chicago, Encyclopedia Britannica, Inc.*

—Mary Leake, *Department of Environmental, Population and Organismic Biology, University of Colorado, Boulder, Colorado, 80309.*

Received 7 February 1979

Ed. Note:

This paper although not original research will prove interesting reading and is being published in the newly created section "Comments and Letters Received".

PROTECT THE RED-EARED SLIDER

My hobby started with buying two baby red-eared sliders. Somehow I got "posessed" and now I keep 60 turtles and tortoises. I have subscriptions from several countries and I bought many books on herps.

I found out, that red-eared sliders are the most common "toy-turtles" in the world. People buy one for the children, it grows too big, and the children are not interested in it anymore. So, let's put the turtle away. But....all zoo's are loaded with red-eared sliders. At least one zoo feeds them to crocodiles....the other zoo's just don't accept them. What to do? Dump it in the river. Or in the toilet. Or put it away in a container in a spare-room, and wait till it's dead. (And you can wait a long time...)

These things really happened, and still happen. In Holland we have a few "asiles" for "waist-turtles". Even the zoo's tell people to go to us. 40 of my present turtles are "waist-turtles", and I've had many more. Most of them died, because of malnutrition, pneumonia, vitamin-deficienties, etc. For some of them I found new homes.

Not all of them are red-eared; I also got *Podocnemys unifilis, Siebenrockiella crassicollis, Cuora amboinensis, Chrysemys picta dorsalis*, etc.

What is the real problem? People buy a turtle, without knowing anything about it, and without any information.

On an exhibition I found out that the public does not know that their baby-turtles grow (if they stay alive) to be 15 inches or more!

They don't know, that it needs warm water, no draft, etc. They even don't knowwhat it has to be fed. In the Dutch pet-shops and supermarkets you can buy turtles but there is hardly any information. (Why should they, if the animal dies, they'll buy a new one!) We have information-leaflets, but theshopkeepers hardly take thetrouble to order them and hand them out.

The real problem is the import. If there were not so many baby turtles imported (1,250,000 per year in Holland!) there would not be so many waist-turtles. Or if the turtles would be larger, more expensive...

We have a group now, that is trying to stop the import, but our commerce finds it more important toearn money (on tanks, heaters, food, filters, etc.) then to protect the animal.

Since a few years we have a law in Holland, that protects many many foreign animals. They areno longer allowed to be imported, traded or kept. (All monkeys, allcrocodiles, allbig cats, many fishes, birds, amphibians, etc.) Also all tortoises and several turtles, like the genus Kachuga, someClemmys, all Podocnemys, anda few others, that were hardly imported in Holland.

But.....the marine-turtles are not on the list. Even though they are very much endangered, but the real-turtle-soup is more important then the real turtle! Maybe we can make a small success, for the inspector of the ministry promised to do something. But....to stop the import is impossible...to set a size isimpossible...(I mean: we wanted to have a regulation that turtles under 3 inches are not allowed to be imported.)

In the meantime our asiles are full, and we fear that we'll have to stop it. Hundreds of turtles are offered, and we hardly can find new homes for them. Now my question to you, American herpetologists, is: Isn't it possible to do something about your export? (Most turtles come fromthe U.S.) In Holland they say, thatall red-eared sliders that areimported were specially grown in the U.S. in turtle-farms. But I don't believe that. Only in Holland 1,250,000 a year, how many over the world?

You can buy red-eared sliders inSingapore, Ethiopia, Europe, every where.

Your red-eared slider is (still) very common, but...for how long, if it goes on like this?

To make lawstakes a lot of time in Holland. I suppose it will be the same in the U.S. Start your action now, and in a few years you'll be able to save the last of your red-eared sliders!

We planned to collect thewaist-turtles, and send them back to the U.S. But...we didn't get permission, for they were afraid of imported diseases. We cannot go on like this. Will you help us? Write to your government. Ask them to give permission to us to bring the red-eared sliders back where they belong. Ask them above all to stop the export of (baby) red-eared sliders. Or/and send your reaction to:

Marja van Barneveld
Taalstraat 31
5261 BA Vught
Netherlands.

Received: 5 March 1979

Ed Note: This letter is being published as received as it stresses one individuals concern over an issue which bothers most of us!

NOTES

NOTES

Society Publications

Back issues of the Bulletin of the Maryland Herpetological Society, where available, may be obtained by writing the Executive Editor. A list of available issues will be sent upon request. Individual numbers in stock are $2.00 each, unless otherwise noted.

The Society also publishes a Newsletter on a somewhat irregular basis. These are distributed to the membership free of charge. Also published are Maryland Herpetofauna Leaflets and these are available at $.05/page.

Information for Authors

All correspondence should be addressed to the Executive Editor. Manuscripts being submitted for publication should be typewritten (double spaced) on good quality 8½ x 11 inch paper, with adequate margins. Submit original and first carbon, retaining the second carbon. Indicate where illustrations or photographs are to appear in text. Cite all literature used at end in alphabetical order by author.

Major papers are those over 5 pages (double spaced, elite type) and must include an abstract. The authors name should be centered under the title, and the address is to follow the Literature Cited. Minor papers are those papers with fewer than 5 pages. Author's name is to be placed at end of paper (see recent issue). For additional information see *Style Manual for Biological Journals* (1964), American Institute of Biological Sciences, 3900 Wisconsin Avenue, N.W., Washington, D.C. 20016. Price is $6.00.

Reprints are available at $.03 a page and should be ordered when manuscripts are submitted or when proofs are returned. Minimum order is 100 reprints. Either edited manuscript or proof will be returned to author for approval or correction. The author will be responsible for all corrections to proof, and must return proof preferably within 7 days.

The Maryland Herpetological Society
Department of Herpetology
Natural History Society of Maryland, Inc.
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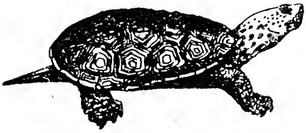

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DECEMBER 1979 VOLUME 15, NUMBER 4

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Volume 15 Number 4 December 1

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The third Wednesday of each month, 8:15 p.m. at the Natural History Society of Maryland (except May-August, third Saturday of each month, 8:00 a.m.). The Department of Herpetology meets informally on all other Wednesday evenings at the NHSM at 8:00 p.m.

BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

VOLUME 15 31 DECEMBER 1979 NUMBER 4

NOTES ON THE TURAN BIOSPHERE RESERVE HERPETOFAUNA, NORTHEASTERN IRAN

Robert G. Tuck, Jr.*

ABSTRACT

One species of amphibian, the green toad (*Bufo viridis oblongus*), and 20 species of reptiles, Comprising the Afghan tortoise (*Agricnemys horsfieldi*), 4 agamid lizards (*Agama agilis, A. n. nupta* (?), *Phrynocephalus mystaceus galli, Ph. scutellatus*), 4 gekkonid lizards (*Agamura persica, Cyrtodactylus caspius, Teratoscincus bedriagai, T. scincus*), 4 lacertid lizards (*Eremias fasciata* (?), *E. persica, E. v. velox, Meislina guttulata watsonana*), 1 varanid lizard (*Varanus griseus caspius*), 1 boiid snake (*Eryx tataricus*), 4 colubrid snakes (*Coluber karelini, C. rhodorhachis ladacensis, Psammophis lineolatus, Spalerosophis diadema schiraziana*), and a single viperid snake (*Pseudocerastes p. persicus*), are documented from the Turan Biosphere Reserve. Collecting data, ecological information, measurements, and relevant observations are given for those forms within the Reserve, and a tentative zoogeographic analysis of the Turan herpetofauna is attempted.

Introduction

The Turan Biosphere Reserve, formerly the Turan Protected Area, which included a wildlife refuge, is administered by the Iran Department of the Environment and covers more than 1.8 x 10^6 hectares on the northeastern margin of the central Iranian desert (Spooner, 1977). Politically, the Reserve lies in Semnan Province, but it is very near the boundary of Khorasan. The approximate location and general area of the Turan Biosphere Reserve are shown on Map 1.

Firouz (1974) described the topography of the region as mountains, foothills, and plains, with desert, semi-desert, and steppe vegetation. He listed representative gamebirds (4 species) and medium to large mammals (14 species) for the region. Harrington (*in* Spooner, 1977) listed 65 species of mammals comprising 21 families in 7 orders within Turan. Unpublished data compiled by the Department of the Environment indicate that 164 species of birds may be encountered in the Turan Biosphere Reserve. Rechinger (1977) provided an annotated checklist of 375 plant species for the area. According to Spooner (1977), both "flora and mammalian fauna generally show great affinity to the Kara Kum in Soviet Tukmenistan to the north."

**Formerly Natural History Museum Advisor, Zoologist, & Curator of Herpetology, Iran National Museum of Natural History.*

Until recently, the amphibians and reptiles of the Turan Biosphere Reserve remained relatively unknown. Data gleaned from Anderson (1966; *in* Fisher, 1968; 1974), Eiselt and Schmidtler (1975), Latifi (1975), Latifi et al. (1966), Tuck (1971), and incidental specimens in the collections of the Iran National Museum of Natural History (Muze-ye Melli-ye Tarikh-e Tabi'i)(MMTT), formed the basis for a preliminary analysis of the Turan herpetofauna circulated by Tuck (unpublished, 1976). Lately, intensive investigations undertaken by the author, as well as collections and observations made by researchers associated with the Turan Programme (Spooner, 1977), have made it possible to compile the material presented in this paper.

Acknowledgements

The author wishes to thank Prof. Brian Spooner for his interest, patience, assistance, discussions, and advice. Valuable assistance was also rendered by Mr. Rasik Bhadresa, and the aid of Misses Mary Martin, Lili Ramiyar, and Roushan Sadrulhefazi, and of Dr. Robin Dennell, is greatefully acknowledged. Mr. Brian O'Regan kindly provided photographs of the Afghan tortoise and desert monitor from within the Turan Biosphere Reserve. Dr. Randell E. Brown submitted specimens and data. Mr. Yadollah Seirani assisted in various phases of specimen identification and measurement. Special thanks are due to Mr. Mohammed Hassan Teheri, shepherd from Yazdu village, and to Mr. Baba Reza, headman of Tejur village, for their enthusiastic assistance in securing specimens.

Species Accounts

Class : AMPHIBIA

Order : SALIENTIA

Family : Bufonidae

Genus : *Bufo* Laurenti 1768

Bufo viridis oblongus Nikolsky 1896.

Turan Biosphere Reserve Material: (9) MMTT 1852, Tejur village, ca. 1100 m, collected 17 July 1977 by R. G. Tuck, Jr. (original no. RGT 3205); MMTT 1988, Baghestan village, 1275 m, collected 16 July 1977 by R. G. Tuck, Jr., and R. Bhadresa (original no. RGT 3202); MMTT 1989 - 1992, Baghestan village, 1275 m, collected 17 July 1977 by R. G. Tuck, Jr. (original nos. RGT 3206 - 3209); MMTT 2083, Kariz village, collected 11 October 1977 by R. Bhadresa (original no. RB-1); MMTT 2084, Nahar village, collected 12 October 1977 by R. Bhadresa (original no. RB-2); MMTT 2085, Delbar village, collected 13 October 1977 by R. Bhadresa (original no. RB-3).

Measurements: Meristic data for these specimens are given in Table 1.

Remarks: The local name for the green toad is "vasagh."

MMTT 1852 was collected during the mid-afternoon in an overgrown irrigation channel in which it was concealed beneath vegetation; the air temperature above the vegetation level registered 35°C. MMTT 1988 was taken at night in the courtyard of the village school; it was parasitized by 3 leeches, one each on the upper foreleg, groin, and thigh. MMTT 1989 - 1992 were collected at night from the edge of a small pond behind the village school. Both MMTT 2083 and 2085 were collected in the evening, while MMTT 2084 was taken about 1200 hrs.

Class : REPTILIA

Order : TESTUDINES

Family : Testudinidae

Genus : *Agrionemys* Khozatsky & Mlynarski 1966

Agrionemys horsfieldi (Gray 1844)

Turan Biosphere Reserve Material: (1) MMTT 1901, 3 km southeast of Delbar village, collected in late January 1977 by R. Bhadresa.

Measurements: This specimen is represented only by its shell, for which the following data are recorded --

carapace length 177 mm
carapace width 146 mm
plastron length 161 mm
plastron width 132 mm
shell height 97 mm

The cervical scute in this individual is very small, practically nonexistant. There are 11 marginal scutes on either side; the two 12th scutes are fused into a single supra-caudal. The specimen has 5 vertebral scutes, and there are 4 pleural scutes on each side.

Remarks: Figure 1 depicts two live Afghan tortoises observed by B. O'Regan in the vicinity of Ahmadabad on 17 April 1977.

Order : SQUAMATA

Suborder: LACERTILIA

Family : Agamidae

Genus : *Agama* Daudin 1802

Agama agilis Oliver 1807

Turan Biosphere Reserve Material: (19) MMTT 1208, 16 km south of 'Abbasabad, 800 - 870 m, collected 11 June 1975 by S. C. Anderson (original no. A 639); MMTT 1226, 34 km south of 'Abbasabad on dirt road, 870 m, collected 11 June 1975 by S.C. Anderson (original no. A650); MMTT 1771-1772, Delbar village, collected 28 July 1976 by R. E. Brown; MMTT 1782, 7.5 km east of Delbar village, 1100 m, collected 5 August 1976 by R. E. Brown (original no. REB 100); MMTT 1849 - 1850, 1 km north of Baghestan village, collected 24 April 1977 by R. Bhadresa; MMTT 1902, Baghestan village, collected 1 May 1977 by M. Martin; MMTT 1996 - 1997, near Posht-e-Aseman village, 1260 m, collected 15 Jult 1977 by R. G. Tuck, Jr. (original nos. RGT 3184 - 3185); MMTT 2001, Baba Kuh abandoned village, 1160 m, collected 15 July 1977 by R.G. Tuck, Jr., and R. Bhadresa (original no. RGT 3195); MMTT 2002, Baba Kuh abandoned village, 1160 m, collected

16 July 1977 by R.G. Tuck, Jr. (original no. RGT 3196); MMTT 2015 - 2016, Delbar village, 1205 m, collected 18 July 1977 by R. Bhadresa (original nos. RGT 3219 - 3220); MMTT 2017 - 2019, Delbar village, 1205 m, collected 19 July 1977 by R. G. Tuck, Jr. (original nos. RGT 3233 - 3234); MMTT 2037, between Khanehkhodi village and Delbar village, 1185 m, collected 20 July 1977 by R. G. Tuck, Jr. (original no. RGT 3248); MMTT 2046, vicinity of Baghestan village, collected 27 July 1977 by M. Martin.

Measurements: Meristic data for these specimens are given in Table 2.

Remarks: MMTT 1996 - 1997 were collected between 0830 and 0930 hrs, by which time the air temperature had reached 32°C. MMTT 2001 was taken just after sunset. MMTT 2002 was collected at 0900 hrs; air temperature 29°C, lizard body temperature 35°C. Both MMTT 2001 and MMTT 2002 were active on a sand and gravel dry river plain running through a major dune field. MMTT 2037 was one of several examples of this species observed living on sand dunes near the village of Qala Bala, between Khanehkhodi and Delbar villages; at the time of capture, 1935 hrs, the temperature of both the air and the surface of the sand was 35°C, while the body temperature of the lizard registered 36°C. All 7 adult females from the Turan Biosphere Reserve contained either ovarian or oviducal eggs; counts, measurements, and dates of collection of these specimens are given in Table 3. Seven live individuals from Delbar village, collected 18 - 19 July 1977 by R. Bhadresa and R. G. Tuck, Jr. (original nos. RGT 3221 - 3224, RGT 3235 - 3237), were presented to W. P. Hall, IIIrd, University of Melbourne, for karyological analysis.

Agama cf. A. nupta nupta de Filippi 1843

Turan Biosphere Reserve Material: (0)

Remarks: An individual believed to belong to this species was first observed in the Turan Biosphere Reserve by the author at Tejur village on 17 July 1977. The lone male evaded all attempts at capture, retreating deep into crevices within the vertical rock surface it inhabited above a spring. This particular large-scaled rock agama was seen several times between 1300 hrs and 1700 hrs; during the interval the air temperature was recorded as 35°C. On 29 August 1977 Mr. Bhadresa returned to Tejur and photographed the same lizard (Figure 2).

On 19 July 1977 the author observed droppings apparently produced by examples of this species on a rocky cliff 10 km (by road) north of Delbar village at an altitude of 1275 m. No actual agamas were seen, however, even though the site was examined from 1840 hrs, 19 July, until 1015 hrs, 20 July. A series of air temperature readings were made at intervals and may indicate that the visit did not overlap the lizards' normal activity periods --

19 July
1850 hrs, 37°C, breezy
2015 hrs, 33°C, windy
2110 hrs, 30°C, "

20 July
0620 hrs, 25°C
0650 hrs, 25°C
0800 hrs, 25°C (shade), 30°C (sun)
0900 hrs, 30°C
0930 hrs, 32°C
1000 hrs, 33°C

Anderson (1966:87) questioned previous reports of *A. nupta* in "extreme northeastern Iran," and cautions (*in litt.*, 2 November 1977) that this Turan sighting may really represent *Agama caucasica* (Eichwald 1831). The individual pictured here, however, closely resembles specimens of *A. nupta* preserved in the collections of the Iran National Museum of Natural History (MMTT) with regard to pattern and visible scalation, but clearly seems to differ from all *A. caucasica* at hand in these respects. Nevertheless, the matter must remain moot until verifiable material has been obtained and deposited into an accessible collection.

Genus : *Phrynocephalus* Kaup 1825

Phrynocephalus mystaceus galli Krassowsky 1932

Turan Biosphere Reserve Material: (4) MMTT 1848, below Kariz road, collected 11 April 1977 by M. Martin; MMTT 1903 - 1904, Tochah village, collected 18 May 1977 by M. Martin; MMTT 2003, vicinity of Baba Kuh abandoned village, ca. 1160 m, collected 16 July 1977 by R. Bhadresa and R. Dennell (original no. RGT 3199).

Measurements: Meristic data for these specimens are given in Table 4.

Remarks: The local name for the fringe-mouth toad-head agama is "kalepasrigi."

All of these specimens were collected on sand dunes. A fifth example, collected by the author on an extensive dune area near Tochah village, 18 July 1977 (original no. RGT 3210), was presented alive to W. P. Hall, IIIrd, for karyological analysis. This individual ran into a burrow when pursued. It was caught at 1315 hrs and had a recorded body temperature of 37°C. At the time of capture other environmental data were noted as follow --

temperature of burrow 37°C
temperature of sand surface 52°C
temperature of air above sand surface 33°C
temperature of sand at depth of 160 - 200 mm 33°C

Specimens of *Phrynocephalus mystaceus galli* from the Turan Biosphere Reserve appear to differ markedly in a number of features from a series collected in Khorasan Province, 35 km north of Gonabad on the road to Torbat-e-Heydarieh, 850 m, on 9 June 1975, by S. C. Anderson and R. B. McCullers (original nos. A 602 - 606). The clear and sharply defined throat patterns seen in these latter examples, now catalogued as MMTT 1193 - 1197, do not appear in the Turan material. Meristic data for this series are summarized in Table 5 and may be compared with those of the previous group.

Phrynocephalus scutellatus (Olivier 1807)

Turan Biosphere Reserve Material: (30) MMTT 1203 - 1207, 16 km south of 'Abbasabad, 800 - 870 m, collected 11 June 1975 by S.C. Anderson (original nos. A 643 - 647); MMTT 1214 - 1224, salt flat 5 km west of Kahak on road to Shahrud, 800 m, collected 10 June 1975 by S. C. Anderson and R. B. McCullers (original nos. A 623 - 633); MMTT 1773, Delbar village, 1300 m, collected 29 July 1976 by R. E. Brown (original no. REB 60); MMTT 1795, 80 km south of Delbar village, collected 24 February 1977 (preserved 14 March 1977) by A. DeVos; MMTT 1995, Chohok spring, 1025 m, collected 17 July 1977 by R. G. Tuck, Jr. (original no. RGT 3204); MMTT 2020 - 2023, Delbar village, 1205 m, collected 18 July 1977 by R. Bhadresa (original nos. RGT 3211 - 3214); MMTT 2028 - 2033, Delbar village 1205 m, collected 19 July 1977 by R. G. Tuck, Jr. (original nos. RGT 3239 - 3244); MMTT 2038, between Khanehkhodi village and Delbar village, 1185 m, collected 20 July 1977 by R.G. Tuck, Jr. (original no. RGT 3247).

Measurements: Meristic data for these specimens are given in Table 6.

Remarks: Twenty-three (77%) of these specimens are juveniles measuring between 18.5 and 31.1 mm ($\bar{x}$ = 24.7 mm, SD = 3.2 mm) and were collected between 10 June and 19 July. Reproductive data taken from the 3 adult females are as follows --

MMTT 1203 (11 June), 11 ovarian eggs, 5 on the left and 4 on the right, the largest measuring 0.3 mm;
MMTT 1795 (24 February), 15 oviducal eggs, 8 on the left and 7 on the right, the largest measuring 4.5 mm;
MMTT 2020 (18 July), 11 ovarian eggs, 6 on the left and 5 on the right, the largest measuring 0.3 mm.

MMTT 1995 was collected on a gravel substrate at 1030 hrs; the air temperature was 33°C, while the surface temperatures recorded in the open and in the shade of a tamerisk bush were 40°C and 34°C, respectively. MMTT 2038 was captured on sand dunes at about 1845 hrs; the temperature above the sand was recorded as 40°C, while temperatures of the sand surface and 150 mm beneath the surface registered 45°C and 38°C, respectively.

Seven living examples of *Phrynocephalus scutellatus* from Delbar village, collected 18 July 1977 by R. Bhadresa (original nos. RGT 3225-3231), were presented to W. P. Hall, IIIrd, for karyological analysis.

Family : Gekkonidae

Genus : *Agamura* Blanford 1874

Agamura persica (Dumeril 1856)

Turan Biosphere Reserve Material: (1) MMTT 2087, Harp village, 4 km east of the pass through the Kuh-e-Majred, collected 14 October 1977 by R. Bhadresa (original no. RB-5).

Measurements: The following counts and measurements (in mm) were taken from this specimen, which is a male --

snout/vent length 63.9
tail 58
number of scales around body 117
number of upper labials 15 + completely divided rostral
number of lower labials 10
number of lamellae under fourth toe 21

Remarks: This individual was collected at 1145 hrs.

Genus : *Cyrtodactylus* Gray 1827

Cyrtodactylus caspius (Eichwald 1831)

Turan Biosphere Reserve Material: (6) MMTT 1775, Delbar village, 1300 m, collected 12 July 1976 by R. E. Brown (original no. REB 64); MMTT 1993, Baghestan village, 1275 m, collected 16 July 1977 by R.G. Tuck, Jr., and R. Bhadresa (original no. RGT 3203); MMTT 2004 -2005, Baba Kuh abandoned village, 1160 m, collected 16 July 1977 by R.G. Tuck, Jr. (original nos. RGT 3197 - 3198); MMTT 2024, Delbar village, 1205 m, collected 19 July 1977 by R.G. Tuck, Jr., (original no. RGT 3245); MMTT 2086, Delbar village, collected 13 October 1977 by R. Bhadresa (original no. RB-4).

Measurements: Meristic data for these specimens are given in Table 7.

Remarks: All of these individuals were collected from the vertical surfaces of walls. MMTT 1993 was taken at night from the mud-brick wall of a fortress. Both MMTT 2004 and 2005 were taken from the interior mud-brick walls of a vacant building within an abandoned village between 0915 and 0945 hrs; other individuals were seen, but not collected. The air temperature within the room was 28° - 29°C, while the body temperature of MMTT 2005 registered 29°C. MMTT 2024 was asleep on the exterior wall of a cement building when it was captured at 1600 hrs; the air temperature was recorded as 35°C, while the lizard body temperature registered 34°C. MMTT 2086 was taken from the wall of a building during the afternoon hours.

MMTT 2005 contains 10 ovarian eggs, 6 on the left and 4 on the right, the largest measuring 1.2 mm in diameter. Preservation of the internal organs of MMTT 2086 is too poor to assess reproductive data.

Four of the 6 examples from Turan possess regenerated tails. Eight other specimens of *Cyrtodactylus caspius* in the collections of the Iran National Museum of Natural History (MMTT) comprise an adult female and 7 juveniles (MMTT 507 - 514) collected in Shahrud city, Semnan Province, on 23 April 1974 by M. Thireau and R. Khazai (original nos. RGT 2869 - 2873, RGT 2904 -2906). While one juvenile, MMTT 508, lost its tail during capture, it is possible to combine data taken from the remaining 7 specimens with those from the Turan Biosphere Reserve samples to produce the tail-loss and regeneration information given in Table 8. Only one example (17%) of the 6 juveniles, which measure between 24.2 and 34.8 mm snout/vent length ($\bar{x}$ = 30.4 mm, SD - 3.9 mm), had lost its tail prior to collection; while 5 (71%) of the 7 adults, which measure between 45.7 and 60.7 mm snout/vent length ($\bar{x}$ = 54.6 mm, SD = 6.0 mm), had lost and regenerated their tails previous to capture.

Genus : *Teratoscincus* Strauch 1863

Teratoscincus bedriagai Nikolsky 1899

Turan Biosphere Reserve Material: (2) MMTT 2039 - 2040, between Khanehkhodi village and Delbar village, 1185 m, collected 20 July 1977 by R. G. Tuck, Jr. (original nos. RGT 3249 -3250).

Measurements: Meristic data for these specimens are given in Table 9.

Remarks: Both examples were captured at 2100 hrs. They were stationed on the surface of a sand dune; surface temperature was 34 C, while the air temperature registered 30 C. MMTT 2039 contains 9 ovarian eggs, 4 on the left, 5 on the right, the largest measuring 1.6 mm in diameter.

Teratoscincus scincus (Schlegel 1858)

Turan Biosphere Reserve Material: (9) MMTT 2006 - 2014, vicinity of Baba Kuh abandoned village, 1160 m, collected 15 July 1977 by R.G. Tuck, Jr., and R. Bhadresa (original nos. RGT 3186 - 3194).

Measurements: Meristic data for these specimens are given in Table 10.

Remarks: All of these plate-tailed geckos were collected after dark. They were resting either on the clay surface of an abandoned field, or, more frequently, on the sand surface of the extensive dune formation that encroached upon the dry bed and gravel flood-plain of the Hojjaj River. Smaller individuals seemed to predominate in the former situation, larger ones in the latter. All examples seen were collected, and there appears to be an appreciable size difference between the sexes in this sample: the 4 males range between 68.6 and 73.0 mm snout/vent length ($\bar{x}$ = 70.9 mm, SD = 1.9 mm), and the 5 females range between 75.4 and 96.3 mm snout/vent length ($\bar{x}$ = 89.4 mm, SD = 8.4 mm). All of the females contain ovarian eggs; counts and measurements are presented in Table 11.

On 16 July 1977 the collection sites on the dune field were revisited and the following temperature data were recorded --

Time	Air	Surface	Shallow Depth	160 - 200 mm Depth
0630 hrs	19°C	---	---	---
0700 hrs	---	20°C	22°C	35.5°C
0715 hrs	---	25°C	23°C	30°C
0740 hrs	24.5°C	25°C	25°C	33°C
1000 hrs	32°C	44°C	31°C	30°C

Lizard activity was not observed until 0900 hrs.

Family : Lacertidae

Genus : *Eremias* Fitzinger *in* Wiegmann 1834

Eremias cf. E. fasciata Blanford 1874

Turan Biosphere Reserve Material: (2) MMTT 1229 - 1230, 42 km southeast of 'Abbasabad (by road), 920 m, collected 11 June 1975 by S. C. Anderson and R. B. McCullers (original nos. A 656 - 657).

Measurements: Meristic data for these specimens are given in Table 12.

Remarks: MMTT 1230 contains 6 ovarian eggs, 3 on either side, the largest measuring 1.0 mm in diameter. Anderson (*in litt.*, 2 November 1977) notes that the identification of these two examples is by no means positive and they may represent an undescribed form. I. S. Darevsky (per. comm.) concurs.

Eremias persica Blanford 1874

Turan Biosphere Reserve Material: (12) MMTT 1201 - 1202, 16 km south of 'Abbasabad, 800 - 870 m, collected 11 June 1975 by S. C. Anderson (original nos. A 641 - 642); MMTT 1776, 2.5 km northeast of Delbar village, 1400 m, collected 13 July 1976 by R.E. Brown (original no. REB 67); MMTT 1778, 7.5 km east of Delbar village, 1200 m, collected 5 August 1976 by R.E. Brown (original no. REB 97); MMTT 1781, 7.5 km east of Delbar village, 1100 m, collected 5 August 1976 by R. E. Brown (original no. REB 99); MMTT 1791, 3.5 km east of Delbar village, collected 5 August 1976 by R.E. Brown (caught by, and removed from stomach of *Coluber karelini*, MMTT 1785: see below); MMTT 1905, Tochah, collected 30 May 1977 by M. Martin; MMTT 1998 - 2000, near Posht-e-Aseman village, 1260 m, collected 15 July 1977 by R.G. Tuck, Jr. (original nos. RGT 3181 - 3183); MMTT 2025 - 2026, Delbar village, 1205 m, collected 18 July 1977 by R. Bhadresa (original nos. RGT 3216 - 3217).

Measurements: Meristic data for these specimens are given in Table 13.

Remarks: The local name for the Persian steppe lacerta is "aroosmar."

The pursuit, capture, and swallowing of MMTT 1791 by a spotted desert racer, *Coluber karelini* (MMTT 1785), was witnessed by the collector. MMTT 1998 - 2000 were collected between 0830 and 0915 hrs; they regurgitated isopods after capture. The tails of MMTT 1778 and MMTT 1998 are 41% and 60% regenerated, respectively, while that of MMTT 2025 has healed and only begun regrowth. Reproductive data taken from specimens of Turan female *E. persica* are presented in Table 14.

Eremias velox velox (Pallas 1771)

Turan Biosphere Reserve Material: (2) MMTT 1228, 34 km south of 'Abbasabad, on dirt road, 870 m, collected 11 June 1975 by S.C. Anderson (original no. A 653); MMTT 1231, 42 km southeast of 'Abbasabad, by road, 920 m, collected 11 June 1975 by S. C. Anderson and R. B. McCullers (original no. A 569).

Measurements: Meristic data for these specimens are given in Table 15.

Remarks: MMTT 1228 was parasitized by a small tick in the axillary region.

Genus : *Mesalina* Gray 1845

Mesalina guttulata watsonana (Stoliczka 1872)

Turan Biosphere Reserve Material: (4) MMTT 1779, 11 km north of Delbar village, 1350 m, collected 2 August 1976 by R. E. Brown (original no.

REB 96); MMTT 1851, between the villages of Kariz, Shahbaz, and Baghestan, collected 19 March 1977 by M. Martin; MMTT 1994, vicinity of Ab-e-Raghn spring, 1530 m, collected 16 July 1977 by R. G. Tuck, Jr., and B. Spooner (original no. RGT 3200); MMTT 2027, Delbar village, 1205 m, collected 18 July 1977 by R. Bhadresa (original no. RGT 3218).

Measurements: Meristic data for these specimens are given in Table 16.

Remarks: The local name for the long-tailed desert lacerta is "malus."

MMTT 1851 was collected at 1200 hrs and contains 18 ovarian eggs, 10 on the left and 8 on the right, the largest measuring 1.2 mm in diameter. MMTT 1994 was collected at 1800 hrs; the air temperature was 30° C. MMTT 2027 was found to be heavily parasitized by invertebrate cysts, which filled the entire abdominal cavity.

The scant number of specimens listed here should not be taken as indicative of the size and extent of the population of *M. guttulata watsonana* within the Turan Biosphere Reserve, for individuals are adept at evading capture, and many already captured quickly escaped before being securely bagged.

In using the generic designation *Mesalina* Gray 1845, Shcherbak (1974) has distinguished the long-tailed desert lacerta and its relatives from the other steppe lacertas (genus *Eremias* Fitzinger *in* Wiegmann 1834) inhabiting Iran, and it is his allocation that is followed here.

Family : Varanidae

Genus : *Varanus* Merrem 1820

Subgenus: *Psammosaurus* Fitzinger 1826

Varanus (*Psammosaurus*) *griseus caspius* (Eichwald 1841)

Turan Biosphere Reserve Material: (0)

Remarks: Although no Turan specimens have been deposited into the collections of the Iran National Museum of Natural History (MMTT), the transcaspian desert monitor is reliably reported as fairly common and widespread within the region (R. Bhadresa, pers. comm.; B. O'Regan, pers. comm.; B. Spooner, pers. comm.). Mr. O'Regan has kindly provided a transparency he made of an example of the transcaspian monitor on 18 April 1977, 10 km south of 'Abbasabad on the road to Dastjerd (Figure 3). Mr. Bhadresa recorded an encounter with a desert monitor in Zygophyllum habitat, 10 km southwest of Tejur, at 1230 hrs, on 28 April 1977.

Suborder: SERPENTES

Family : Boiidae

Genus : *Eryx* Daudin 1803

Eryx tataricus (Lichtenstein 1823)

Turan Biosphere Reserve Material: (2) MMTT 2047, Baghestan village threshing ground, collected 20 July 1977 by M. Martin; MMTT 2048, Baghestan village, collected 1 August 1977 by M. Martin.

Measurements: Meristic data for these specimens are given in Table 17.

Family : Colubridae

Genus : *Coluber* Linnaeus 1758

Coluber karelini Brandt 1838

Turan Biosphere Reserve Material: (2) MMTT 1785, 3.5 km east of Delbar village, 1200 m, collected 5 August 1976 by R. E. Brown (original no. REB 97); MMTT 1847, between the villages of Baghestan and Shahbaz, collected 19 March 1977 by M. Martin.

Measurements: Meristic data for these specimens are given in Table 18.

Remarks: The local name for the spotted desert racer is "sek-mar."

MMTT 1785 was observed to pursue, capture, and swallow a Persian steppe lacerta, *Eremias persica* (MMTT 1791: see above).

Coluber rhodorhachis ladacensis (J. Anderson 1871)

Turan Biosphere Reserve Material: (1) MMTT 1906, Baghestan village fortress, collected 25 May 1977 by M. Martin.

Measurements: Meristic data for this specimen are given in Table 19.

Although preserved, the head has been completely severed from the body, so that the snout/vent length figures given must be considered to be only approximate.

Genus : *Psammophis* Fitzinger 1826

Psammophis lineolatus (Brandt 1836)

Turan Biosphere Reserve Material: (2) MMTT 1783, north of Zamanabad, collected 16 August 1976 by R.E. Brown (original no. REB 108); MMTT 2034, Delbar village, 1205 m, collected 20 July 1977 by R. Bhadresa (original no. RGT 3246).

Measurements: Meristic data for these specimens are given in Table 20.

Genus : *Spalerosophis* Jan *in* de Filippi 1865

Spalerosophis diadema schiraziana (Jan *in* de Filippi 1865)

Turan Biosphere Reserve Material: (4) MMTT 1774, Delbar village, collected 29 June 1976 by R. E. Brown (original no. REB 62); MMTT 1908, on the Salehabad - Talkhab road near encroaching sand dunes, 1200 m, collected 11 July 1977 by M. Martin (original no. RGT 3179); MMTT 1987, Baghestan village fortress, collected 25 May 1977 by M. Martin; MMTT 2035, Delbar village, 1205 m, collected 21 July 1977 by R. G. Tuck, Jr. (original no. RGT 3251).

Measurements: Meristic data for these specimens are given in Table 21.

Remarks: MMTT 1980 was swallowing a rodent at the time it was struck by a vehicle; the prey, badly crushed, according to the collector, was not saved.

Family : Viperidae

Genus : *Pseudocerastes* Boulenger 1896

Pseudocerastes persicus persicus (Dumeril, Bibron, and Dumeril 1854)

Turan Biosphere Reserve Material: (3) MMTT 1780, 7.5 km east of Delbar village, collected 5 August 1976 by R. E. Brown (original no. REB 96); MMTT 2036, Delbar village, 1205 m, collected 18 July 1977 by R. Bhadresa (original no. RGT 3232); MMTT 2041, Annabu, 3 km northwest of Delbar village, collected 27 July 1977 by R. Bhadresa.

Measurements: Meristic data for these specimens are given in Table 22.

Remarks: In addition to these collected specimens, Mr. R. Bhadresa observed a live Persian horned viper 9 km south of Ahmadabad at 1530 hrs on 13 October 1977.

Conclusion

The 21 species of Amphibia and Reptilia listed in this paper undoubtedly do not represent the total herpetofaunal complement of the Turan Biosphere Reserve. Nevertheless, judging from the tortoise and lizard forms collected or observed within the area, it is possible to calculate the probable zoogeographic relationships represented by the sample at hand, based upon Anderson's (1968) designations and equating Spooner's (1977) Kara Kum element with "Aralo-Caspian." The following tabulation results from considering the 14 testudinate and lacertilian examples known to occur in the Turan Biosphere Reserve --

Aralo-Caspian Faunal Class	14.3% (2 species)
Iranian/Aralo-Caspian Faunal Class	7.1% (1 species)
Iranian Faunal Class	57.1% (8 species)
Iranian/Saharo-Sindian Faunal Class	21.4% (3 species)

While no study comparable to Anderson's work exists for the snakes, distributions of the 6 serpent species so far documented from the Reserve, as given by Bannikov et al. (1971), provide the following picture --

Aralo-Caspian Faunal Class	50% (3 species)
Iranian Faunal Class	50% (3 species)

It would seem that the ophidiofauna of the Reserve may show considerable affinity to that of the Kara Kum, Soviet Turkmenistan, in the sense of Spooner (1977).

By combining the faunal class assignments for all 21 species noted and including the green toad, *Bufo viridis oblongus*, as a member of the Iranian faunal class, the following tentative tabulation results --

Aralo-Caspian Faunal Class	23.8% (5 species)
Iranian/Aralo-Caspian Faunal Class	4.8% (1 species)
Iranian Faunal Class	57.1% (12 species)
Iranian/Saharo-Sindian Faunal Class	14.3% (3 species)

Pending further collecting and study, it may be concluded that the known Turan Biosphere Reserve herpetofauna, as in the cases of the floral and mammalian components, shows an appreciable relationship to that which may be regarded as characteristic of the Kara Kum to the north. It is too early, however, to apply precise terminology concerning the extent of the zoogeographic situation.

A thorough, wider ranging investigation of the amphibian and reptile fauna of the Reserve would provide the materials and data required to settle this question.

Note: Political boundaries and Iranian Governmental agencies cited in this paper refer to pre-revolutionary Iran and may no longer exist, nor conform to terminology employed by the current Islamic Republic of Iran.

Table 1. Measurements (in mm) for Specimens of *Bufo viridis oblongus* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Snout/Tympanum Distance	Snout/Eye Distance	Width of Rostrum	Width of Eye	Width of Tympanum	Length of Thigh	Length of Tibia	Length of First Digit	Length of Internal Metatarsal	Length of Paratoid
1852	♂	72.1	19.8	11.8	9.4	7.2	2.2	26.5	28.6	4.4	3.0	12.0
1988	♀	48.0	12.2	5.5	6.7	5.1	2.1	20.0	18.6	2.8	2.0	7.5
1989	♂	58.7	15.0	7.0	7.2	6.0	1.8	25.2	23.3	2.9	2.8	11.9
1990	♀	56.4	14.6	7.2	7.3	5.4	2.1	24.6	21.5	3.4	2.1	10.7
1991	♀	59.9	14.8	6.1	7.3	5.6	1.8	23.0	23.2	3.7	3.2	12.1
1992	♀	52.3	14.2	6.9	6.5	4.8	1.7	20.3	19.5	3.6	2.5	9.0
2083	♀	66.6	15.9	8.0	8.2	5.3	1.5	25.4	24.9	3.7	3.0	13.2
2084	♂	46.2	11.4	6.5	5.9	3.8	1.0	15.3	16.8	3.1	2.7	9.3
2085	♀	71.8	17.4	7.5	9.9	6.5	2.2	23.0	25.7	4.3	4.2	13.0

Table 2. Counts and Measurements (in mm) of Specimens of *Agama agilis* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows Around Body	Number of Upper Labials	Number of Lower Labials	Number of Rows of Callose Pre-anal Scales	Number of Lamellae Under Fourth Toe
1208	♀	82.5	132	73	19	15	1 (faint)	23
1226	♂	72.7	104	69	19	18	2	27
1771	♂	98.1	122	68	20	19	3	25
1772	♀	89.4	135	65	15	16	-	26
1782	juv.	30.0	54	-	19	17	-	28
1849	♀	78.3	119	63	18	16	-	26
1850	♂	67.0	109	72	17	17	2	25
1902	♀	70.6	114	68	17	18	-	26
1996	♀	90.2	126	68	17	18	-	23
1997	♀	88.3	116	68	16	16	1 (faint)	26
2001	♂	82.5	134	68	15	17	2	22
2002	♂	93.5	151	73	19	18	2	26
2015	juv.	40.7	71	66	14	16	-	26
2016	juv.	33.0	58	72	16	20	-	28
2017	♂	83.2	123	64	19	19	2	27
2018	♂	83.4	129	69	20	18	2	26
2019	juv.	42.0	73	72	18	17	-	26
2037	♀	69.3	95	74	18	18	1 (faint)	24
2046	♂	74.9	126	65	19	18	2	28

Table 3. Reproductive Data for Female Specimens of *Agama agilis* Collected in the Turan Biosphere Reserve.

MMTT Number	Date of Collection	Number of Oviducal Eggs (Left / Right)	Diameter of Largest Egg (mm)	Number of Ovarian Eggs (Left / Right)	Diameter of Largest Egg (mm)
1208	11 June	-- / --	--	9 / 10	1.5
1772	28 July	5 / 4	17.0	-- / --	--
1849	24 Apr.	4 / 4	9.1	-- / --	--
1902	1 May	4 / 3*	4.7	-- / --	--
1996	15 July	-- / --	--	11 / 8	1.1
1997	15 July	-- / --	--	10 / 8	1.5
2037	20 July	-- / --	--	7 / 0	0.8

*13 very small (1.1 mm) eggs, 8 left and 5 right, appeared to be undergoing resorption.

Table 4. Counts and Measurements (in mm) of Specimens of *Phrynocephalus mystaceus galli* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows Around Body	Number of Upper Labials to Edge of Mouth Fringe.	Number of Lower Labials to Edge of Mouth Fringe	Number of Lamellae Under Fourth Toe
1848	juv.	46.0	51	126	14	10	30
1903	juv.	55.5	71	123	18	10	31
1904	juv.	51.5	60	120	15	9	31
2003	♂	98.4	113	116	17	11	30

Table 5. Counts and Measurements (in mm) of Specimens of *Phrynocephalus mystaceus galli* Collected in Khorasan Province.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows Around Body	Number of Upper Labials to Edge of Mouth Fringe	Number of Lower Labials to Edge of Mouth Fringe	Number of Lamellae Under Fourth Toe
1193	♀	73.5	65	120	12	7	31
1194	♂	65.3	71	133	14	8	32
1195	♀	73.7	80	128	12	9	29
1196	♂	55.6	57	128	12	9	30
1197	♀	54.6	55	127	13	7	26

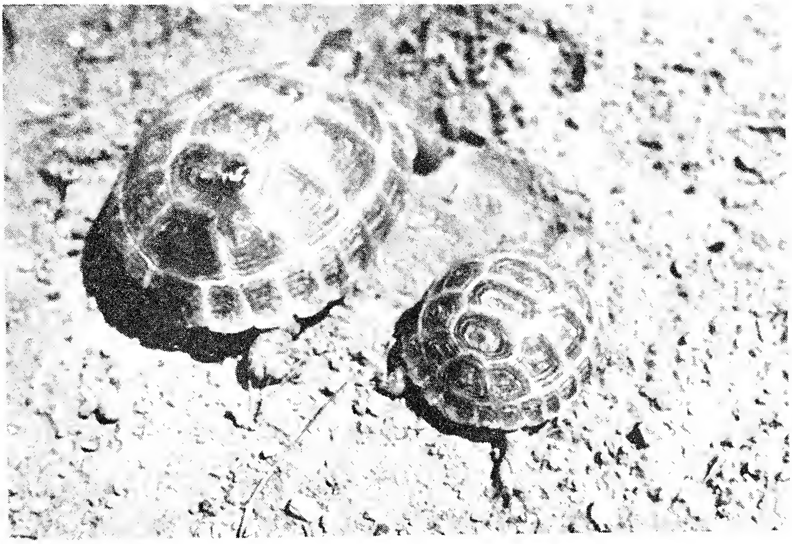


Figure 1. Two examples of the Afghan tortoise, *Agrionemys horsfieldi*, photographed near Ahmadabad on 17 April 1977. (Photo courtesy of B. O'Regan)

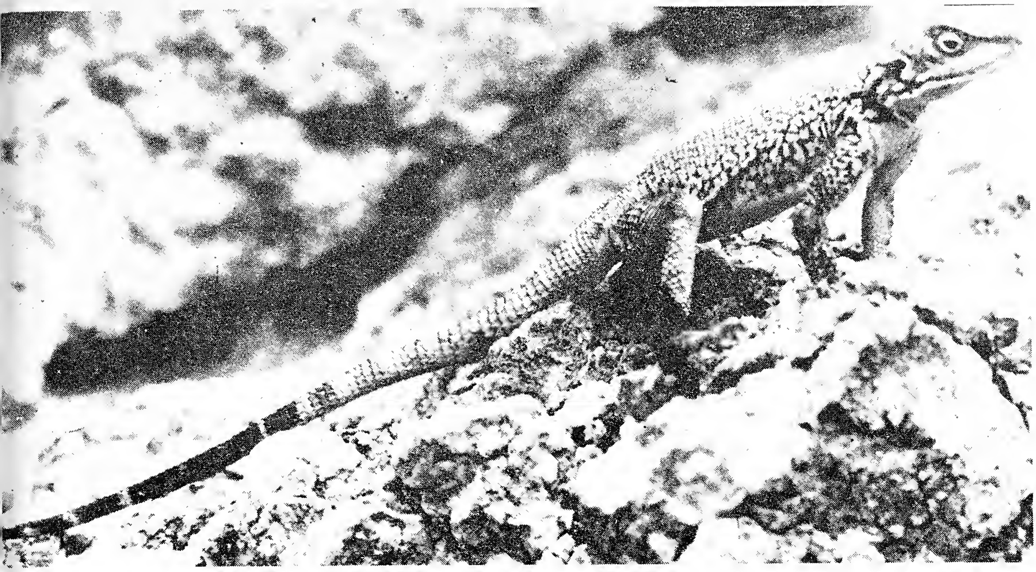


Figure 2. A male large-scaled rock agama, tentatively identified as *Agama nupta nupta*, photographed at Tejur village on 29 August 1977. (Photo courtesy of R. Bhadresa)

Figure 3. A transcaspian desert monitor, *Varanus griseus caspius*, photographed south of 'Abbasabad on 18 April 1977. (Photo courtesy of B. O'Regan).

Table 6. Counts and Measurements (in mm) of Specimens of *Phrynocephalus scutellatus* Collected in the Turan Biosphere Reserve

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scales Across Belly	Number of Upper Labials	Number of Lower Labials	Number of Lamellae Under Fourth Toe
1203	♀	44.3	55	42	13	12	25
1204	♂	41.1	52	39	13	13	24
1205	juv.	22.4	--	37	12	12	23
1206	juv.	22.1	29	37	15	12	25
1207	juv.	23.5	32	39	12	11	28
1214	♂	48.9	69	43	13	13	25
1215	juv.	24.1	34	44	12	13	27
1216	juv.	24.6	38	41	12	14	27
1217	juv.	21.6	37	38	14	11	25
1218	juv.	24.2	35	35	12	12	25
1219	juv.	26.6	40	37	15	15	24
1220	juv.	21.7	32.5	44	11	11	26
1221	juv.	20.7	31	39	11	11	23
1222	juv.	21.1	31	41	12	14	22
1223	juv.	24.7	39	43	14	11	26
1224	juv.	18.5	27	45	13	13	24
1773	♂	40.6	70	28	13	13	25
1795	♀	44.1	65	38	11	12	23
1995	juv.	26.4	39	43	14	13	27
2020	♀	45.2	64	42	13	12	24
2021	juv.	30.0	46.5	41	12	12	25
2022	juv.	25.0	39	45	12	11	27
2023	juv.	23.8	37	42	12	11	25
2028	juv.	31.1	45.5	40	12	13	24
2029	juv.	29.2	47	40	13	12	30

2030	juv.	26.2	38	35	14	11	26
2031	juv.	27.8	43	38	11	11	26
2032	juv.	28.7	44.5	44	13	13	26
2033	juv.	25.5	39	40	13	12	22
2038	♂	43.6	60	38	15	18	28

Table 7. Counts and Measurements (in mm) of Specimens of *Cyrtodactylus caspius* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scales Across Belly	Number of Upper Labials	Number of Lower Labials	Total Number of Femoral Pores	Number of Lamellae Under Fourth Toe
1775	♂	47.2	55*	29	10	9	25	25
1993	♂	60.7	65*	30	11	9	25	22
2004	♂	58.3	66*	29	12	8	27	24
2005	♀	45.7	52*	30	11	8	28 (faint)	22
2024	♂	54.0	74	28	10	8	29	23
2086	♀	59.2	79	34	12	8	0	23

*regenerated

Table 8. Tail-Loss and Regeneration in Specimens of *Cyrtodactylus caspius* Collected in Seman Province, Iran.

MMTT Number	Sex	% Original Tail	% Tail Regenerated
507	♀	13	87
509	juv.	100	-
510	juv.	100	-
511	juv.	-	- healed
512	juv.	100	-
513	juv.	100	-
514	juv.	100	-
1775	♂	73	27
1993	♂	18	82
2004	♂	65	35
2005	♀	52	48
2024	♂	100	-
2086	♀	100	-

Table 9. Counts and Measurements (in mm) of Specimens of *Teratoscincus bedriagai* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scales Around Body	Number of Upper Labials	Number of Lower Labials
2039	♀	56.1	28	47	10	9
2040	♂	55.5	29	47	9	10

Table 10. Counts and Measurements (in mm) of Specimens of *Teratoscincus scincus* Collected in the Turan Biosphere Reserve

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scales Around Body	Number of Upper Labials	Number of Lower Labials
2006	♀	95.2	55	31	10	10
2007	♀	96.3	70	32	10	9
2008	♀	91.4	57	32	10	10
2009	♀	88.5	56	34	9	9
2010	♀	75.4	52	31	9	9
2011	♂	70.0	47	32	11	10
2012	♂	68.6	36	31	10	9
2013	♂	73.0	53	32	10	10
2014	♂	71.8	50	--*	11	9

*skin torn

Table 11. Reproductive Data for Female Specimens of *Teratoscincus scincus* Collected in the Turan Biosphere Reserve*

MMTT Number	Number of Ovarian Eggs (Left / Right)	Diameter of Largest Egg (mm)
2006	5 / 0	2.2
2007	7 / 3	3.0
2008	4 / 4	1.6
2009	5 / 5	2.2
2010	5 / 3	2.5

*all collected night of 15 July 1977

Table 12. Counts and Measurements (in mm) of Specimens of *Eremias (cf. E. fasciata)* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Gular Scales	Number of Dorsal Scale Rows	Number of Upper Labials	Number of Lower Labials	Number pf Femoral Pores	Number of Lamellae Under Fourth Toe	Number of Ventrals, Lateral Series	Number of Ventrals, Transverse Series
1229	♂	60.6	113	28	53	10	7	16/17	28	18	32
1230	♀	43.1	74	29	49	9	8	15/16	28	18	34

Table 13. Counts and Measurements (in mm) of Specimens of *Eremias persica* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Gular Scales	Number of Dorsal Scale Rows	Number of Upper Labials	Number of Lower Labiels	Number of Femoral Pores	Number of Lamellae Under Fourth Toe	Number of Ventrals, Lateral Series	Number of Ventrals, Transverse Series
1201	♀	83.6	122	31	62	11	8	21/19	24	16	31
1202	♀	67.2	118	31	61	10	8	21/21	25	16	31
1776	♂	87.5	154	40	66	10	9	22/22	25	17	28
1778	♀	80.7	96*	34	66	11	9	20/20	25	15	30
1781	juv.	37.2	76	31	57	10	7	19/17	21	18	29
1791	♀	80.0	118	33	67	10	8	22/19	23	15	30
1905	♂	81.9	164	33	62	9	8	22/23	26	16	30
1998	♀	78.6	109*	36	63	11	9	17/18	27	16	31
1999	♀	74.9	115	33	58	10	11	18/17	24	16	30
2000	♀	71.9	97	36	61	13	8	20/20	25	16	33
2025	♀	78.0	23**	36	59	10	8	19/19	26	15	28
2026	juv.	39.8	72	30	40	10	8	21/20	25	--	--

*regenerated **healed

Table 14. Reproductive Data for Female Specimens of *Eremias persica* Collected in the Turan Biosphere Reserve.

MMTT Number	Date of Collection	Number of Oviducal Eggs (Left / Right)	Diameter of Largest Egg (mm)	Number of Ovarian Eggs (Left / Right)	Diameter of Largest Egg (mm)
1201	11 June	-- / --	--	12*/ 13*	3.9*
1202	11 June	-- / --	--	5 / 8	0.9
1778	5 Aug	-- / --	--	8 / 4	0.7
1791	5 Aug	-- / --	--	4 / 4	0.9
1998	15 July	-- / --	--	12 / 10	1.3
1999	15 July	2 / 2	13.7	5 / 9	1.6
2000	15 July	-- / --	--	** / **	**
2025	18 July	-- / --	--	** / **	**

*8 of these ovarian eggs, 4 on either side, were yellow-orange in colour, the largest measured as given; the remainder were white in colour, the largest measured 1.3 mm in diameter.

** both MMTT 2000 and 2025 contain numerous, indistinct, ovarian eggs on both sides.

Table 15. Counts and Measurements (in mm) of Specimens of *Eremias velox* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Gular Scales	Number of Dorsal Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Femoral Pores	Number of Lamellae Under Fourth Toe	Number of Ventrals, Lateral Series	Number of Ventrals, Transverse Series
1228	♂	59.9	112	29	59	10	9	20/19	21	16	31
1231	♂	63.5	81*	35	66	10	9	21/20	26	16	31

*broken

Table 16. Counts and Measurements (in mm) of Specimens of *Mesalina guttulata watsonana* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Gular Scales	Number of Dorsal Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Femoral Pores	Number of Lamellae Under Fourth Toe	Number of Ventrals, Lateral Series	Number of Ventrals, Transverse Series
1779	juv.	34.9	62	25	41	8	8	12/9+ (very faint)	21	10	28
1851	♀	47.0	81	26	41	9	8	11/12	22	11	30
1994	juv.	27.3	55.5	21	43	8	8	13/12	21	10	30
2027	♀	50.7	74	24	41	8	8	14/15	20	10	31

Table 17. Counts and Measurements (in mm) of Specimens of *Eryx tataricus* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Ventral Scutes	Condition of Anal Plate	Number of Subcaudal Scutes
2047	juv.	186	28	51	12	13	--*	single	30 pairs + 1
2048	o	345	46	49	11	15	185	single	29 pairs + 1

*specimen badly damaged

Table 18. Counts and Measurements (in mm) of Specimens of *Coluber karelini* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Ventral Scutes	Condition of Anal Plate	Number of Subcaudal Scutes	Number of Temporal Scales
1785	o	660	234	19	9	10	208	divided	103 pr. + 1	2+3+3/2+3+3
1874	♀	465	166	19	9	9	210	divided	102 pr. + 1	2+2+3/2+3+3

Table 19. Counts and Measurements (in mm) of the Specimen of *Coluber rhodorhachis ladacensis* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Ventral Scutes	Condition of Anal Plate	Number of Subcaudal Scutes	Number of Temporal Scales
1906	♀	745	219+*	19	9	9	214	divided	76 + prs.	2+3+3/2+2+3

*tip of tail missing

Table 20. Counts and Measurements (in mm) of Specimens of *Psammophis lineolatus* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Ventral Scutes	Condition of Anal Plate	Number of Subcaudal Scutes	Number of Temporal Scales
1783	juv.	196	62	17	9	10	180	divided	91 pairs + 1	1+2+2/1+2+2
2034	♀	548	142	17	9	12	181	divided	65 pairs + 1	2+2+3/2+2+3

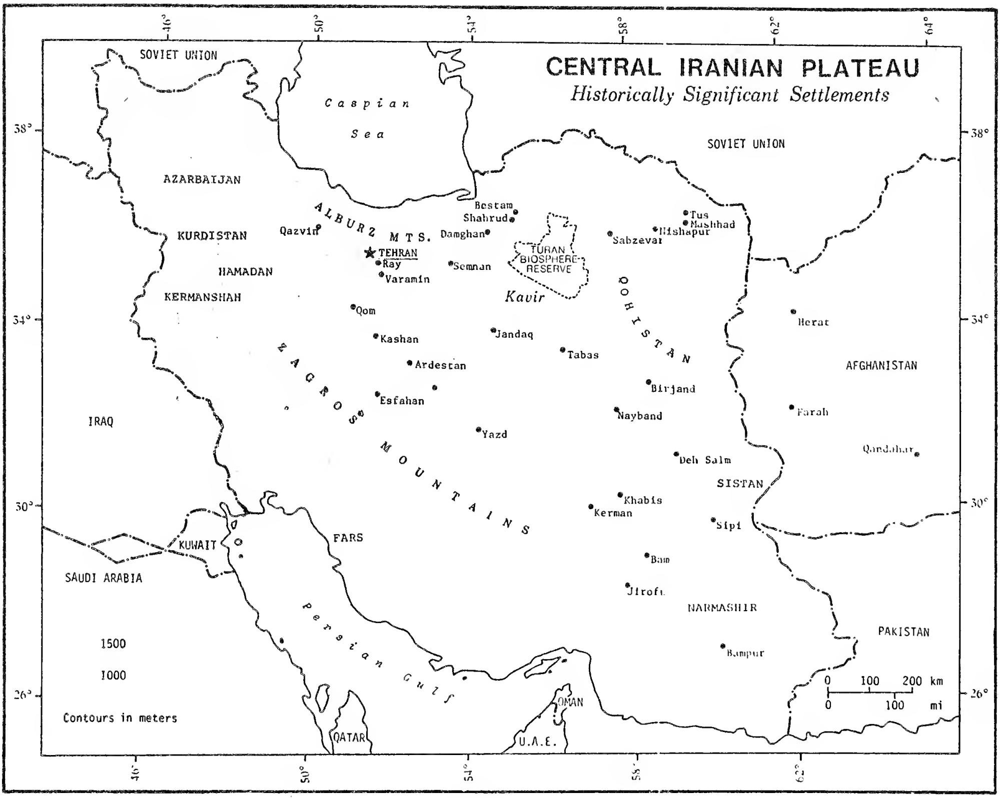
Table 21. Counts and Measurements (in mm) of Specimens of *Spalerosophis diadema schiraziana* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Ventral Scutes	Condition of Anal Plate	Number of Subcaudal Scutes	Number of Temporal Scales
1774	o	958	203	27	14	15	241	single	78 pairs + 1	4+5/5+6
1908	o	958	202	27	12	14	240	single	77 pairs + 1	3+3+4/5+5+4
1987	o	823	130+*	29	--**	--**	249	single	51+ pairs	---/---**
2035	o	920	166	27	12	12	233	single	61 pairs + 1	4+4+5/5+4+4

*tail broken, distal portion missing
**head badly crushed

Table 22. Counts and Measurements (in mm) of Specimens of *Pseudocerates persicus persicus* Collected in the Turan Biosphere Reserve.

MMTT Number	Sex	Snout/Vent Length	Tail Length	Number of Scale Rows	Number of Upper Labials	Number of Lower Labials	Number of Ventral Scutes	Condition of Anal Plate	Number of Subcaudal Scutes
1780	♀	596	73	23	12	15	156	single	35 pairs + 1
2036	juv.	316	48	23	12	16	154	single	44 pairs + 1
2041	♀	730	81	23	13	15	153	single	36 pairs + 1



MAP 1

Map 1. The Central Iranian Plateau, showing historically significant settlements and the Turan Biosphere Reserve. (Map courtesy of Dr. Hasan Mohammadi, Deputy Director, Department of the Environment, Imperial Government of Iran, Tehran).

Literature Cited

Anderson, S. C.
1966. The turtles, lizards, and amphisbaenians of Iran. Unpublished doctoral dissertation, Stanford University, xvii + 643 pp.. Available from University Microfilms, Inc., Ann Arbor, Michigan.

______________.
1968. Zoogeographic analysis of the lizard fauna of Iran. Pp. 305 - 371 *in* Fisher, W. B. (ed.), *THE CAMBRIDGE HISTORY OF IRAN*, Vol. 1, *THE LAND OF IRAN*. Cambridge, at the University Press, 784 pp.

______________.
1974. Preliminary key to the turtles, lizards, and amphisbaenians of Iran. *Fieldiana: Zoology*, Vol. 65, No. 4, June 13, 1974, pp. 27 - 44.

Bannikov, A.G., I.S. Darevsky, and A.K. Rustamov.
1971. (The amphibians and reptiles of the USRR). Moscow, 303 pp. (in Russian).

Eiselt, J., and J.F. Schmidtler.
1973. Froschlurche aus dem Iran unter Berucksichtigung ausseriranischer Populationsgruppen. *Ann. Naturhistor, Mus. Wein, 77* pp. 181 - 243.

Firouz, E.
1974. *ENVIRONMENT IRAN*. The National Society for the Conservation of Natural Resources and Human Environment, Tehran. 53 pp., maps, and photographs.

Latifi, M.
1975. (The poisonous snakes of Iran and the treatment of snakebite: Part 1, The poisonous snakes of Iran). (Medical Review Journal), Vol. 4, No. 5, Imperial Year 2534, pp. 418 - 425, (in Persian).

__________, A.R. Hoge, and M. Eliazan.
1966. The poisonous snakes of Iran. *Mem. Inst. Butantan, Simp. Internac.*, Vol. 33, No. 3, pp. 735 - 744.

Rechinger, K. H.
1977. Plants of the Touran Protected Area, Iran. *Iran. Journ. Bot.*, Vol. 1, No. 2, pp. 155 - 180.

Shcherbak, N.N.
1974. (Palearctic lizards). Academy of Sciences of the Ukranian Soviet Socialist Republic, Kiev. 296 pp. (in Russian).

Spooner, B. (ed.)
1977. Case study on desertification -- Iran: Turan. Prepared in the Department of the Environment, Tehran. 97 pp.

Tuck, R. G., Jr.
1971. Amphibians and reptiles from Iran in the United States National Museum Collection. *Bull. Md. Herpetol. Soc.*, Vol., 7, No. 3, September 1971, pp. 48 - 86.

_______________.
1976. Preliminary comments and a provisional checklist of the amphibians and reptiles of the Turan Protected Area, Semnan Province, Iran. Unpublished report circulated within the Iran Department of the Environment, Tehran. 4 pp.

Iran National Museum of Natural History (MMTT), Department of the Environment, P. O. Box 1430, Tehran, Iran.

Present address: *Maturango Museum of the Indian Wells Valley, P.O. Box 1776, Ridgecrest, California 93555.*

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OCCURRENCE OF THE WEST INDIAN FROG, *ELEUTHERODACTYLUS JOHNSTONEI*, IN SOUTH AMERICA AND ON THE ISLAND OF CURACAO[1]

Jerry D. Hardy, Jr. and Herbert S. Harris, Jr.

For a number of years *Eleutherodactylus johnstonei* Barbour was generally regarded as a synonym of *Eleutherodactylus martinicensis* (Tschudi) (Parker, 1933; Grant, 1959). Schwartz (1967) presented unequivocal evidence, however, to show that *johnstonei* and *martinicensis* are, in fact, very distinct species. *Eleutherodactylus johnstonei* presumedly originated somewhere in the eastern Caribbean. It has had a long history of inter-island introductions (usually documented under the name *martinicensis*) and is now known to occur on at least fifteen eastern Caribbean islands as well as in Jamaica and Bermuda (Schwartz and Thomas, 1975; Maclean, Kellner, and Dennis, 1977; Hardy, Drewry, and Cole, MS).

The ease with which *johnstonei* is transported is emphasized by Barbour's statement (1930) that it occasionally appears "in hot houses in Europe and North America". The "*Hylodes martinicensis*" which Gunther (1895) reported as surviving in the Kew Gardens (London) from about 1885 to at least 1898 were, in fact, probably *Eleutherdactylus johnstonei.*

In 1970 and 1971 populations of *Eleutherodactylus* were observed and sampled in Georgetown, Guyana, and in Caracas and Cumaná, Venezuela. These frogs were tentatively identified in the field as either *Eleutherodactylus johnstonei* or *Eleutherodactylus martinicensis*. Since it is sometimes difficult to distinguish these two species morphologically, identification was ultimately based on laboratory comparisons of vocal patterns and electropherograms of leg muscle proteins. On the basis of these comparisons we have concluded that these frogs are *Eleutherodactylus johnstoni.*

More recently (1975) Charles W. Myers observed similar frogs near Willemsted, Curaçao, in the Netherlands Antilles. On the basis of vocal patterns, these frogs are also identified as *Eleutherodactylus johnstonei.*

Eleutherodactylus johnstonei produces a two-note whistled call (Fig. 1a). Published accounts of this call indicate that the first note varies from 1950 to 2150 Hz in frequency and from 0.07 to 0.09 seconds in duration, while the frequency of the second note varies from 3300 to 3700 Hz, and its duration from 0.18 to 0.27 seconds (Watkins, Baylor, and Bower, 1970; Lemon, 1971). Both notes are monotonal. *E. johnstonei* also produces a characteristic occasional call which typically consist of a rising "whee" note followed by one or more "ticks".

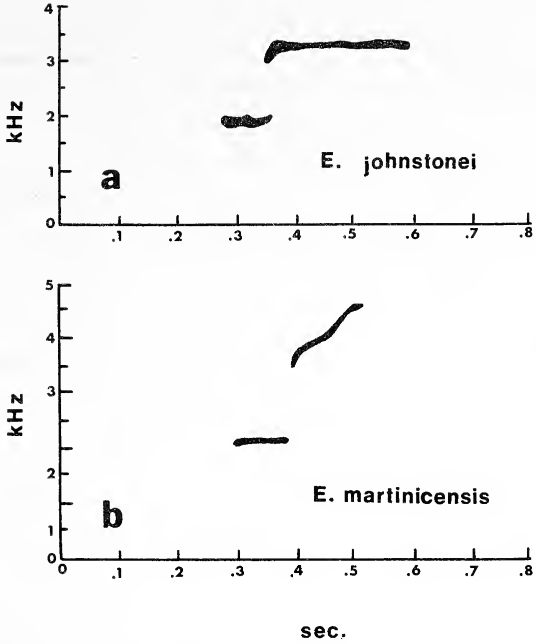

Figure 1. Sonogram tracings of the principal call of a) *Eleutherodactylus johnstonei* and b) *Eleutherodactylus martinicensis*.

Eleutherodactylus martinicensis produces a two-note whistled call (Fig. 1b) the first note of which is remarkably similar in frequency, duration, and structure to that of *E. johnstonei*. The second note, however, rises sharply (in contrast to the monotonal second note of *johnstonei*) and may terminate, as in the example illustrated, at frequencies as high as ca. 4600 Hz (well above the maximum recorded frequency of *E. johnstonei*). The occasional call of *E. martinicensis*, of which adaquate recordings are not available, consist of a prolonged series of series of "ticks", and is similar to the occasional call of *Eleutherodactylus coqui*, *E. portoricensis*, and *E. antillensis* as described by Drewry (1970).

Sonograms taken from recordings made in Georgetown, Guyana; Caracas and Cumaná, Venezuela; and near Willemstad, Curaçao (Fig. 2), clearly demonstrate that these frogs are *Eleutherodactylus johnstonei*, not *Eleutherodactylus martinicensis*. This conclusion is strengthened by recordings of occasional calls made in Cumaná, Venezuela, which structurally match occasional calls of known *johnstonei* recorded on St. Vincent (Fig. 3).

In electropherograms of leg muscle proteins of *Eleutherodactylus martinicensis* there are four major protein bands, the mid-points of which are located at points equivalent to 43,65,71, and 78 percent of the gel length; while in *Eleutherodactylus johnstonei* there are only three major bands, the mid-points of which are located at points equivalent to 25, 58, and 76 percent of the gel length (Fig. 4). Electropherograms of leg

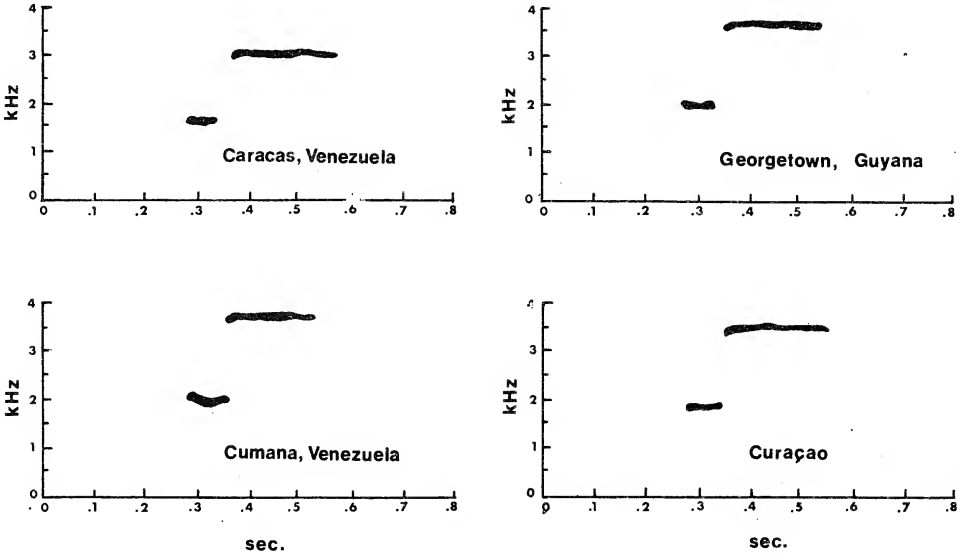

Figure 2. Sonogram tracings of the principal call of *Eleutherodactylus johnstonei* from South America and Curaçao.

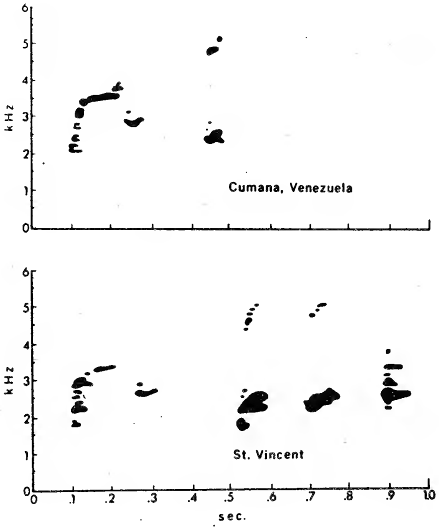

Figure 3. Sonogram tracings of theoccasional call of *Eleutherodactylus johnstonei* from South American and West Indian populations. The number of "tick" notes canvary from one to three or more in a given individual.

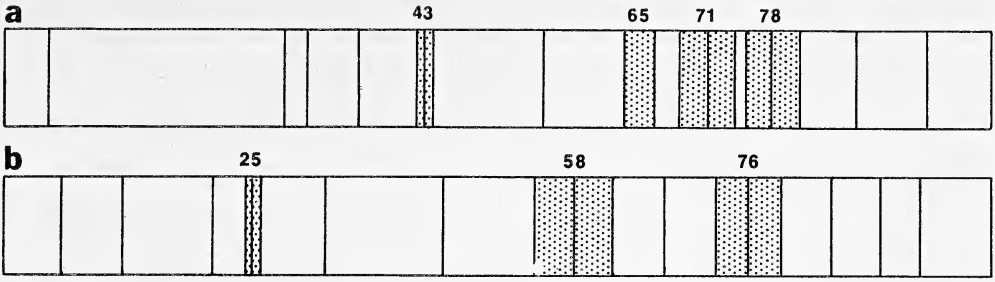

Figure 4. Electropherograms of leg muscle proteins as separated on 7% acrylamide gels. a) *Eleutherodactylus martinicensis*, Pointe-au-Pitre, Guadeloupe (n = 10). b) *Eleutherodactylus johnstonei* St. Vincent (n = 11). Figures are percent migration.

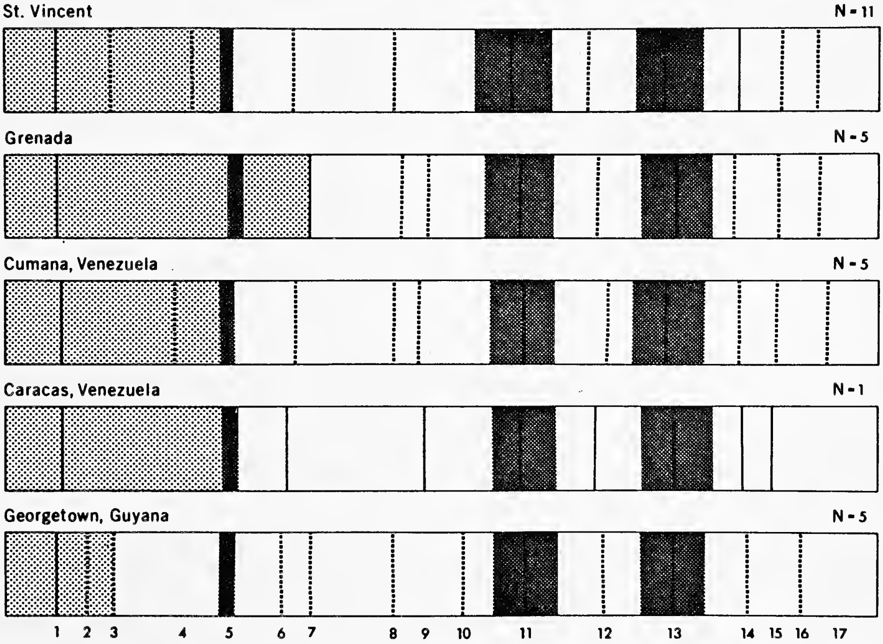

Figure 5. Electropherograms of *Eleutherodactylus johnstonei* leg muscle proteins from South American and West Indian populations as separated on 7% acrylamide gels. Vertical bars represent mean values for each protein observed. Solid vertical bars represent proteins found in all individuals within a sample; dotted vertical bars represent proteins of less frequent occurrence.

muscle proteins of the South American frogs (Fig. 5) clearly match *Eleutherodactylus johnstonei*, not *Eleutherodactylus martinicensis*. Seventeen protein fractions have been observed in the combined West Indian and South American samples, of which 4 (bands 1, 5, 11, and 13) are always present. Bands 12 and 14 are present in all populations, but not in all specimens of each population. With the exception of bands 2, 10, and 16, which occur only in the Georgetown population, the remaining bands are of infrequent occurrence, but occur at least once in both the South American and West Indian samples. Variations in these minor bands may be due to protein polymorphism.

Eleutherodactylus johnstonei has apparantly not spread throughout the city of Georgetown, Guyana, and is absent from the suburbs and open country immediately surrounding the city. A series of frogs recently identified as *johnstonei* (American Museum of Natural History) demonstrate, however, that the species has been in the city since at least 1923. Georgetown may have, in fact, been the point of earliest colonization of *E. johnstonei* on the South American mainland.

Over one hundred years ago Lichtenstein (1856) recorded "*Hylodes martinicensis*" (a name frequently applied to *johnstonei* prior to its description) from Caracas, Venezuela. It is doubtful, however, that his material represented either *johnstonei* or *martinicensis* or was even of West Indian origin. Juan Rivero (personal communication) first recorded *johnstonei* in Caracas in June, 1958, and assumed, on the basis of his field experience in Venezuela, that it had been recently introduced. Biologists in Caracas, informed us that the call of *johnstonei* was not commonly heard in the city until around 1960.

In a letter dated 10 March 1971, Juan Leon summarized the spread of *johnstonei* in Cumaná, Venezuela. An unspecified number of specimens was brought from Caracas in December, 1967, and released in the garden of the Chancellor's house at San Luis, Cumaná. As of March, 1971, this population had spread two miles east of the Chancellor's house and was estimated to include over 1,000 individuals. Small numbers of frogs are known to have been released in gardens 6 and 12 miles east of the Chancellor's house, but it is not known whether or not these introductions were successful. In early 1968 three males and four females were taken from the Chancellor's house to the campus of the University of Oriente, also in Cumaná. According to Mr. Leon, this population contained approximately 200 individuals in March, 1971.

Observations made at Willemstad in 1975 by Charles W. Myers suggest that *Eleutherodactylus johnstonei* was, at that time, a recent arrival in Curaçao. Males were heard calling in a garden near the western edge of Willemstad, but not in other nearby gardens or in the city itself.

Pough, Stewart, and Thomas (1977) noted that introduced species are "likely to make their first landfall in a coastal area" and that "the coastal margins of many Carribbean islands are hot and arid and successful colonizers must be able to tolerate these conditions". In their studies of Jamaican frogs they found that *E. johnstonei* and *E. planirostris* (both introduced in Jamaica) select higher temperatures, have higher CTM values, and are able to withstand greater water losses than two endemic Jamaican species, *E. cundalli* and *E. gossei*. They concluded that the two introduced species are "evidently preadapted to being colonists because they can withstand hot, dry conditions". In St. Vincent we observed a single male *johnstonei* calling from a small boulder within 20 yards of the surf. Other males were calling from a nearby Coccoloba grove. Schwartz (1967) also recorded *johnstonei* from extremely xeric coastal areas (as well as from a wide variety of other habitats) and concluded that this species "is much less restricted in its habitat requirements than are most other West Indian *Eleutherodactylus*".

In addition to the physiological factors discussed by Pough, Stewart, and Thomas (1977), certain aspects of behavior may also function to make *johnstonei* a successful colonists.

Julian Kenny (personal communication) tells of a box of *johnstonei* which was inadvertantly spilled by a visiting biologist in the Maracas Valley, Trinidad. By evening of the same day, the males had established call sites and were actively calling. All of the males were subsequently recaptured and the introduction of *johnstonei* into Trinidad was prevented. This observation suggest that *johnstonei* adapts readily and immediately to new environments.

Wingate (1965) suggested communal breeding and egg laying in *johnstonei*. In captivity *johnstonei* call, mate, and produce viable eggs even when crowded. Clutches of fertilized eggs were occasionally found on moist paper towels in small plastic boxes containing eight to ten adult frogs. Egg deposition did not occur in ripe individuals of other eastern Carribbean species (including *martinicensis*) maintained under essentially identical conditions. Hughes (1962) found that *johnstonei* would breed in "boxes of dampened straw"; while Chibon (1960, 1962) obtained numerous clutches of eggs in a terrarium containing wet soil, gravel, and extremely dense vegetation (there is unequivocal evidence, based on Chibon's description of hatchlings, to show that his frogs were *E. johnstonei*; not *martinicensis* as he supposed). These observations, collectively suggest that *johnstonei* has an unusually low requirement for space and isolation during courtship activity.

In some, but not all species of *Eleutherdactylus*, the eggs are guarded by the male or female parent. Bayley (1950) states that, in *johnstonei*, the eggs are guarded by the female and that, when a clutch of eggs is discovered, there are usually four or five other frogs sheltered nearby. Although the other frogs escape immediately, the female must be prodded before leaving the eggs, and will sometimes urinate on them while escaping. Lemon (1971) and Adamson, Harrison, and Bayley (1960) agreed that it is the female that guards the eggs. The later authors noted that the female urinates on the eggs if disturbed while brooding. Chibon (1960) stated that the female is found very close to the eggs (but note apparantly not on or touching them). Wingate (1965) found one to five adults present with field collected eggs. Pope (1917), on the other hand, did not mention the presence of an adult frog with a clutch of field collected eggs in Bermuda; and Groome (personal communication) specifically observed unguarded clutches of eggs in Grenada. Eggs deposited in laboratory containers were either unguarded when discovered, or had one or more frogs sitting near, but not on them. Some of these eggs hatched successfully although they were heavily covered with fungus. These observations suggest that guardianship of the eggs in *E. johnstonei* is variable and apparently not as highly developed as in some other members of the genus.

It is evident, then, that both physiological and behaviorial factors are probably involved in the remarkable ability of *Eleutherodactylus johnstonei* to colonize new areas. There is little information, however, on the effects of this colonization on either endemic or introduced species of *Eleutherodactylus* in areas which *johnstonei* has colonized.

On Jamaica, where multiple introductions have apparently taken place (Perkins, 1942), *johnstonei* could conceivably co-exist, in time, with at least 15 other species of *Eleutherodactylus*. It is otherwise known to occur with *gossei* in Bermuda; with *martinicensis* in Antigua, Guadeloupe, and Martinique; with *pinchoni* in Guadeloupe; and with the frog currently referred to *urichi* in Grenada and St. Vincent.

Pough, Stewart, and Thomas (1977) studied the ecological relationships of *johnstonei* and *planirostris* (both introduced) with two endemic Jamaican species, *cundalli* and *gossei*. They recorded *johnstonei* primarily from disturbed habitats not suitable to the native species. Indeed competition with a variety of native species may account for the initial slow spread of *johnstonei* in Jamaica (about 6 miles in 40 or 50 years as reported by Perkins, 1942). On the other hand Pough, Stewart, and Thomas (1977) found that when coconut husk piles were denuded of frogs during the dry season, the husk piles were re-populated predominately by the introduced species (*johnstonei* and *planirostris*). The anuran fauna of these husk piles in subsequent seasons was unfortuneately not discussed.

Eleutherodactylus johnstonei arrived in Bermuda around 1880, while *Eleutherodactylus gossei* did not arrive until about 1906 (Dunn and Conant, 1937). The ranges of these two species were initially mutually exclusive, but they came together in about 1916 (Pope, 1917). *E. johnstonei* is now island-wide in distribution, while the range of *gossei* has apparently become static. Where the two species occur together, *gossei* is less abundant than *johnstonei* except in very moist situations (Wingate, 1965).

Hardy, Drewry, and Cole (unpublished MS), working in Guadeloupe, have found that *johnstonei* may displace *martinicensis* in agricultural environments. The peculiar limited distribution of *martinicensis* in Martinique (predominately in the forested uplands of the northern third of the island) may reflect similar displacement by *johnstonei*. Schwartz (1967) recorded no recently collected specimens of *martinicensis* from Antigua, an island on which few natural habitats remain. Here, too, *johnstonei* may be displacing (or may have displaced) *martinicensis* by selectively occupying disturbed (i.e. agricultural) habitats.

In St. Vincent the frog currently referred to *E. urichi* is far more abundant at the summit of Mt. Soufriere (where *johnstonei* does not occur) than it is on the lower slopes of the mountains where it occurs syntopically with *johnstonei*. These two areas are ecologically distinct however (ground bromeliads at the summit; heavy forests and agricultural areas on the lower slopes), and this, rather than competition with *johnstonei*, may account for the differences in relative abundance. In Grenada, on the other hand, "*urichi*" occurred in St. George's in 1910. At that time *johnstonei* had probably been on Grenada for no more than 25 years (Barbour, 1914; Groome, 1970) and was probably restricted to low, coastal areas. It had, however, reached the interior highlands (Grand Etang) by at least 1937 (Cochran, 1938). *Eleutherodactylus* "*urichi*" no longer occurs in St. George's (or the lowlands around St. George's), while *johnstonei* is quite abundant both in and around the city. Both species now occur in the forests surrounding Grand Etang; but, in this area, *johnstonei* is conspicuously more abundant than "*urichi*".

These observations strongly suggest that *johnstonei* may, indeed, displace both native and introduced populations of *Eleutherodactylus* in areas which it has colonized. This seems to be particularily (but probably not exclusively) true of disturbed habitats. The spread of *Eleutherodactylus johnstonei* on the South American mainland may, therefore, in time drastically effect members of the local *Eleutherodactylus* fauna.

SPECIMENS EXAMINED

Eastern Caribbean

Grenada. USNM 194388-96, Grand Etang, 26 June 1970; USNM 194397-8, Grand Etang, 9 July 1971.

St. Vincent. USNM 194399-400, Lowrt, 24 June 1970; USNM 194401-14, Lowrt, 5 July 1971; USNM 194415, Soufriere, River Soufriere, 1000 feet, 7 July 1971.

Netherlands Antilles

Curaçao. AMNH 90933-4, near western edge of Willemstad, 29 August 1975.

South America

Guyana. USNM 194416-28, Georgetown, Belair Park, 6 July 1970.

Venezuela. USNM 194429-41, Caracas, "late 1960's"; USNM 194442-6, Cumaná, San Luis, 6 July 1970.

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Literature Cited

Adamson, L., R.G. Harrison, and Iris Bayley.
1960. The development of thewhistling frog *Eleutherodactylus martinicensis* of Barbados. *Proc. Zool. Soc. London 133*(3):453-69, 4 plates.

Barbour, Thomas.
1914. A contribution to the zoogeography of the West Indies, with especial reference to amphibians and reptiles. *Memoirs Mus. Comp. Zool. XLIV* (2):205-359.

______________.
1930. A list of Antillean reptiles and amphibians. *Zoologica XI* (4):61-116.

Bayley, Iris.
1950. The whistling frogof Barbados. *Jour. Barbados Mus. andHist. Soc. XVII*(4):161-70, 2 plates.

Chibon, P.
1960. Developpement au laboratoire d'*Eleutherodactylus martinicensis* Tschudi, batracien anoure a developpement direct. *Bull. Soc. Zool. de France LXXXV*(5-6):412-8.

__________.
1962. Differenciation sexuelle de *Eleutherodactylus martinicensis* Tschudi batracien anoure a developpement direct. *Bull. Soc. Zool. Fr. LXXXV*(5-6)412-8.

Cochran, Doris M.
1938. Reptiles and amphibians from the Lesser Antilles collected by S. T. Danforth. *Proc. Biol. Soc. Wash. 51*:147-56.

Drewry, George E.
1970. The role of amphibians in the ecology of Puerto Rican rain forest. *Ann. Rep., Puerto Rico Nuclear Center, Rain Forest Project*, p. 16-63.

Dunn, E. R. and Roger Conant.
1937. The herpetological fauna of Bermuda. *Herpetologica 1*:78-80.

Grant, Chapman.
1959. Herpetology of Barbados, B.W.I. *Herpetologica 15*(2):97-101.

Groome, John R.
1970. A natural history of the island of Grenada. *Caribbean Printers Limited, Arima, Trinidad,* viii+115.

Gunther, Albert.
1895. Introduction of a West Indian frog into the Royal Gardens, Kew. *Nature 52*(1357):643.

Hardy, Jerry D., Jr., Geroge E. Drewry, and Charles Cole.
(MS). Frogs of the genus *Eleutherodactylus* from Guadeloupe West Indies.

Hughes, Arthur.
1962. An experimental study on the relationships between limb and

spinal cord in the embryo of *Eleutherodactylus martinicensis*. *Jour. Embryol. Expt. Morph. 10*(4):575-601.

Lemon, Robert E.
1971. Vocal Communication by the frog *Eleutherodactylus martinicensis*. *Canadian Jour. Zool. 49*(2):211-7.

Lichtenstein, J.
1856. Nomenclator Reptilium et Amphiborum Musei Zoologica Berlinensis. Namenverzeichnifs der in der zoologischen Sammlung der Koniglichen Universitat zu Berlin aufgestellten Arten von Reptilien und Amphibien nach irhem Ordnungen, Familien und Gattungen. Gedruckt in der Buchruckerei der Koniglichen Akademie der Wissenschaften. *Berlin* (1856): ii + 48.

Maclean, William P., Richard Kellner, and Howard Dennis.
1977. Island lists of West Indian amphibians and reptiles. *Smithsonian Herpetological Information Service* (40), 47 p.

Parker, H. W.
1933. Some amphibians and reptiles from the Lesser Antilles. *Annals and Mag. Nat. Hist.*, 10th Ser 11(61):151-8.

Perkins, L.
1942. Whistling frogs in St. Ann. *Nat. Hist. Notes, Nat. Hist. Soc. Jamaica 1*(4):4.

Pope, P.H.
1917. The introduction of West Indian Anura into Bermuda. *Bull. Mus. Comp. Zool. LXI*(6):121-31.

Pough, F. Harvey, Margaret M. Stewart, and Richard G. Thomas.
1977. Physiological basis of habitat partitioning in Jamaican *Eleutherodactylus*. *Oecologia (Berlin) 27*:285-93.

Schwartz, Albert.
1967. Frogs of the genus *Eleutherodactylus* in the Lesser Antilles. *Stud. Fauna Curaçao and other Carib. Islands 24*:1-62.

_______________, and Richard Thomas.
1975. A check-list of West Indian amphibians and reptiles. *Carnegie Mus. Nat. Hist., Spec. Publ.* (1), 216 p.

Watkins, William A., Edward R. Baylor, and Anne T. Bower.
1970. The call of *Eleutherodactylus johnstonei*, the whistling frog of Bermuda. *Copeia 1970*(3):558-61.

Wingate, David B.
1965. Terrestrial herpetofauna of Bermuda. *Herpetologica 21*(3): 202-18.

Department of Herpetology, Natural History Society of Maryland
2643 N. Charles Street, Baltimore, Maryland 21218.

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SURFACE ACTIVITY AND HORIZONTAL MOVEMENTS IN A MARKED POPULATION OF *SISTRURUS MILIARIUS BARBOURI*

James A. Hudnall

Field observations on activity and field movements of the Dusky Pigmy Rattlesnake (*Sistrurus miliarius barbouri* Gloyd) were made in Florida in a cypress-sawgrass-palmetto habitat 5 miles west of Palm Beach Gardens, Palm Beach County (Fig. 1). Reported here are observations on 64 individuals, 50 of which were marked in a local population (16 recaptured 1-5 times) between March 26, 1975 and November 14, 1976. These snakes are evening-crepuscular and nocturnal from Spring to Fall, shifting to afternoon-diurnal during Winter. Evidence was found suggesting the occurrence of home ranges in this species.

Fig. 1. Study area in December 1977. Major plant species include saw grass (*Cladium jamaicensis*), pond cypress (*Taxodium distichum*), and saw palmetto (*Serenoa repens*).

The study area (Fig. 1) borders a canal, no. C-18, maintained by the Central and Southern Florida Flood Control District. The soil from the digging of the canal was piled up ca. 7 m away and paralled to the banks to form sand-shell rock levees ca. 23 m wide and 2.5 m high. These levees were weedy and periodically mown, leaving dense vegetation only on the steep canal bank and 1.5 m from the lip intact. Transects to capture snakes were walked along the mown vegetation interface or edge; recapture data provided one-dimensional field movements. On capture individuals were tagged, weighed, measured, sexed (sexed based on external tail morphology) and released.

The tagging method used employs colored beads on monofilament suture-line that is sewn into the snake's tail, and the length measurements were made using both photographic and chill-coma methods. These methods are described in detail elsewhere (Hudnall, in press).

Time and Season of Surface Activity. -- Transects (29 times) were completed by 1200 hrs (86.2%); a few afternoon (1500-1900 hrs) observations are included. Most individuals (63 = 84% of 75 observations) were found coiled in a resting position. Of the 12 observations of actively moving individuals at the time of capture, 5 were seen in the afternoon. Only 1 observation of a coiled snake was made in the afternoon. It was found that 25 (39.7%) of 63 coiled snakes were positioned such that morning sunlight would strike them within the first two hours after dawn; the others were primarily located to the west of vegetative cover or in erosion cuts in the bank such that they would remain shaded for most of the morning.

A linear regression of overnight low temperatures against number of Dusky Pigmy Rattlesnakes seen during an observation session produced a non-significant line (r = 0.127, df = 27).

Numbers of observations of *Sistrurus miliarius barbouri* were distributed as follows based on successful field sessions: April, 5 observed in 3 sessions; May, 12 observed in 6 sessions; June, 4 observed in 3 sessions; September, 17 observed in 6 sessions; October, 18 observed in 4 sessions; November, 14 observed in 5 sessions; December, 5 observed in 2 sessions. These data coincide predictably with data of Chamberlain (1935) for *Sistrurus miliarius* in South Carolina and data of Palmer and Williamson (1971) in North Carolina. Of Chamberlain's observations, 65% were made from July to September while Palmer and Williamson recorded 66% of their sitings during these months. Most of mine were observed from September to November, explainable with colder and harsher weather arriving earlier in the northern states. It was concluded by Chamberlain (1935), and I concur, that "it appears that some individuals may be active at almost any time during the year except in the coldest weather." In coastal south Florida "coldest weather" is usually no more than 5 consecutive days in duration. No evidence of denning behavior was found; only single individuals were observed with the exception of one occasion (September) when two snakes (male and female) were located within 4 m of each other.

Thus, the over-all picture for *Sistrurus miliarius barbouri* in my study area is a year-around active snake lacking a hibernation period. They seem to be afternoon-crepuscular and early evening nocturnal from March-October (assume July-August with no personal observations), being found coiled and asleep in the mornings and moving to cover for the day by noon. From November-February they seem to be primarily afternoon-diurnal, most of which time is spent basking or moving to and from a basking site.

During all seasons, it was found that very few individuals (ca. 5 out of ca. 55 observations) were inclined to strike when harassed with a moving boot. The usual reaction was to coil to strike, rattle, then retreat.

Only three snakes assumed to be young-of-the-year were captured during this study: 11 October 1975, SVL = 220 mm; 18 October 1975, SVL = 229 mm; 23 November 1975, SVL = 227 mm. Each had a button at the time of capture, and the 229 mm snake possessed one additional segment. Snout-vent lengths of August *S. m. streckeri* reported by Fleet and Kroll (1978) in east Texas did not exceed 161 mm; unless newborn *S. m. barbouri* exceed this, the juveniles reported here would be 1-3 months old.

TABLE 1

ID#	Snout-vent Length at First Capture (mm)	No. Times Recaptured	$\bar{x} \pm$ St. Error Distance Travelled (m)	Total Movement Since First Capture (m)	Max. Distance From First Capture Point (km)	m/day	Days From First to Last Capture
20	459	5	179.6 ± 81.5	898.0	0.2393	10.7	84
19	375	3	81.0 ± 67.1	243.0	0.2258	3.9	62
36	416	3	89.5 ± 34.6	268.5	0.1128	0.9	294
21	469	2	121.2 ± 114.5	242.3	0.2423	5.8	42
28	479	2	151.7 ± 80.3	303.3	0.2320	0.9	355
4	526	1	93.6	93.6	0.0936	7.2	13
5	445	1	9.1	9.1	0.0091	0.6	14
7	420	1	30.2	30.2	0.0302	1.9	16
8	476	1	66.8	66.8	0.0668	4.8	14
18	422	1	69.5	69.5	0.0695	8.7	8
22	296	1	118.9	118.9	0.1189	3.4	35
25	362	1	9.1	9.1	0.0091	1.3	7
30	331	1	132.3	132.3	0.1323	6.3	21
33	461	1	16.8	16.8	0.0168	2.4	7
40	384	1	37.8	37.8	0.0378	0.2	162
42	411	1	89.0	89.0	0.0890	1.6	57
N=16			$\bar{x}$	164.3		3.8	74.4

Table 1. Field movements of marked and recaptured *Sistrurus miliarius barbouri* in southern Florida.

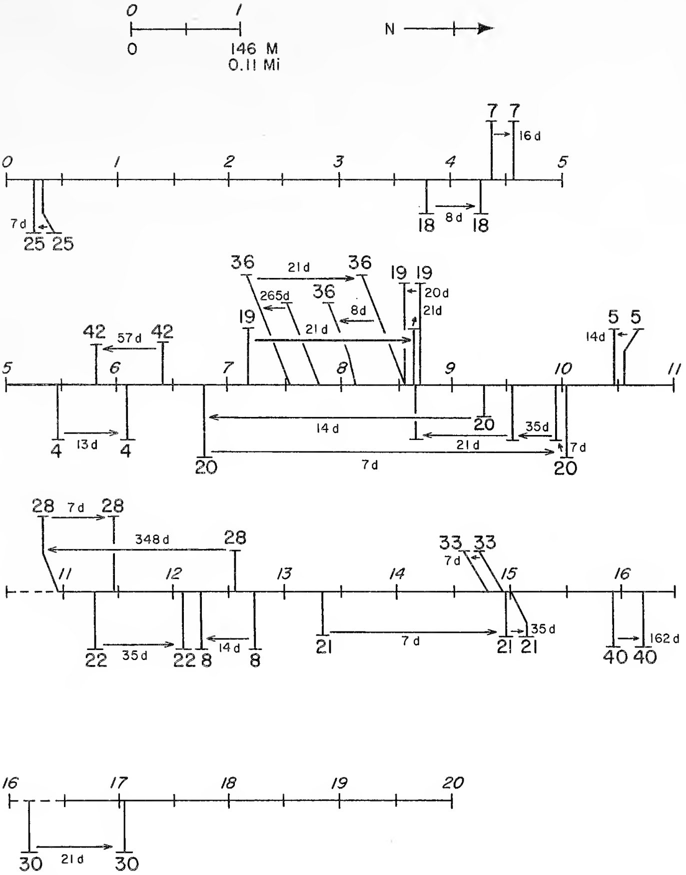

Fig. 2. Diagrammatic map of recaptures of marked Dusky Pigmy Rattlesnakes; the 2920 m transect line is indicated here in four divided parts. Time elapsed in days (d) is shown between each capture point.

No gravid individuals were noted at any time during the study.

Field Movements of Marked Individuals. --Reduced data for movements of recaptured individuals is given in Table 1. Average distance traveled per capture and total movement, while variable, both indicate that individual *Sistrurus miliarius barbouri* actively move within this restricted habitat. The measurement of maximum distance from the initial capture point reveals that the snakes are generally not moving unidirectionally, and may be moving within a definable stable home range. The capture points plotted for snake number 20 (male, see Fig. 2) is a strong case supporting the existence of home ranges in the Florida study area; several of the other individuals also indicate definite home range behavior.

Of fifty snakes marked over 1.5 years, 8 of the 16 total recaptured individuals (50%) were recaptured within 1-3 weeks and never seen again. Fitch (1949), in discussing low recapture percentages and large movements recorded for some *Crotalus viridis oreganus* in California, concluded that some individuals in his population were wandering randomly while some long trips seemed to be shifts to new, restricted home ranges. The sedentariness through time of several of his crotalid snakes, as with mine, strongly suggest limited home ranges in rattlesnakes. Fleet and Kroll (1978) reported a gravid female *S. m. streckeri* in east Texas that was observed 7 times from 1 July 1976 to 3 August 1976; it remained within 2 m of its original capture point.

The data reported here for a marked population support an earlier impression of highly localized behavior of unmarked individuals in similar Florida habitats as observed over the past twelve years of field observations on the species. The conclusion on home range behavior in *Sistrurus miliarius barbouri* is also in agreement with the criterion of the long-term movement of individual snakes not being exceeded greatly by short-term movements of other individuals (Stickel and Cope, 1947).

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Literature Cited

Chamberlain, E. B.
1935. Notes on the Pigmy Rattlesnake, *Sistrurus miliarius* Linnaeus, in South Carolina. *Copeia 1935*:146-147.

Fitch, H. S.
1949. Study of snake populations in central California. *Am. Midl. Nat. 41*:513-579.

Fleet, R. R. and J. C. Kroll.
1978. Litter size and parturition behavior in *Sistrurus miliarius streckeri*. *Herp. Review 9*:11

Hudnall, J. A.
1980. New methods for measuring and tagging snakes. *Herp. Review* (in press).

Palmer, William M. and Gary M. Williamson
1971. Observations on the natural history of the Carolina Pigmy Rattlesnake, *Sistrurus miliarius miliarius* Linnaeus. *J. Elisha Mitchell Sci. Soc. 87*:20-25.

Stickel, W. H. and J. B. Cope
1947. The home ranges and wandering of snakes. *Copeia 1947*:127-136.

Department of Ecology and Evolutionary Biology, University of Arizona,
Tucson, Arizona 85721, U.S.A.

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A STUDY OF THE HOMING INSTINCT IN *Terrapene c. carolina* IN MARYLAND

During the six week period from 9 June 1978 to 22 July 1978, the ovements of 13 displaced eastern box turtles, *Terrapene c. carolina* Linnaeus), were studied. This project was conducted in conjunction with ngoing studies of the eastern box turtle at the Douglas Point Field tation for Terrestrial Studies, a 1400 acre tract of land on the eastern hore of the Potomac River in Charles County, Md., approximately 48 kilmeters south of the District of Columbia.

Upon capture, each turtle was fitted with a thread trailing device hich was a modification of that used by Stickel (1950). Previous exerimenters have shown that this type of trailing device does not sigificantly alter the turtle's pattern of movement (Stickel, 1950). Where ossible, turtles were trailed for several days within their home range o obtain an idea of their normal movement patterns and to get an approxmation of the extent of their home range. After the home range inforation had been obtained, the turtles were relocated. Ten of the turtles ere relocated from 500 meters to 900 meters from their home range. The emaining three turtles were displaced 1.6 km, 4 km, and 8 km from their apture point.

Of the 10 turtles displaced less than 900 meters, nine returned to heir home range. The pattern of movement observed during their return as markedly different from that observed within their home range. The ovements observed for those turtles within their home range consisted f repeated doubling, turning, and little unidirectional movement. This ype of home range movement pattern is consistant with that observed by ther authors (Dolbeer, 1969; Gould, 1957; Nichols, 1939; Stickel, 1950). owever, the pattern of movement observed in those turtles returning to heir home range consisted of an initial period of erratic movement usually less than 10 meters) followed by a period of unidirectional ovement which continued until the individual had returned to the vicinity f its home range. For five individuals, this unidirectional movement as actually in the form of a slight arc rather than a straight path owards its home range. In all but one case, however, this arcing patern of movement could be accounted for because the box turtle was folowing either a road or a stream valley. As noted in a previous study Lemkau, 1970), the returning turtles tend to follow natural or manmade oundaries such as streams, roads, and washouts.

As mentioned above, one of the ten turtles did not attempt to return o its home range. This particular individual had been displaced approximetely 600 meters. This individual, however, did not exhibit a typical ome range pattern of movement upon relocation. Rather, the pattern of ovement was very erratic, characterized by numerous circling movements nd more turns than were observed in the home range movements observed or this individual.

Of the three turtles relocated more than 1.6 km, none attempted to return to its point of capture. Within several days of release, all three individuals began to exhibit a pattern of movement similar to that seen for the home range. This type of behavior was also seen in a 1974 study in which seven three-toed box turtles (*Terrapene c. triunquis*) were removed 1.6 km to 3.2 km from their capture point and established new home ranges rather than returning to their original ones (Schwartz & Schwartz, 1974).

On the basis of this study it appears that at least some eastern box turtles exhibit a homing instinct. However, the distance from which a box turtle will return to its home range does seem to be limited. For some individuals, this critical distance appears to be less than 1.6 km.

Literature Cited

Dolbeer, R. A.
1969. Population density and home range size of the eastern box turtle (*Terrapene c. carolina*) in eastern Tennessee. *Assoc. Southeastern Biol. Bull.* 16 :49 (abstract).

Gould, E.
1957. Orientation in the box turtle, *Terrapene c. carolina*. *Biological Bulletin* 112 (3):336-348.

Lemkau, P. J.
1970. Movements of the box turtle, *Terrapene c. carolina* (L.), in unfamiliar territory. *Copeia 1970*: 781-783.

Nichols, J. T.
1939. Range and homing of individual box turtles. *Copeia 1939*:125-127.

Schwartz, C. W. and E. R. Schwartz.
1974. The three-toes box turtle in central Missouri: Its population home range, and movements. *Terrestrial Series #5, Missouri Department of Conservation, Jefferson City, Missouri.*

Stickel, Lucillet.
1950. Population and home range relationships of the box turtle, *Terrapene c. carolina* (Linneaus). *Ecological Monographs.* 20: 351-378.

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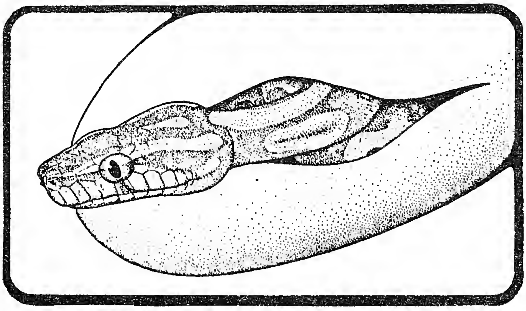

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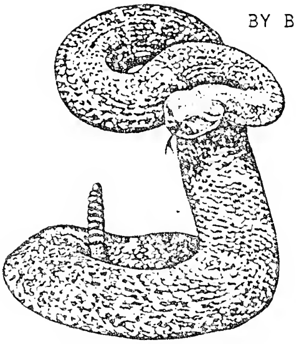

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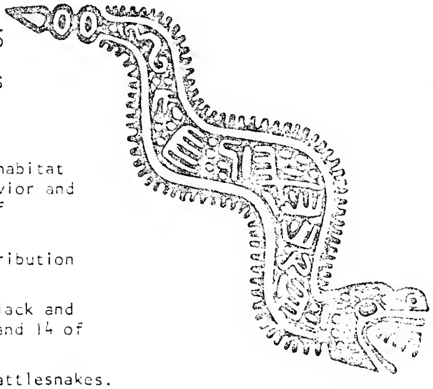

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