TEXAS J. SCI. 55(3):195-200

AUGUST, 2003

REPRODUCTION IN THE SPECKLED RACER, *DRYMOBIUS MARGARITIFERUS* (SERPENTES: COLUBRIDAE), FROM MEXICO AND CENTRAL AMERICA

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Abstract.—Reproductive tissue was examined from 100 preserved specimens of *Drymobius margaritiferus* from Mexico and Central America. Males exhibited a prolonged period of sperm production encompassing the four seasons of the year. The smallest spermiogenic male measured 380 mm SVL and was from Costa Rica. Females were reproductively active (enlarged ovarian follicles or oviductal eggs) during the four seasons, suggesting an extended period of reproduction. There was no evidence (oviductal eggs with yolk deposition in progress in the same female) to indicate females produce more than one clutch of eggs per year. The smallest reproductively active female (enlarged ovarian follicles > 12 mm) measured 440 mm SVL and was from Costa Rica. Mean clutch size (n = 24) was 5.1 ± 1.5 *SD*, range = 2-8.

The speckled racer, *Drymobius margaritiferus*, occurs from southern Texas on the Atlantic coast and southern Sonora, Mexico on the Pacific coast, south through Central America and into South America along the Caribbean coast of Colombia where it occurs in a wide variety of habitats ranging from lowland tropical rain forest, pine savannas and thorn forest to pine woods and cloud forest (Wilson 1974). There is anecdotal information on clutch sizes (Stuart 1935; 1943; 1948; Gaige et al. 1937; Werler 1949; 1951; Scott 1962; Hardy & McDiarmid 1969; Tennant 1984; Solórzano & Cerdas 1987; Werler & Dixon 2000) and appearance of young (Neill 1962; 1965). The purpose of this paper is to provide additional information on the ovarian cycle and the first observations on the testicular cycle of *D. margaritiferus* from an examination of preserved specimens from Mexico and Central America.

A sample of 100 adult specimens of *D. margaritiferus* from Mexico (n = 37): (females n = 20, mean snout-vent length, [SVL] = 553 mm ± 67 *SD*, range = 430-728 mm; males n = 17, SVL = 566 mm ± 84 *SD*, range = 462-807 mm) and Central America (n = 63): (females n = 27, SVL = 559 mm ± 100 *SD*, range = 438-730 mm; males n = 36, SVL = 490 mm ± 62 *SD*, range = 380-625 mm) was examined from the herpetology collections of the Natural History Museum of Los Angeles County, Los Angeles (LACM) and the University of Arizona, Tucson (UAZ). Snakes were collected 1959-1986. Counts were made

of enlarged ovarian follicles (> 12 mm length) or oviductal eggs. Data from two *D. margaritiferus* clutches from Costa Rica (Solórzano & Cerdas 1987) are included. The left testis, vas deferens and a portion of the kidney were removed from males and the left ovary was removed from females for histological examination. Tissues were embedded in paraffin and sectioned at 5 μm. Slides with tissue sections were stained with Harris' hematoxylin followed by eosin counterstain. Histological slides were examined to determine the stage of the testicular cycle and for the presence of yolk deposition (secondary vitellogenesis *sensu* Aldridge 1979). Because some of the specimens were road kills, not all tissues were available for histological examination due to damage or autolysis. Number of specimens examined by reproductive tissue were: testis = 53, vas deferens = 39, kidney = 42, ovary = 47. An unpaired *t*-test was used to compare mean clutch sizes between Mexico and Costa Rica.

Material examined.—The following adult specimens of *Drymobius margaritiferus* were examined: COSTA RICA: ALAJUELA PROVINCE (LACM 58890, 58891, 150547, 150600), CARTAGO PROVINCE (LACM 150543, 150552-150554, 150557, 150559, 150566, 150568, 150570-150572, 150575, 150576, 150578, 150582, 150596, 150597, 150604), GUANACASTE PROVINCE (LACM 58889, 150535, 150538, 150551, 150574, 150577, 150587, 150595, 150607), HEREDIA PROVINCE (LACM 150602), LIMÓN PROVINCE (LACM 131136, 131137, 150544, 150546, 150558, 150560, 150573, 150579, 150584, 150585, 150601, 150603, 150605, 150606), PUNTARENAS PROVINCE (LACM 150539, 150542, 150545, 150548, 150580, 150586), SAN JOSÉ PROVINCE (LACM 150541, 150549, 150563-150565, 150581, 150592-150594); GUATEMALA: HUEHUETENANGO PROVINCE (LACM 40048), IZABAL PROVINCE (LACM 59070); MEXICO: NAYARIT (LACM 20497, 20498, 25901), OAXACA (LACM 127051), SINALOA (LACM 6804-6817, 6819, 7237-7239), SONORA (LACM 25197, UAZ 46658, 46659), TAMAULIPAS (LACM 20495, 20496), VERACRUZ (LACM 8585, 58888, 122123-122126, 122130, 122133, 130084); NICARAGUA: LEÓN PROVINCE (LACM 67650).

Results and Discussion

. Testicular histology of *D. margaritiferus* was similar to that reported by Goldberg & Parker (1975) for two colubrid snakes, *Masticophis taeniatus* and *Pituophis catenifer*. All testes examined exhibited spermiogenesis with metamorphosing spermatids and mature sperm present. The following numbers of males were determined to be undergoing spermiogenesis by month: February (5), March (2), April

(7), May (11), June (11), July (6), August (6), September (2), October (1), November (2). All 39 vasa deferentia examined contained sperm: February (3), March (1), April (5), May (8), June (10), July (5), August (5), September (2). Forty of 42 (95%) kidney sexual segments examined were enlarged and contained secretory granules: February 5/5 (100%), March 1/1 (100%), April 6/6 (100%), May 8/8 (100%), June 10/10 (100%), July 5/5 (100%), August 3/4 (75%), September 1/2 (50%), October 1/1 (100%). Mating usually coincides with the enlargement of kidney sexual segments (Saint Girons 1982). The smallest spermiogenic males measured 380 mm SVL (LACM 150539) and 385 mm SVL (LACM 150546). Males smaller than this size were not examined so the minimum size at which *D. margaritiferus* commences sperm formation is not known.

Females with enlarged follicles (> 12 mm length) or oviductal eggs were observed February-September, with one female undergoing early yolk deposition in January (Table 1). The smallest reproductively active *D. margaritiferus* female (enlarged ovarian follicles) measured 440 mm SVL and was from Costa Rica (LACM 150560). Two females examined slightly smaller than this size (LACM 6819, SVL 430 mm and LACM 58891, SVL 438 mm) were not undergoing yolk deposition. The only smaller female examined (LACM 58889, SVL 355 mm) appeared to be a juvenile and was from Costa Rica. It was not undergoing yolk deposition and was excluded from the study to avoid the possibility of including juveniles in analysis of the ovarian cycle. Examination of additional females will be needed to determine the minimum size at which females commence reproduction. There was no evidence that females produce more than one clutch of eggs in a reproductive season (oviductal eggs and yolk deposition in progress in the same female) although the presence of either yolk deposition, enlarged follicles or oviductal eggs during four seasons suggests that this might be possible (Table 1).

All clutch sizes are listed in Table 2. Mean clutch size for seven egg clutches from Mexico was 5.6 $\pm$ 0.8 *SD*, range = 5-7. Mean clutch size for seventeen egg clutches from Costa Rica (including two of Solórzano & Cerdas 1987) was 4.9 $\pm$ 1.7 *SD*, range = 2-8. The difference between these values was not significant (unpaired *t*-test, $t = 0.92$, $df = 22$, $P = 0.37$). Combined mean clutch size ($n = 24$) was 5.1 $\pm$ 1.5 *SD*, range = 2-8. The range in clutch sizes of 2-8 are identical to those reported for *D. margaritiferus* by Tennant (1984). A variety of individual clutch sizes for *D. margaritiferus* have been

Table 1. Monthly distribution of stages in the seasonal ovarian cycle of *Drymobius margaritiferus* from examination of adult specimens (combined data from Mexico, n = 20, Nicaragua, n = 1 and Costa Rica, n = 26) and two clutch sizes* from Solórzano & Cerdas (1987). Values shown are the numbers of females exhibiting each of the four conditions.

Month	n	Inactive	Early yolk deposition	Enlarged follicles > 12 mm length	Oviductal eggs
January	1	0	1	0	0
February	1	0	0	0	1*
March	5	1	0	2	2*
April	1	0	0	1	0
May	6	1	1	1	3
June	6	2	0	2	2
July	20	8	4	4	4
August	3	1	1	0	1
September	2	0	0	2	0
November	2	2	0	0	0
December	2	2	0	0	0

reported. In Guatemala, eggs were found in the oviducts of females during June, one female from 30 July contained eggs ready to be deposited, and females from May-June contained well-developed eggs (Stuart 1935; 1943; 1948). From eastern Nicaragua, one female collected in August contained fully developed eggs (Gaige et al. 1937). A female from Mexico laid seven eggs on 22 April, while another female laid two eggs on 29 July (Werler 1949; 1951). Scott (1962) reported on two females from Sinaloa, one from 12 June and another from early August, each of which contained six well developed ova without shells. A female from Brownsville, Texas contained four oviductal eggs (Werler & Dixon 2000). A pair of *D. margaritiferus* were observed mating in Sinaloa on 30 March (Hardy & McDiarmid 1969). The presence of non-reproductive females (Table 1) during the period when other females were reproductively active may suggest that only a portion of the female population reproduces in a given year. However, because reproductively active females were found during all four seasons, it is possible that non-reproductive females may have produced a clutch earlier or later in the year. Snakes in temperate areas have a much shorter period in which to produce eggs, (see Goldberg 2000; 2002).

The preceding observations on females, plus the presence of males undergoing spermiogenesis and sperm in the vasa deferentia in all four seasons indicate a prolonged reproductive cycle for *D. margaritiferus*. The reproductive cycles of tropical snakes are variable and while there may be potential for year-round breeding, most studies have shown

Table 2. Clutch sizes for *Drymobius margaritiferus* (estimated from counts of yolked follicles > 12 mm length or oviductal eggs*) from Mexico and Costa Rica.

Date	SVL (mm)	Clutch size	Country/State/ Province	Source
28 June	522	squashed*	Mexico/Nayarit	LACM 20497
16 July	550	5*	Mexico/Sonora	UAZ 46658
19 July	510	5	Mexico/Sinaloa	LACM 6804
23 July	491	5*	Mexico/Sinaloa	LACM 6807
23 July	608	6	Mexico/Sinaloa	LACM 6809
23 July	635	7*	Mexico/Sinaloa	LACM 6808
23 July	600	5	Mexico/Sinaloa	LACM 6810
27 July	728	6*	Mexico/Veracruz	LACM 8585
10 February	447	4*	Costa Rica/San José	Solórzano & Cerdas (1987)
6 March	713	8*	Costa Rica/San José	LACM 150592
22 March	710	6*	Costa Rica/San José	LACM 150594
26-27 March	500	4	Costa Rica/San José	LACM 150581
27 March	517	5*	Costa Rica/San José	Solórzano & Cerdas (1987)
21 April	694	8	Costa Rica/Guanacaste	LACM 150595
11 May	485	5*	Costa Rica/Cartago	LACM 150597
23 May	730	6	Costa Rica/Cartago	LACM 150575
28 May	565	6*	Costa Rica/Cartago	LACM 150566
29 May	659	7*	Costa Rica/San José	LACM 150564
11 June	465	3	Costa Rica/Cartago	LACM 150559
13 June	528	2*	Costa Rica/Cartago	LACM 150552
26 June	440	4	Costa Rica/Limón	LACM 150560
20 July	490	5	Costa Rica/Alajuela	LACM 58890
21-23 August	572	4*	Costa Rica/Guanacaste	LACM 150577
4 September	480	4	Costa Rica/Limón	LACM 150579
5 September	500	3	Costa Rica/Limón	LACM 150584

reproduction is limited to part of the year or, in cases of extended breeding, there is an annual peak with reduced levels at other times (Fitch 1982). To accurately characterize the reproductive cycle of *D. margaritiferus*, seasonal collections of gonads from males and females from a limited geographic area during the same year should be examined.

ACKNOWLEDGMENTS

I thank G. L. Bradley (University of Arizona), D. A. Kizirian (Natural History Museum of Los Angeles County) for permission to examine specimens and K. R. Beaman (Natural History Museum of Los Angeles County) for comments on the manuscript.

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