Reproductive cycle of the Namaqua sand lizard, Pedioplanis namaquensis (Squamata: Lacertidae), from southern Africa

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The reproductive cycle of the Namaqua sand lizard, *Pedioplanis namaquensis*, from southern Africa is described from histological examination of gonadal material from museum specimens. Males followed a seasonal testicular cycle in which sperm was produced in January–March and September–December. Testes in regression were present in March and May. Females with enlarged ovarian follicles (>4 mm length) or oviductal eggs were collected between November and February. Clutch size for 14 females was 3.8 ± 0.97 S.D. eggs, range 3–5. Histological evidence is presented that two clutches may be produced in the same reproductive season.

Key words: ***Pedioplanis namaquensis*, Lacertidae, reproductive cycle, southern Africa.**

The Namaqua sand lizard, *Pedioplanis namaquensis,* inhabits karroid veld, arid savanna and semi-desert and is found in the Eastern Cape Province of South Africa, through the Karoo, Namaqualand, Namibia and Botswana to southern Angola (Branch 1998). Little information is known about reproduction of *P. namaquensis.* Branch (1998) reported that 3–5 eggs are laid in November. Pianka (1986) reported a mean clutch size of 3.9 ± 1.5 S.D. for 29 *P. namaquensis* (as *Eremias namaquensis*). The purpose of this paper is to supplement known information on reproduction in *P. namaquensis* by presenting data from a histological examination of gonadal material from museum specimens. Herein I supply information on the seasonal timing of the male and female reproductive cycles, clutch sizes, sizes of neonates, and give histological evidence that *P. namaquensis* may produce more than one clutch in a reproductive season. Elucidating the reproductive cycle of an organism is fundamental to understanding the evolution of lizard life-history strategies. Such data are also required in formulating conservation policies.

One hundred and eighty-six lizards were examined from the herpetology collection of the Natural History Museum of Los Angeles County, (LACM), Los Angeles, California, U.S.A. The sample consisted of 56 females (mean snout–vent length (SVL) = 50.1 mm ± 2.9 S.D., range 43–55 mm); 116 males (mean SVL = 48.7 mm ± 3.3 S.D., range 42–56 mm) and 14 juveniles (mean SVL = 28.7 mm ± 4.7 S.D., range 21–36 mm). *Pedioplanis namaquensis* were collected between 1969 and 1970 as part of an ecological study by Pianka (1971) or in 1972 and 1981. Museum catalogue numbers and collection locality information are given in Appendix I.

For histological examination purposes, the left testis and epididymis were removed from males and the left ovary was removed from females. Enlarged follicles (>4 mm length) or oviductal eggs were counted. Tissues were embedded in paraffin and cut into sections of 5 μm. Slides were stained with Harris hematoxylin followed by eosin counterstain. Testes slides were examined to determine the stage of the spermatogenic cycle and epididymides were examined for the presence of sperm. Ovary slides were examined for the presence of yolk deposition or corpora lutea. Statistical analyses were performed using Instat (vers. 3.0b, Graphpad Software, San Diego, CA). The relationship between body size (snout–vent length, SVL) and clutch size was examined by regression analysis; an unpaired *t*-test was used to compare *P. namaquensis* male and female mean body sizes (SVL) and juvenile body sizes (SVL).

Pedioplanis namaquensis is largely inactive (brumation) during winter months (Huey *et al.* 1977), thus, no samples were available from this period. Seasonal changes in the testicular cycle are presented in Table 1. In the regressed testes, the germinal epithelium was exhausted and the predominant cells were Sertoli cells and spermatogonia. Small quantities of sperm were present in the epididymides in four of the eight males with regressed testes (Table 1). There was a renewal of the germinal epithelium for the next period of

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Table 1. Monthly distribution of reproductive conditions in seasonal testicular cycle of 116 *Pedioplanis namaquensis*. Values are the numbers of males exhibiting each of the three conditions.

Month	*n*	Regressed	Recrudescence	Spermiogenesis
January	3	0	0	3
February	24	0	0	24
March	17	7	0	10
May	1	1	0	0
September	6	0	3	3
October	28	0	4	24
November	25	0	2	23
December	12	0	0	12

spermiogenesis in testes undergoing recrudescence. Primary and secondary spermatocytes were the predominant cells. Some spermatids but no spermatozoa may have been present. During spermiogenesis, the seminiferous tubules were lined by clusters of spermatozoa and metamorphosing spermatids and the epididymides were packed with sperm. Testes in regression were present in March and May while testes in recrudescence were present between September and November and testes undergoing spermiogenesis were present between January and March and between September and December (Table 1).

Female *P. namaquensis* were significantly larger than males (t = 2.8, d.f. = 170, P = 0.01). The seasonal ovarian cycle is presented in Table 2. Ovaries without yolk deposition were found in March, May, and between October and December. Ovaries in early yolk deposition (follicles containing basophilic yolk granules) were collected in January, February, October, November and December. Small spring sample sizes prevent knowing exactly when the earliest clutch of eggs is produced. Corpora lutea (evidence of previous clutch) were found only in January. Females with enlarged ovarian follicles (>4 mm length) were collected in February, November and December. Females with oviductal eggs were from January and February. The relationship between female SVL and clutch size was not significant (P = 0.32). Mean clutch size of 14 females was 3.8 ± 0.97 S.D. eggs, range 3–5. This is close to the value of 3.9 ± 1.5 S.D. eggs reported by Pianka (1986) for 29 *E. namaquensis*. His values were based on counts of oviductal eggs which were removed prior to depositing *E. namaquensis* at LACM. Thus, the numbers of female *P. namaquensis* with oviductal eggs in Table 2 of my study may be lower than what actually occurred. Branch (1998) reported clutches of 3–5 eggs for *P. namaquensis*. The presence of early yolk deposition for a second clutch and corpora lutea from a previous clutch in the same female (LACM 80459) and eggs in the oviducts and yolk deposition under way in ovarian follicles for a second clutch in another female (LACM 80420) (Table 2) demonstrates that female *P. namaquensis* may produce two clutches in a reproductive season.

Table 2. Monthly distribution of reproductive conditions in seasonal ovarian cycle of 56 *Pedioplanis namaquensis*. Values shown are the numbers of females exhibiting each of the four conditions.

Month	*n*	No yolk deposition	Early yolk deposition	Enlarged follicles (>4 mm length)	Oviductal eggs
January	5	0	3[a]	0	2
February	21	0	4	14	3[b]
March	3	3	0	0	0
May	1	1	0	0	0
October	3	2	1	0	0
November	9	3	5	1	0
December	14	4	9	1	0

[a]Early yolk deposition for subsequent clutch and corpora lutea from previous clutch in one of these females.
[b]Ovductal eggs and yolk deposition for subsequent clutch in one of these females.

Fourteen juveniles (mean SVL = 28.7 mm ± 4.7 S.D.) were examined. The smallest juveniles were from January (n = 4, mean SVL = 22.8 mm ± 1.7 S.D., range 21–25 mm) and were presumably neonates. Other juveniles from March–May and July (n = 10, mean SVL = 31.1 mm ± 2.9 S.D., range 28–36 mm) were significantly larger (t = 5.3, P = 0.0002, d.f. = 12) and exhibited growth compared to sizes of January neonates.

Pedioplanis namaquensis has a seasonal testicular cycle in which spermiogenesis begins in spring and continues through summer. Recrudescence (recovery) occurred during spring. Testicular regression began in March. The ovarian cycle of *P. namaquensis* was also seasonal with oviductal eggs or enlarged ovarian follicles present in spring and summer (November–February). Nkosi *et al.* (2004) reported that reproduction in *Pedioplanis burchelli* took place in spring–summer and gonadal activity of males and females was synchronized. Clutch size ranged from 4–6 eggs per female (mean: 4.5 ± 1.4 S.E.). The lacertid lizard *Meroles cuneirostris* from Namibia exhibited a similar testis cycle wherein spermiogenesis occurred in spring/summer followed by autumnal regression (Goldberg & Robinson 1979). Females of *M. cuneirostris* contained oviductal eggs over a five-month period (September–March) and could also produce two clutches per year (Goldberg & Robinson 1979).

Reports in the literature suggest considerable variation in the reproductive life histories of lacertid lizards from southern Africa. *Meroles suborbitalis*, for example, is active all year long and mates in early winter (Pianka 1971). Furthermore, there may be considerable variation in different parts of a species' range. For example, in the central Namib Desert, breeding in female *M. suborbitalis* appears to be continuous and females may lay clutches throughout the year, whereas in the Kalahari mating occurs in early winter and females may lay two clutches per season (Branch 1998). Also, female *Meroles anchietae* are capable of continuous reproductive activity with a maximum occurring in winter (Goldberg & Robinson 1979). Histological examinations of seasonal gonad samples from other lacertid lizards from southern Africa will be required before variations in the reproductive cycles of these species can be known.

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Appendix I

Natural History Museum of Los Angeles County (LACM) accession numbers and locality information for *Pedioplanis namaquensis*.

BOTSWANA: Kgalagadi District, 11 km S Tsabong (26°08′S, 22°28′E) LACM 80454–80456, 80458, 80459, 80461, 80463, 80464, 80467–80472, 80476–80478, 80480–80482, 80485; Kgalagadi District, Gemsbok National Park (25°00′S, 22°00′E) LACM 139031, 139032, 139034–139036, 139038; Kgalagadi District, 9 km N, 11 km E, Twee Rivieren (26°23′S, 20°43′E) LACM 80393, 80394, 80396–80399, 80401, 80404, 80406–80409, 80412–80425, 80428, 80430–80432, 80439, 80440, 80442–80445, 80449–80453. SOUTH AFRICA: *Northern Cape Province*: 29 km S, 40 km E Rietfontein (27°00′S, 20°27′E) LACM 80153–80156, 80159–80163, 80165–80170; 24 km N, 83 km E Upington (27°22′S, 21°25′E) LACM 80382, 80383, 80388, 84093, 84094; Kalahari Gemsbok National Park (26°43′S, 20°61′E) LACM 139042, 139044–139049; 31 km N, 100 km E Upington, (28°13′S, 22°16′E) LACM 80173–80178, 80185; *North West Province*: Kalahari Gemsbok National Park (25°45′S, 20°44′E) LACM 80187–80197, 80202–80209, 80210, 80212–80215, 80217, 80218, 80220, 80221, 80224, 80225–80235, 80237, 80239, 80241, 80242, 80248, 80250, 80262, 80263, 80493. NAMIBIA: Erongo Region, Swakop River, 47 km S Wilhelmstal (22°21′S, 16°21′E) LACM 77540, 77544, 77545, 77548, 77550, 77554–77556, 77558, 77559, 77561–77564, 77566, 77567; Khomas Region, 110 km E Windhoek (22°41′S, 18°08′E) LACM 77400, 77413–77416; Erongo Region, Walvis Bay, Namib Desert Park (22°57′S, 14°29′E) LACM 127484; Karas Region, 89 km ENE Koes (26°56′S, 18°15′E) LACM 77177, 77185, 77186, 77189, 77191, 77193, 77198, 77199, 77200, 77201, 77203, 77204; Karas Region, 51 km S, 29 km E Aroab (27°14′S, 19°56′E) LACM 80489, 80490, 80492.