Reproductive cycle of the common rough-scaled lizard, Ichnotropis squamulosa (Squamata: Lacertidae) from southern Africa.

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Abstract.--The reproductive cycle of the common rough-scaled lizard, Ichnotropis squamulosa from southern Africa was studied from a histological examination of gonads. The smallest reproductively active male and female I. squamulosa measured 47 mm and 58 mm SVL, respectively. Males began (spermiogenesis) sperm production and females began yolk deposition in February (summer). The reproductive cycle of I. squamulosa differs from that of other lacertid lizards from southern Africa which typically begin sperm production in late winter or early spring concurrent with the onset of yolk deposition. This difference in timing of reproduction may enhance survival of I. squamulosa as its young appear in spring by which time neonates of other lacertid species are larger and have different dietary preferences.

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The common rough-scaled lizard, Ichnotropis squamulosa frequents arid and mesic savannah and ranges through Maputaland, Northern Cape, extreme south and central Mozambique, through Botswana, Zimbabwe and eastern Namibia to Angola and Tanzania (Branch 1998). It is a sit and wait predator that brumates during winter (Pianka 1971) and has a short life span of only eight to nine months (Broadley 1967; Schmidt 2001). There are previous reports on its reproductive biology (Fitzsimons 1943; Broadley 1967; 1974; 1979; Jacobsen 1987; Schmidt 2001). The purpose of this paper is to present additional information on the reproductive cycle of I. squamulosa gathered from a histological examination of gonadal material from museum specimens. The reproductive cycle of I. squamulosa is compared with those of other lizards from southern Africa.

METHODS AND MARERIALS

One hundred and one lizards were examined from the herpetology collection of the Natural History Museum of Los Angeles County, (LACM), Los Angeles, California. The sample consisted of 32 females (mean snout-vent length [SVL] = 56.3 mm [+ or -] 4.4 SD, range: 48-66 mm), 37 males (mean SVL = 53.0 mm [+ or -] 5.4 SD, range: 39-63 mm) and 32 juveniles (mean SVL = 33.4 mm [+ or -] 3.7 SD, range: 28-39 mm). Ichnotropis squamulosa were collected during 1969 and 1970 as part of an ecological study by Pianka (1971; 1986) or in 1972 and 1973.

For histological examination, the left testis and epididymis were removed from males. The stages in the testicular cycle were identified. The left ovary was removed from females for histological examination to check for the presence of vitellogenesis (yolk deposition) and/or corpora lutea. Tissues were embedded in paraffin and cut into sections at 5 [micro]m. Slides

were stained with Harris hematoxylin followed by eosin counterstain (Presnell & Schreibman 1997). An unpaired t-test was used to compare I. squamulosa male versus female mean body sizes (SVL) and mean body sizes of November versus January juveniles (Instat vers. 3.0b, Graphpad Software, San Diego, CA).

Material examined.--Samples consisted of the following specimens of Ichnotropis squamulosa:

BOTSWANA (n = 82) KGALAGADI DISTRICT, 11 km S. Tsabong (26[degrees]08'S, 22 [degrees]28'E) 80272-80280, 80282, 80284, 80288, 80290-80292, 80295-80301, 80304, 80305, 80307-80318, 80320-80322, 80326-80335, 80337-80342, 80345-80351, 80353, 80354, 80356-80358, 80360-80364, 80369, 80371-80374, 80376-80381.

NAMIBIA (n = 12) OTOZONDJUPA REGION, 40 km WNW Grootfontein (19[degrees]34'S, 18[degrees]07'E) 77833, 77835, 77836; 30 km ENE Otavi (19[degrees]40'S, 17[degrees]24'E) 77879-77887.

REPUBLIC OF SOUTH AFRICA (n = 7) NORTHERN CAPE PROVINCE, 31 km N, 100 km E. Upington (28[degrees]13'S, 22[degrees]16'E) 80265-80271.

RESULTS AND DISCUSSION

Stages observed in the testicular cycle of I. squamulosa are given in Table 1: (1) Regression, seminiferous tubules contain mainly spermatogonia and primary spermatocytes; (2) Recrudescence, there is an increase in numbers of germ cells and cell divisions are noted. Secondary spermatocytes are abundant, a few spermatids may be present; (3) Late recrudescence, secondary spermatocytes and spermatids predominate; no sperm are present; (4) Early spermiogenesis, clusters of metamorphosing spermatids line portions of the lumina of the seminiferous tubules, occasional spermatozoa are seen; (5) Spermiogenesis, borders of seminiferous tubules are lined by rows of metamorphosing spermatids and spermatozoa are abundant. Monthly stages of the testicular cycle are in Table 1. While data is lacking from each month, a large February sample (n = 33) which contained 7/33 (21%) testes in recrudescence (germ cell renewal prior to the next period of sperm formation) and 21/33 (64%) in spermiogenesis indicates that I. squamulosa probably commences sperm formation during that month. Spermiogenesis continues at least through April (Table 1). The smallest reproductively active male (spermiogenesis underway) measured 47 mm SVL (LACM 80337) and was from February.

Table 1. Monthly distribution of reproductive conditions in the seasonal testicular cycle of 37 Ichnotropis squamulosa from southern Africa. Values are the numbers of males exhibiting each of the five conditions.

Month	n	Regression	Recrudescence	Laterecrudescence
January	1	1	0	0
February	33	1	1	6
April	3	0	0	0

Month	Early spermiogenesis	Spermiogenesis
January	0	0
February	2	23
April	0	3

Females of I. squamulosa were larger than males (unpaired t-test = 2.7, df = 67, P = 0.008). Three stages were observed in the ovarian cycle (Table 2): (1) No yolk deposition, ovary is

quiescent; (2) Early yolk deposition, scattered vitellogenic granules are present; (3) Both corpora lutea from a previous clutch and concomitant yolk deposition for a subsequent clutch are present in the same female. It appears that the I. squamulosa female population commences reproductive activity in February as two females (2/29, 7%) exhibited early yolk deposition (Table 2). However, Jacobsen (1987) reported 1 of 3 I. squamulosa females from January contained enlarged ovarian follicles. Yolk deposition continued through April (Table 2). Laying of eggs was underway by May as one female (LACM 80381, SVL = 66 mm) exhibited corpora lutea from a recent clutch. The same female was concurrently undergoing yolk deposition for an additional clutch indicating I. squamulosa females have the potential for producing two egg clutches in the same year. The smallest reproductively active I. squamulosa (early yolk deposition) measured 58 mm SVL and was from February (LACM 80357).

Table 2. Monthly stages in the ovarian cycle of 32 Ichnotropis squamulosa from southern Africa. Values are the numbers of females exhibiting each of the three conditions.

Month	n	No yolk deposition	Early yolk deposition	Corpora lutea & yolk deposition
February	29	27	2	0
April	2	1	1	0
May	1	0	0	1

Juveniles were collected in November (n - 12, mean SVL = 32.3 mm [+ or -] 4.1 S.D., range: 28-38 mm) and January (n = 20, mean SVL = 34.1 mm [+ or -] 3.4 S.D., range: 28-39 mm). There was no significant size difference between the two months (unpaired t-test, t = 1.3, df - 30, P = 0.21). Presumed neonates of 28 mm SVL were collected in both November and January. There is a report of hatchling I. squamulosa measuring 28-30 mm SVL (Broadley 1979).

Histological observations indicate that spermiogenesis likely commences in February concomitant with males acquiring breeding coloration (Schmidt 2001). The smallest male to undergo spermiogenesis in this study (47 mm SVL) was smaller than the minimum SVL (55 mm) in Schmidt (2001).

Broadley (1979) reported a gravid female from 10 April. Eggs are laid in April-May with isolated cases as late as July (Jacobsen 1987). Pianka (1986) reported two I. squamulosa females, each with a clutch of 4 eggs; a range of 10-12 eggs are deposited (Fitzsimmons 1943). This value of 58 mm SVL for the smallest breeding female in this study was identical with that of Schmidt (2001).

Ichnotropis squamulosa has a short life span of only eight to nine months; young are born October to November after a five month incubation period (Schmidt 2001). November collections reported herein consisted of only juveniles. Broadley (1974; 1979) similarly reported only juveniles in November and December. Hatchlings reach adult sizes in four to five months; breeding occurs in March and April with eggs being deposited in April and May (Broadley 1979; Schmidt 2001).

Ichnotropis squamulosa is sympatric with Ichnotropis capensis however, the timing of their reproductive cycles differ so as to avoid competition for food (Broadley 1967, 1979; Jacobsen 1987). Ichnotropis capensis mate in October-December (Branch 1998) at which time I. squamulosa have not yet reached maturity.

The reproductive cycle of I. squamulosa differs from that of other lacertid lizards from southern Africa which typically begin sperm production in late winter or early spring concurrent with the

onset of yolk deposition (Goldberg 2006a; 2006b; 2006c; 2006g; 2006h; Goldberg & Robinson 1979; Nikosi et al. 2004). This difference in timing of reproduction may enhance survival of I. squamulosa as its young appear in spring at which time neonates of other species of lacertids have reached sub-adult or adult size and have different dietary preferences. Aporosaura anchietae is an apparent exception as some reproduction occurs throughout the year (Goldberg & Robinson 1979). This may, in part, be due to its ability to utilize seeds in their diet which are available year-round, (Robinson & Cunningham 1978).

CONCLUSIONS

Reproduction in I. squamulosa is synchronous in that spermiogenesis and ovarian reproductive activity occur at the same time, however each take place in autumn whereas they occur primarily during spring in other lizards from southern Africa (Goldberg & Robinson 1979; Flemming 1994; Flemming & Bates 1995; Nkosi et al. 2004; Goldberg 2006a; 2006b; 2006c; 2006d; 2006e; 2006f; 2006g; 2006h). There are, however, exceptions in which male and female reproductive activity are asynchronous as in Cordylus giganteus (cf. Van Wyk 1991; 1995) and Pseudocordylus melanotus (cf. Flemming 1993a; 1993b). In addition, females of the agamid lizard, Agama atra follow a condensed reproductive cycle in which ovarian activity occurs only in September to November (Van Wyk 1984).

There is a report in a field guide (Branch 1998) that the sympatric congener, I. capensis may produce two clutches in a year. However, additional work is needed to verify whether I. squamulosa, in fact, may produce more than one egg clutch per year. Follicular atresia (spontaneous degeneration of oocytes with reabsorption of yolk) is common late in the reproductive season (Goldberg 1973). It is thus uncertain if the one I. squamulosa female from the May sample with corpora lutea and concomitant yolk deposition would have produced a second egg clutch or undergone follicular atresia.

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