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Notes on reproduction in five species of *Emoia* (Squamata: Scincidae) from Papua New Guinea

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Abstract. Males of *Emoia caeruleocauda, E. jakati, E. longicauda, E. obscura* and *E. pallidiceps* from Papua New Guinea exhibit extended periods of sperm formation. *Emoia caeruleocauda, E. longicauda, E. obscura* produced clutches of 2 eggs; *E. jakati* and *E. pallidiceps* produced clutches of 1-2 eggs. One *E. obscura* female contained corpora lutea from a previous clutch and concomitant yolk deposition, and two contained oviductal eggs and concomitant yolk deposition for subsequent clutches, indicating the production of multiple clutches under natural conditions. Estimates of minimum sizes for sexual maturity are given for each *Emoia* species.

Key words. Scincidae, *Emoia caeruleocauda, Emoia jakati, Emoia longicauda, Emoia obscura, Emoia pallidiceps,* reproduction, Papua New Guinea.

The skink genus *Emoia* consists of 72 species ranging from southeastern Asia to the islands in the Central Pacific (Brown 1991). The greatest diversity of *Emoia* species occurs on New Guinea and adjacent islands (Brown 1991). Ecological data are available for relatively few of these species, probably reflecting the remoteness of most species from centers of herpetological research activity. Nonetheless, most species investigated to date lay two eggs and hatchling sizes have been reported for several species (Greer 1968, Brown 1991, Morrison 2003).

Emoia caeruleocauda is known from Borneo, Palau, Mariana Islands, Caroline Islands, Marshall Islands, southern Philippines, Sulawesi, Moluccas, New Guinea and associated island archipelagos, Solomon Islands, Vanuatu and Fiji; *Emoia jakati* is known from Palau, Caroline Islands, Marshall Islands, New Guinea and adjacent island archipelagos, and Solomon Islands (Brown 1991, McCoy 2006). *Emoia longicauda* is known from New Guinea, Cape York Peninsula in Queensland, Australia, Admirality Islands and Mussau Island, north of New Ireland; *Emoia obscura* and *Emoia pallidiceps* are restricted to New Guinea (Brown 1991). All these species except for *E. longicauda,* which has not been studied, produce clutches of two eggs (Brown 1991, McCoy 2006). The purpose of this report is to present the first histological information on reproductive cycles for each of these species based on an examination of gonadal material of specimens from Papua New Guinea. Estimates of minimum sizes at maturity are given for each species. The first information on the reproductive biology of *E. longicauda* is presented.

Emoia skinks from Milne Bay Province, Papua New Guinea were examined from the herpetology collection of the Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii. Skinks were collected from 2002 to 2004 as part of biodiversity surveys and were studied from a geographically constrained region (Milne Bay Province) so as to minimize the potential for confounding geographic variation in the reproductive cycles (Appendix). Survey schedules disallowed comprehensive sampling throughout the year but were sufficiently spaced in time to allow some inference of yearly reproductive patterns. The left testis and ovary were removed, processed by standard histological techniques and stained with Harris' hematoxylin followed by eosin

counterstain (Presnell & Schreibman 1997). Histology slides were deposited at BPBM. Maturity of males was recognized by their having spermiogenesis in progress, of females by their undergoing yolk deposition. Clutch size of females was determined from enlarging follicles or oviductal eggs. Lizard snout-vent length (SVL) was measured using a plastic millimeter rule to the nearest millimeter.

Two stages were observed in the testicular cycle: (1) recrudescence, in which there is a proliferation of cells in the germinal epithelium for the next period of spermiogenesis (sperm formation). Primary and secondary spermatocytes are the predominant cells; some spermatids but no spermatozoa may be present; (2) spermiogenesis, in which seminiferous tubules are lined by spermatozoa and clusters of metamorphosing spermatids are present.

Emoia caeruleocauda: The sample (n = 24) consisted of 14 females with mean SVL = 46.3 mm ± 2.1 SD, 0.57 SE, range = 43-49 mm; 7 males with mean SVL = 49.0 mm ± 3.5 SD, 1.3 SE, range = 44-54 mm; 3 neonates with mean SVL = 24.0 mm ± 2.7 SD, 1.5 SE, range = 22-27 mm. All males were undergoing spermiogenesis except for one male obtained in January that was in late recrudescence. It measured 44 mm SVL (BPBM 16730) and contained metamorphosing spermatids but no sperm. Males undergoing spermiogenesis were from: January (3 males); April (1); September (2). The smallest reproductively active male (spermiogenesis in progress) measured 45 mm SVL (BPBM 19985) and was taken April 2004. Reproductively active females were present in the three months sampled (January, April and September) (Table 1). Mean clutch size for 11 females was 2.0, 0.0 SD, 0.0. SE. The smallest reproductively active females measured 43 mm SVL (BPBM 19981) from April 2004 and (BPBM 16722) from January 2003. One neonate (BPBM 16728) was from January, two (BPBM 19982, 19983) were from April.

Emoia jakati: The sample (n = 43) consisted of 14 females with mean SVL = 44.3 mm ± 2.1 SD, 0.56 SE, range = 41-48 mm; 25 males with mean SVL = 41.6 mm ± 3.5 SD, 0.70 SE, range = 33-47 mm; 4 neonates with mean SVL = 26.0 mm ± 2.6 SD, 1.3 SE, range = 23-29 mm. All males were undergoing spermiogenesis: January (5 males), August (4), September (16). The smallest reproductively active male measured 33 mm SVL (BPBM 15934) and was taken September 2002. Reproductively active females were present in the three months sampled (January, August and September) (Table 1). Mean clutch size for 12 females was 1.8 ± 0.39 SD, 0.11 SE, range: 1-2. The smallest reproductively active females with oviductal eggs (BPBM 15935) and enlarged ovarian follicles (> 6 mm) (BPBM 15955) both measured 41 mm SVL and were from September 2002. One neonate was from April (BPBM 19988), one from August (BPBM 15922), two from September (BPBM 15937, 15950).

Emoia longicauda: The sample (n = 24) consisted of 14 females with mean SVL = 81.1 mm ± 5.1 SD, 1.3 SE, range = 69-87 mm; 9 males with mean SVL = 86.4 mm ± 8.8 SD, 2.9 SE, range = 68-100 mm; 1 neonate with SVL = 38 mm. All males were undergoing spermiogenesis: January (6 males), April (1) and May (2). The smallest reproductively active male measured 68 mm SVL (BPBM 16801) and was taken January 2003. Reproductively active females were present in three of the four months sampled: January, February, and May (Table 1). The one April female was reproductively inactive. Mean clutch size for 6 females was 2.0, 0.0 SD, 0.0. SE. The smallest reproductively active female measured 77 mm SVL (BPBM 16792) and was from January 2003. Two females, 69 mm SVL (BPBM 16797) and 72 mm SVL (BPBM 16804) were not reproductively active. One neonate (BPBM 20742) was from April.

Emoia obscura: The sample (n = 57) consisted of 24 females with mean SVL = 51.6 mm ± 5.0 SD, 1.0 SE, range = 39-60 mm; 29 males with mean SVL = 49.7 mm ± 6.6 SD, 1.2 SE, range = 34-60 mm; 4 neonates with mean SVL = 27 mm ± 1.8 SD, 0.91 SE, range = 25-29 mm. All males were undergoing spermiogenesis: April (18 males), May (8) and September

Tab. 1. Stages in ovarian cycle of five species of *Emoia* skinks from Papua New Guinea. *Two *E. obscura* females with oviductal eggs also contained follicles undergoing yolk deposition. **Represents one *E. obscura* from September (not in the table) with corpora lutea from a previous clutch and yolk deposition for a subsequent clutch.

	Number of specimens	Quiescent	Early yolk deposition	Enlarged follicles > 3 mm	Oviductal eggs
Emoia caeruleocauda	14				
January	9	1	0	7	1
April	3	0	2	1	0
September	2	1	0	0	1
Emoia jakati	14				
January	4	0	1	1	2
August	1	0	0	1	0
September	9	1	1	4	3
Emoia longicauda	14				
January	5	2	0	1	2
February	1	0	0	1	0
April	1	1	0	0	0
May	7	2	3	2	0
Emoia obscura	24				
February	1	0	0	1	0
April	10	0	1	5	4*
May	7	2	2	2	1
September**	5	0	0	2	2
October	1	0	0	0	1
Emoia pallidiceps	22				
January	6	0	2	3	1
February	9	0	1	5	3
April	1	0	0	1	0
August	1	0	0	1	0
September	2	0	0	1	1
October	3	0	1	2	0

(3). The smallest reproductively active male measured 34 mm SVL (BPBM 15551) and was taken 22 April 2002. Reproductively active females were present in the five months sampled: February, April, May, September, and October (Table 1). One female from September (BPBM 15974) contained corpora lutea from a previous clutch and yolk deposition for a subsequent clutch, and two females from April (BPBM 15524, 15529) with oviductal eggs were also undergoing yolk deposition for a subsequent clutch, indicating *E. obscura* may produce multiple clutches the same year. Mean clutch size for 18 females was 2.0, 0.0. SD, 0.0 SE. The smallest reproductively active female measured 39 mm (BPBM 15974) and was from September 2002. One neonate (BPBM 15526) was from April, one from May (15561), one from August (BPBM 15562) and one from September (BPBM 15976).

Emoia pallidiceps: The sample (n = 35) consisted of 22 females with mean SVL = 51.3 mm ± 5.0 SD, 1.1 SE, range = 43-60 mm; 12 males with mean SVL = 49.0 mm ± 4.4 SD, 1.3 SE, range = 41-55 mm; 1 neonate with SVL = 25 mm. All males were undergoing sper-

miogenesis: January (10 males); February (1) and August (1). The smallest reproductively active male measured 41 mm SVL (BPBM 17181) and was from January 2003. Reproductively active females were present in the six months sampled: January (6), February (10), April (1), August (1), September (2), and October (3) (Table 1). Mean clutch size for 17 females was 1.9 ± 0.24 SD, 0.06 SE, range = 1-2. The smallest reproductively active female measured 43 mm SVL (BPBM 15983) and was from September 2002. One neonate (BPBM 17193) was from January.

Previous studies on reproduction in *Emoia* have indicated long periods of reproductive activity with reproduction possible throughout the year (Baker 1947, Alcala & Brown 1967, Schwaner 1980). Baker (1947) reported that in Vanuatu, where *Emoia cyanura* exhibited year-round reproductive activity, there was a peak in November and December. Our samples confirm extended reproduction for both males and females but were too small to identify a peak period of activity, if one exists for these species. Neonates for several species (*E. caeruleocauda, E. jakati, E. obscura*) were found throughout a span of 4-6 months too, consistent with extended reproduction.

The relationship between lizard size and clutch size is not clear. Schwaner (1980), who studied *Emoia* with larger body sizes from American Samoa reported *E. nigra* females to reach maturity at 86 mm SVL and produce clutches of 2-4 eggs and *E. samoense* to reach maturity at 84 mm and produce clutches of 4-7 eggs. In contrast, *E. lawesii* matured at 78 mm SVL and had a mean clutch size of only 1.8, and *E. adspersa* matured at 64 mm SVL and had a mean clutch size of only 1.9.

Data presented herein indicate clutches of two eggs are uniformly produced by *E. caeruleocauda, E. longicauda,* and *E. obscura*, whereas *E. jakati* and *E. pallidiceps* produced either 1 or 2 eggs. Clutches of two eggs appear to be the case for most species of *Emoia* (Greer 1968, Brown 1991, McCoy 2006) although occasional production of one egg per clutch also occurs (Zug 1991).

The number of clutches produced by *Emoia* in a year is not known. However, the tropical climate that they inhabit permits year-round activity, which will enhance the possibility of multiple clutch production. In captivity, *E. caeruleocauda* females produced clutches approximately every thirty days (McCoid et al. 1997). Our finding of both corpora lutea and early yolk deposition in one female, as well as two females with oviductal eggs and yolk deposition for subsequent clutches in wild *E. obscura*, indicate production of multiple clutches in wild populations during the same year.

We do not know of prior histological studies of the testicular cycles of *Emoia* lizards, however, Zug et al. (1982) reported year-round spermatogenesis in the skink *Carlia bicarinata* at Port Moresby, Papua New Guinea with peaks during March to April and August to October. Wilhoft (1963) reported *Carlia* (as *Leiolopisma*) *rhomboidalis* underwent spermiogenesis throughout the year in tropical Australia. Our histological results for *Emoia* in Milne Bay Province, Papua New Guinea confirm extended periods of spermiogenesis for *E. caeruleocauda, E. jakati, E. longicauda E. obscura* and *E. pallidiceps*.

Subsequent investigations on different species of *Emoia* will be needed to ascertain a more complete picture of variability in the reproductive cycles (clutch sizes and duration of spermiogenesis) exhibited by members of this genus; however, this study goes some way toward indicating protracted breeding of these lizards in New Guinea.

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Appendix

Emoia caeruleocauda (n = 24) – Papua New Guinea: Milne Bay Province; Fergusson Island (BPBM 15915-15918), Misima Island (BPBM 16718-28, 16730-31, 16733), Sudest Island (BPBM 19981-83, 19985-87).

Emoia jakati (n = 43) – Papua New Guinea: Milne Bay Province; Fergusson Island (BPBM 15921-30, 15932, 15934-41, 15944, 15946, 15948, 15950-15952, 15954-55), Normanby Island (BPBM 15959, 15961-62, 16868-73, 16875-77), Misima Island (BPBM 16868-73, 19988).

Emoia longicauda (n = 24) – Papua New Guinea, Milne Bay Province; Misima Island (BPBM 16789, 16791-93, 16795-97, 16799-02, 16805, 17392, 20742, 20744-20745), Halowia (BPBM 16804), Duabo (BPBM 17392), Rossel Island (BPBM 20746-51, 20753-54).

Emoia obscura (n = 57) – Papua New Guinea: Milne Bay Province: Cloudy Mts. (BPBM 15521-26, 15528-34, 15537-52), Mt. Pekopekowana (BPBM) 15553-54, 15561-62, 15564-65, 15569, 15571-77, Fergusson Island (BPBM 15963-68, 15970-71), Dadue (BPBM 15972-74), Normanby Island (BPBM 15976), Duabo (BPBM 15979), Halowia (BPBM 17178).

Emoia pallidiceps (n = 35) – Papua New Guinea: Milne Bay Province: Cloudy Mts. (BPBM 15580), Fergusson Island (BPBM 15981), Normanby Island (BPBM 15982-84, 15987, 17179-81, 17183-89, 17191-96, 17198-200), Mt. Simpson (BPBM 17201-07, 17209-10, 17215).

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