

# Reproduction in the common house gecko, *Hemidactylus frenatus* (Squamata: Gekkonidae) from Hawaii

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**ABSTRACT** - A histological examination of gonadal material from *Hemidactylus frenatus* indicated males produced sperm (determined by spermiogenesis) during the ten months samples were available. The smallest mature male (spermiogenesis) measured 34 mm SVL, the largest 59 mm SVL. *H. frenatus* females were reproductively active (determined by yolk deposition, enlarged ovarian follicles > 4 mm or oviductal eggs) in all months except November (N = 1). Mean clutch size (N = 40) was  $1.95 \pm 0.22$  SD, range = 1–2. The smallest mature female measured 38 mm SVL, the largest 53 mm SVL. There was a decrease in female reproductive activity in October, when 92% of 13 females had quiescent (inactive) ovaries. A similar decrease in October reproductive activity was earlier documented in the introduced anole, *Anolis sagrei*, on Oahu, Hawaii, suggesting a shared response to changing environmental conditions.

## INTRODUCTION

*Hemidactylus frenatus* Duméril and Bibron, 1836 is found worldwide in tropical and subtropical regions but has been transported widely by man; it is native to southern and/or southeastern Asia (Bauer, 1994). A global list of introductions for *H. frenatus* and supporting literature is in Kraus (2009). In Hawaii, *H. frenatus* was first observed on Oahu in June, 1951 (Hunsaker & Breese, 1951). There have been numerous reports on its reproduction in different parts of its introduced range: Jalisco, Mexico (Ramírez-Bautista et al. 2006); Java, Indonesia (Church, 1962); Ryukyu Archipelago, Japan (Ota, 1994); Taiwan (Lin & Cheng, 1984, Cheng, 1988); American Samoa (Schwaner, 1980); Fiji (Zug, 1991); and Panay Island, Philippines (Gaulke, 2011). The purpose of this paper is to present data on reproduction from a histological examination of *H. frenatus* gonadal material from Hawaii.

## METHODS

We examined a sample of 163 *H. frenatus* consisting of 82 adult males (mean snout-vent length = mean SVL = 49.7 mm  $\pm$  5.5 SD, range = 34–59 mm), 77 adult females (mean SVL = 46.2 mm  $\pm$  3.4 SD), range = 38–53 mm and four juveniles (mean SVL = 32.2 mm  $\pm$  1.5 SD, range = 30–33 mm), from Hawaii, USA and deposited in the herpetology collections of the Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii, USA; Museum of Zoology, University of Michigan (UMMZ), Ann Arbor, Michigan, USA; and Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA (Appendix). The *H. frenatus* were collected in the period 1963 to 2007 from Hawaii, USA: Hawaii (N = 62), Kahoolawe (N = 14), Kauai (N = 6), Lanai (N = 2), Maui (N = 31), Molokai (N = 24), Oahu (N = 24).

We opened the abdominal cavity and removed the left testis or ovary for histological examination. We cut histological sections at 5  $\mu$ m and stained them with hematoxylin followed by eosin counterstain (Presnell & Schreiber, 1997). We examined slides of testes to determine the stage of the testicular cycle, and ovaries to detect the presence of yolk deposition. We counted enlarged follicles > 4 mm and oviductal eggs. We deposited histology slides at BPBM, LACM and UMMZ. We measured the snout-vent length (SVL) of each lizard from the tip of the snout to the anterior margin of the vent. We compared *H. frenatus* male and female mean body sizes (SVL) using an unpaired t-test in the program InStat (vers. 3.0b, Graphpad Software, San Diego, CA).

## RESULTS

Males of *H. frenatus* averaged larger than females (unpaired t-test = 4.79, df = 157, P < 0.0001). Three stages were noted in the monthly testicular cycle (Table 1): (1) Regression: seminiferous tubules contain spermatogonia and interspersed Sertoli cells; (2) Recrudescence: a renewal of germinal epithelium has commenced for the next period of spermiogenesis, primary spermatocytes predominate; in late recrudescence, secondary spermatocytes and occasional spermatids may be present; (3) Spermiogenesis: the lumina of the seminiferous tubules are lined with sperm or clusters of metamorphosing spermatids. The smallest reproductively active male (showing spermiogenesis) measured 34 mm SVL (BPBM 6573) and was collected during August on Molokai. The seminiferous tubules of one smaller male (SVL = 33 mm) (BPBM 28112) exhibited recrudescence, and it was classified as a subadult. Virtually all males showed spermiogenesis, which occurred in all months for which samples were available (Table 1).

Four stages were noted in the monthly ovarian cycle

(Table 2): (1) Quiescent: no yolk deposition; (2) Early yolk deposition: basophilic yolk granules in ooplasm; (3) Enlarged follicle: follicles > 4 mm (4); Oviductal eggs. Mean clutch size (N = 40) was  $1.95 \pm 0.22$  SD, range = 1–2. (2 clutches of 1 egg each, 38 clutches of 2 eggs each). The smallest reproductively active female (with 2 oviductal eggs) measured 38 mm SVL (BPBM 12706) and was collected on Oahu during July. There was no evidence (oviductal eggs plus concomitant yolk deposition in the same female) to indicate that *H. frenatus* produces more than one clutch in the same year, which may reflect our small sample sizes. However, in view of the extended period of female reproduction (Table 2), it seems possible for a female to have deposited a clutch and subsequently initiated yolk deposition for a second clutch. Three subadult *H. frenatus* (30, 33, 33 mm SVL) were collected—two from July, and one from August.

## DISCUSSION

The reproductive cycle of *H. frenatus* is similar to that of other tropical lizards in exhibiting an extended period of sperm formation and egg production (Baker, 1947; Fitch, 1982). This was shown to occur in Bandung (6.9176°S) Java, Indonesia, where *H. frenatus* reproduces throughout the year without undergoing a definite seasonal cycle (Church, 1962). On Panay Island (11.7104°N) Philippines, *H. frenatus* reproduces throughout the year (Gaulke, 2011). However in northern populations, *H. frenatus* exhibits seasonality in the reproductive cycle. For example, on Kita-Daitojima Island (25.9500°N) of the Ryukyu Archipelago, Japan, *H. frenatus* produces eggs from April to September (Ota, 1994). In Taichung (24.1500°N), Taiwan, *H. frenatus* females are reproductively active from late March to September (spring and summer) (Lin & Cheng, 1984). Thus *H. frenatus* may possibly switch from year-round to seasonal reproduction under climates and resultant ecological conditions associated with slightly higher latitudes (24–26°N), than in Hawaii (18.9–22.2°N). It is interesting that 92% (12/13) of *H. frenatus* females from October exhibited quiescent ovaries (Table 2). Only (11%) 2/19 of *H. frenatus* females from October to March contained oviductal eggs, in contrast to (33%) 19/58 from April to September. Similarly, there seems to be a reduction in rate of spermiogenesis in male *H. frenatus* from November to March (Table 1). A similar reduction in female reproductive activity was also observed in *Anolis sagrei* on Oahu, Hawaii, with 78% (7/9) of females from October inactive (Goldberg et al., 2002). October is the start of the cool-wet season in Hawaii, which runs from October to March (U.S. Climate Data 2015). Whether the October decrease in *H. frenatus* and *A. sagrei* reproductive activity is in some way associated with conditions during the start of the cool-wet season in Hawaii merits subsequent investigation. But this skewed reproductive patterns suggests that Hawaii may be a transition point in climate between the tropics, which allow for yearlong reproduction and the more northern latitudes of Taiwan and the Ryukyus, which restrict reproduction to a clearly seasonal pattern.

**Table 1.** Monthly stages in the testicular cycle of 82 adult male *H. frenatus* from Hawaii.

Month	N	Regression	Recrudescence	Spermiogenesis
Feb	1	0	0	1
April	9	0	0	9
May	10	0	1	9
June	6	0	0	6
July	6	0	0	6
Aug	28	0	0	28
Sept	11	0	0	11
Oct	9	1	0	8
Nov	2	0	0	2

**Table 2.** Monthly stages in the ovarian cycle of 77 adult female *H. frenatus* from Hawaii.

Month	N	Quiescent	Early yolk deposition	Enlarged follicles > 4 mm	Oviductal eggs
Jan	4	1	1	1	1
Feb	1	0	0	1	0
April	13	4	3	3	3
May	5	3	1	0	1
June	2	0	0	1	1
July	8	1	1	3	3
Aug	21	7	3	1	10
Sept	9	7	0	1	1
Oct	13	12	0	0	1
Nov	1	1	0	0	0

## ACKNOWLEDGMENTS

We thank Kathleen Imada (BPBM), Christine Thacker (LACM) and Greg Schneider (UMMZ) for facilitating our examination of *H. frenatus*.

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- Appendix:** Museum accession numbers for *Hemidactylus frenatus* from Hawaii examined by island from the Bishop Museum (BPBM), Honolulu, Hawaii, USA; University of Michigan, Museum of Zoology (UMMZ), Ann Arbor, Michigan, USA; and the Natural History Museum of Los Angeles County (LACM, Los Angeles, California, USA). BPBM Hawaii Island: BPBM 6540–6542, 8405, 8585, 11273, 11274, 21714–21717, 21723–21733, 23950, 23956, 23957, 23968–23970, 27132; LACM 145395–145403, 137525–137527, 137529–137538, 138317; UMMZ 225220, 225225, 225244, 225248–225250, 225252, 225253, 227359, 275251; Kahoolawe: BPBM 11577–11579, 11580–11586, 11590, 11592, 11597, 13509; Kauai: BPBM 11249, 11251, 27319; UMMZ 227360, 227361, 227363; Lanai: BPBM 13846, 27320; Maui: BPBM 11074, 13946–13953, 13955–13960, 13974–13976, 13987, 13989, 13990, 13992, 13996; UMMZ 225215, 225219, 225221–225223, 225228–225230; Molokai: BPBM 6573, 6610–6614, 6632–6644, 28108–28112; Oahu: BPBM 2012, 6186, 6550, 6559, 8405, 8557, 10559, 11234, 11235, 11239, 11240, 12680, 12685, 12691, 12692, 12695, 12706, 12987, 13101, 13102, 24175, 28111, 28112, 28668, 31902; UMMZ 227022.

Accepted: 15 January 2016