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Parturition and litter characteristics of the Little Whip Snake
Suta flagellum (Elapidae)

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Abstract

The behaviour and physical appearance of gravid females, parturition, and the relationship between litter size, maternal size, neonate size and relative clutch mass were examined in captive-bred litters of the Little Whip Snake *Suta flagellum* from southern Victoria. Mean litter size was 3.74 (range 2 to 6) and the mean gestation period was 142 days (range 128 to 151; n = 9). Gravid females routinely emerged to bask under an artificial heat source and most continued to accept food up to parturition. Parturition typically occurred in February and March, always took place within refugia, and did not favour any particular time of the day. There was a strong positive correlation between maternal snout-to-vent length (SVL) and both litter size and neonate mass, but no trade-off was evident between litter size and neonate size. Two measures of the relative clutch mass ranged from 0.218 to 0.942 and were also strongly correlated with litter size. Mean neonate SVL was 115 mm and represented 41% of the mean adult SVL. The neonatal sex ratio was unity and sexual dimorphism was evident, with males having significantly longer tails than females; SVL, head length and mass did not differ significantly between the sexes. Neonates lacked the ventral pigmentation of adults but were otherwise similar in appearance following their first slough 7 to 14 days after birth. (*The Victorian Naturalist* **141**(3), 68-84)

Keywords: Little Whip Snake, *Suta flagellum*, parturition, neonates, litters

Introduction

Data on standard measures of reproductive effort and investment are lacking for many species of Australian reptiles and much of the available data on reproduction in the Australian elapids have been derived from the dissection of museum specimens (White et al. 1995). Data obtained from museum specimens have been very useful in establishing basic reproductive and ecological information about species but limited by the complete exclusion of mass as a variable, meaning that standard measures of reproductive effort (i.e. the relative clutch mass) are unable to be determined. Furthermore, most ecological studies on the Australian elapids have focused primarily on medium-sized to large elapid species (e.g. Schwaner 1985; Shine 1987; Schwaner and Sarre 1990; Whitaker 2000, 2001; Rohr 2001; Webb, Christian, and Fisher 2002, Webb, Brook, and Shine 2002; Pringle et al. 2003; Whitaker and Shine 2003) with few exceptions (e.g. Webb, Brook, and Shine 2002, Webb et al. 2004, Llewelyn et al. 2005; Webb et al. 2009; Scott et al. 2013).

The Little Whip Snake *Suta flagellum* is a small (maximum total length < 0.45 m) viviparous (live-bearing) nocturnal elapid snake whose distribution extends from south-eastern New South Wales (NSW) through north-eastern, central and western Victoria into the south-eastern corner of South Australia (SA), with a disjunct population extending from Gawler, SA, south through the Fleurieu Peninsula (Rawlinson 1965; Cogger 2018; Robertson and Coventry 2019; Wilson and Swan 2021). It is a common inhabitant of the grassland plains to the north and west of Melbourne, where it is typically found sheltering beneath surface stone during daylight hours, particularly during the cooler months (Rawlinson 1965; James 1979; Fyfe and Booth 1984; Turner 1989, 2019). Information available on the reproductive biology of *S. flagellum* consists of brief descriptions of several captive-born litters (Fyfe 1980; Turner 1985), descriptions of courtship and mating (Turner 1992), the timing of mating and parturition in captivity and in the field (Fyfe and Booth 1984; Turner 1989, 2019; Valentic 1993a,b), the seasonal timing of vitellogenesis and ovulation, litter size and its relationship to female size (Shine 1988). Shine's (1988) study of the reproductive biology of the genus was based on museum specimens and, while the total number of *S. flagellum* examined in the latter study was quite large (n = 234), the proportion of females with developing embryos in the sample was very small (1.4%; 1 of 72 adult females; from data in Table 1 and Fig. 1) and litter size was based on either oviductal young

or enlarged ovarian follicles. Furthermore, the small number of specimens from Victoria resulted in them being pooled with the NSW sample and thus limited data are available on the reproductive characteristics of Victorian populations of *S. flagellum*. There is presently no information available on relative clutch mass or sex ratio at birth, and limited data on neonate size in *S. flagellum* and the genus in general (Greer 1997; Maryan et al. 2020—neonate size was excluded). In this work data obtained from 23 captive-bred litters of *S. flagellum* are presented on each of these aspects. In this report, the physical appearance and behaviour of gravid females prior to and immediately following parturition, the act of parturition, and the appearance and behaviour of neonates are described.

Methods

Captive maintenance

Snakes were all originally from grasslands north and west of Melbourne and were housed indoors at the author's residence. Initially they were housed in an unheated $60 \times 30 \times 30$ cm glass enclosure with a pegboard lid and situated at a north-facing window which received limited direct sunlight from May to October and natural light year-round. Later, snakes were housed together in a $100 \times 50 \times 50$ cm laminated wood enclosure with a perspex front and perforated lid. From September through to April (inclusive) from 09:00 to 20:00, light and heat were provided during the day by a 60-watt incandescent globe situated 25 cm above the floor at one end; outside this period the enclosure assumed room temperature which

rarely fell below 10°C. The temperature directly beneath the heat source typically ranged from 27 to 33°C, while beneath the refuge closest to the heat source it was typically 2 to 3°C cooler. Females nearing parturition were transferred to small plastic containers $22 \times 14 \times 7$ cm which were placed on top of the heated enclosure. In all enclosures, coarse gravel was used as substrate material with small wooden boxes or stones provided as daytime refugia. Water was provided in a small dish. Females were removed from the enclosures immediately following birth, while neonates remained together in the same enclosure. Offspring are referred to as 'neonates' prior to their first slough and 'juveniles' thereafter. Snakes were fed on a natural diet of small skinks (mainly Garden Skinks *Lampropholis guichenoti*) and, for snakes housed together, feeding was supervised.

Measurements

A 500 mm rigid plastic ruler (± 1 mm) was used to measure snout-to-vent lengths (SVL) and tail lengths (TL) of gravid females while a 150 mm steel ruler (± 0.5 mm) was used for neonates. SVL and TL were measured along the midline once snakes had relaxed their body muscles. Head length (HL), from the tip of the snout to the extremal point of contact of the parietal scales along the mid-line, was measured using a vernier caliper (± 0.02 mm). Repeatability estimates for SVL, TL and HL in females and neonates indicated a high degree of accuracy ($r > 0.9$ in all cases; Lessells and Boag 1987). Mass was recorded using an Ohaus Cent-O-Gram balance (± 0.01 g). The pre-parturient mass (PrPM) of females was

Table 1. Litter characteristics of Little Whip Snakes *Suta flagellum*. Sample size (n), mean, standard deviation (s.d.), minimum and maximum values are given. TCM = total clutch mass, PrPM = pre-parturient

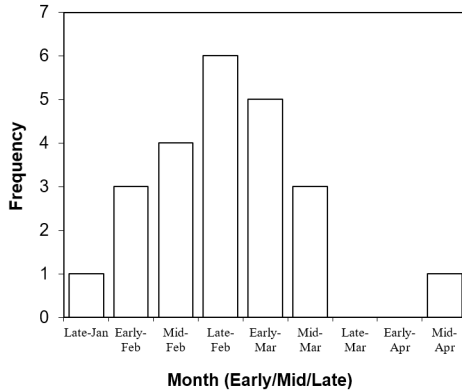| Variable	n	Mean	s.d.	Min.	Max.
Litter Size	23	3.74	1.053	26	
Maternal SVL (mm)	23	287.8	20.01	240	315
TCM (g)	19	8.02	2.728	3.36	13.24
PrPM (g)	13	24.24	5.699	15.37	33.89
PoPM (g)	19	15.74	3.142	10.22	23.47
RCM1	13	0.583	0.2101	0.306	0.942
RCM2	19	0.516	0.1637	0.218	0.821
Gestation period (days)	9	142.0	7.3	128	151

Fig. 1. Timing of parturition in 23 litters of the Little Whip Snake *Suta flagellum*.

also recorded for some, but not all, litters; the most recent measurement was made between 1 to 7 days prior to parturition. The post-parturient mass (PoPM) of the parent female was also recorded within 36 hours of parturition. Although the term 'clutch' refers specifically to a small group of eggs, it is used in standard reproductive measures for both oviparous and viviparous species, hence the total clutch mass (TCM) was determined for each litter by summing the mass contribution of unfertilised ova, stillborn neonates (where they occurred), and live neonates. Litter size did not include unfertilised ova but did include fully–formed stillborn neonates. The SVL, TL, HL and mass of all neonates in each litter were recorded. All measurements were taken within 12 hours of birth (the majority within 4 hours). The sex of adult *S. flagellum* was easily determined by examining the tail which in males is longer and thickens before tapering whereas in females it is considerably shorter and tapers uniformly (Rawlinson 1965; Fyfe and Booth 1984; Turner 1989, 1992, 2019). In neonates, this difference in shape is not apparent. However, the sex of neonates was determined by examination of the (post-anal) subcaudal region (see Turner 1999). Neither the parent female nor neonates were offered food until after measurements were taken. Two measures of the relative clutch mass (RCM) were calculated and these corresponded to the 2 most widely used measures in the literature (Seigel and Fitch 1984; Shine 1992): (i) RCM1—the ratio of the difference between the pre- and post-parturient mass and the post-parturient mass of the parent female, $RCM1 = (PrPM-PoPM)/PoPM$; (ii) RCM2—the ratio of the total clutch mass (TCM) to the post-parturient mass of the parent female, $RCM2 = TCM/PoPM$. It is clear from these definitions that $RCM1 > RCM2$ since the latter does not account for the loss of maternal body fluids and tissues during parturition.

Data analyses
Statistical analyses were performed using Statistica (V.12) and MS Excel. For all quantitative variables, the mean ± 1 standard deviation (s.d.) along with sample size (n) are quoted. The coefficient of variation (CV) was computed to compare the relative variability of numerical variables with similar measurement errors. Each litter produced was treated as an independent data point even though 2 litters involved repeated reproduction by the same female (but several years apart). Kolmogorov-Smirnov tests were used to assess whether variables were normally distributed. When assumptions were met, the strength of the linear relationship between pairs of variables was examined using Pearson's correlation coefficient, *r*, and when

they were not, Spearman's rank correlation coefficient r. Partial correlation coefficients were calculated to examine the relationship between pairs of variables controlling (removing) the effects of one (first order) or two (second order) variables in the group. These results were checked for consistency using multiple linear regression (see Freckleton 2002). As TCM is not a linearly independent variable and was significantly (highly) correlated with nearly all other variables (except PoPM), it was excluded from partial correlation analyses (see Graham 2003). Ordinary least squares (OLS) regression was used to determine equations of lines of best fit when assumptions of this method were met. When they were not, Theil-Sen regression was used (using KTRLine V.1; Granato 2006). The latter method is robust and less sensitive to outliers. The 95% confidence intervals (CIs) were computed for the coefficients of regression equations. Residual scores resulting from female mass vs SVL OLS regression were computed as measures of reproductive condition despite their known shortcomings (Weatherhead and Brown 1996; Schulte-Hostedde et al. 2005). Since SVL in snakes is usually strongly correlated with other morphometric variables such as HL, TL, and mass, ANCOVA was used to determine whether significant differences existed in these measurements between male and female neonates with SVL as the covariate. The chi-squared (χ^2) test of homogeneity (with Yate's correction for continuity), and Student's t-test for comparison of means was used when the assumptions were satisfied, and when they were not the Mann-Whitney U-test was employed. As multiple statistical tests were performed, the Benjamini and Hochberg (1995) FDR control procedure was employed to control Type 1 errors with $\alpha = 0.05$. Two results whose statistical significance was altered by the procedure are indicated by asterisks (*) below. Probabilities are two-tailed unless otherwise stated.

Results

A total of 23 litters were produced by 20 different female *S. flagellum*. Of these 20 females, 3 were the progeny of captive females. Captive female *S. flagellum* only ever produced one litter per year.

Features that distinguish gravid from non-gravid females
Physical

Some females examined in late spring (October–November) were conspicuously gravid with swollen girths and taut abdominal regions indicating the presence of oocytes (enlarged ova) and that ovulation had occurred. By contrast, other gravid females were comparatively slender in appearance even within weeks of parturition. In instances where the reproductive status of females was uncertain, 3 techniques were employed:

(i) Palpation of the abdominal region revealed a tautness and sometimes discernible 'lumps' representing either oocytes or developing embryos. This technique was generally, but not completely, reliable.

(ii) Females were grasped behind the head in the usual manner of handling, and the body was allowed to hang vertically and unsupported for a brief time. The usual reaction of *S. flagellum* handled in this way was to wrap the mid and posterior body around the hand or wrist of the handler which then enables the snake to exert a force back towards the body to pull its head free. Non-reproductive females were able to lift their entire body mass vertically up to the level where the head was secured. By contrast gravid females were unable to lift their bodies vertically to where they were secured. When the tail was also held to prevent movement and the snake was thus suspended vertically from 2 points, there was a noticeable distension of the posterior third of the body. Being held vertically in this way resulted in the reproductive mass accumulating in the distal third of the body. This process was done in less than 5 seconds so as not to cause discomfort or unduly stress the snake.

(iii) The reverse situation of dangling a gravid female by its tail (with the head unsecured) for a few seconds resulted in the reproductive mass sliding to the centre of the body. When suspended in this way, gravid females were typically incapable of raising their heads much above the mid-body level. In non-reproductive

females there was no difficulty in lifting the head to the point of restraint. These techniques proved useful in resolving the reproductive status of female *S. flagellum*, which even in late stages were not conspicuously gravid. They indicated that the vertical movements (at least) of gravid females are physically restricted by their reproductive mass.

Behavioural

Gravid females typically emerged from beneath cover to bask during the day, a behaviour observed also in the field (Turner 2001). The earliest that basking was observed following mating was 27 days, but all females were basking within 50 days of mating. Emergence to bask typically occurred mid-morning and continued through to when the heat source was switched off. Gravid females kept together in the same enclosure would emerge individually from their refuge to bask together in direct body contact beneath the heat source (Fig. 2). Sometimes females would not emerge from refuges but instead would just expose the posterior third of the body at the edge of stones, while otherwise remaining concealed. Females that did emerge completely from cover would assume loose open coils when basking together, with the head concealed beneath body coils. Apart from minor changes in their posture they otherwise remained in roughly the same position. On cool days, females would often be found directly below the heat source 'basking' before the heat source was switched on, apparently in anticipation. Gravid females continued to bask up until the day of parturition. While the body temperature of gravid females was not directly measured, during the day for the 11 hours that the heat source was on the temperature never fell below 28 °C either below stones or directly below the heat source where it was 30–32 °C; once switched off the enclosure assumed room temperature (which during the summer months was always above 15 °C) within 2 hours. Males and non-gravid females (including some which had mated) never emerged to bask during the day and were active only at night. Gravid females by contrast were rarely observed to be active at night and they typically

Fig. 2. Two gravid female Little Whip Snakes *Suta flagellum* intertwined and basking directly beneath the heat source a short distance from their refuge (a stone—partially visible top right). When basking, their heads always remained concealed from direct light.

continued to feed throughout gestation. Only 3 females refused food within 2 weeks of parturition. Most females sloughed 2 to 4 weeks prior to parturition (n = 14).

Gestation period

The gestation period was determined for only 9 litters (4 of these were reported previously; Turner 1985) with a mean 142 ±7.3 days and ranged from 128−151 days (Table 1). During this period, growth in gravid females was negligible and SVL measurements prior to mating did not differ significantly from those recorded immediately after parturition (*t* paired = −0.77, 20 df, *P* (1-tailed) = 0.225).

Parturition
Timing

Parturition took place from late January through to mid-April and occurred within refugia. It was witnessed in its entirety on only 3 occasions, and in part on another 4 occasions. It occurred almost entirely in the months of February and March with 12 and 9 litters respectively produced in these months (Fig. 1) with one litter produced on 31 January and another on 18 April. The latter birth consisted of 2 stillborn neonates which, if excluded, moves the latest birth back a month to 16 March.

Parturition occurred at any time of day: late night/early morning 22:00 to 10:00 (n = 13) compared to afternoon/evening 13:00 to 22:00 (n = 8; χ^2 = 0.808, 1 df, P = 0.382; the timing in 2 litters was not known with sufficient accuracy). Except for one litter (in which a stillborn neonate was produced 2 days prior to the rest of the litter), all neonates in each litter were born within the same 12 hour period. Recently-born neonates were readily identified by their moist or wet skin and the attached remnants of the chorion sac. On 3 occasions when the timing of parturition was most accurately recorded, it was estimated to have lasted between 1.25−1.75, 1.5−2.0 and 2.25−3.20 hours for the entire litter. The actual birth of young, from first appearance at the vent to complete emergence from the female, constituted only a small fraction of these times (< 20 minutes, n = 12; also see below).

Behaviour

Maintenance of an open posture was typical of gravid females nearing parturition. Several days before parturition some gravid females became restless for brief periods but were otherwise inactive. Associated with this behaviour was intermittent involuntary twitching of the body, particularly the mid and distal portions. On occasions vertical arching of the fore- and mid-body regions followed by rapid side-to-side movement of the distal third of the body was observed. The arching of the anterior body was also observed in females in the process of giving birth and usually within seconds of the emergence of neonates from the vent. One female exhibited this behaviour intermittently 5 days before parturition. In between these movements the female would lie motionless in an open coil.

A total of 8 neonates (from 3 litters) were observed being born in their entirety (Figs. 3a and b). Cover was removed so that observations were possible. The birth of a single neonate is described as the process was generally similar in all observed instances. The neonate emerged sideways (mid-body first) and upright from the female's vent. It was enclosed in a thin transparent chorion sac. The total time of emergence was approximately 6 minutes. The neonate, having emerged from the female, was immediately active (though still enclosed in the sac). It then made 3 stretching movements of its entire body to break out of the sac. On the first 2 attempts it was not successful, the sac stretching like elastic to accommodate its movements. On the third attempt, however, the sac was pierced in the region of the snout and the head and the forebody emerged. It then remained motionless for some 10 minutes, except for some chewing-like movements of the jaws followed by tongue-flicker. After this, it began to move around the enclosure, in the process completely emerging from the sac, turning it inside out, until it found suitable cover. The parent female continued to move about the enclosure, stopping to drink for several minutes, and did not exhibit any apparent interest in the neonate.

Most neonates emerged from females enclosed in the chorion sac. Some neonates, however, emerged from the female partially or completely out of the sac presumably due to it rupturing *in utero*. For example, in one litter a neonate emerged head-first, was quite alert,

Fig. 3(a). A female Little Whip Snake *Suta flagellum* giving birth. The second neonate is emerging from the female and is enclosed in thin transparent sac.

Fig. 3(b). All five neonates an hour after the birth of the last neonate.

Fig. 3(c). Lateral skin fold visible along posterior third of the female—this fold remained visible for several weeks following birth.

and commenced tongue flickering when still only half-way out of the female. The orientation of neonates emerging from females varied from upright, inverted, sideways to head- or tail-first (n = 8). The chorion sac of most neonates was entirely depleted or nearly so; the exceptions were stillborn neonates that were attached to large pale orange yolk-filled sacs. Within 2 hours of emergence, the empty sacs had shrivelled and detached from live neonates. Stillborn neonates were always completely enclosed in the sac (n = 9).

Litter characteristics

Litter size data are given in Table 1 and in Fig. 4. In 2 litters, single large (approx. 30 × 15 mm) pale orange oocytes were produced (along with live neonates). The mean maternal SVL of 288 mm was greater than the 279 mm determined by Shine (1988), but all maternal SVL measurements fell within the range stated in that work.

Correlation coefficients for pairs of reproductive variables are given in Table 2. There was a strong positive correlation between litter size and maternal SVL ($P < 0.0001$; n= 23). The OLS regression equation was: Litter Size = $0.039 \times$ SVL $- 7.464$ (CI's: slope 0.0228

to 0.0550, intercept -12.1075 to -2.8199, $F_{1,21} = 25.29$, $P < 0.0001$; Fig. 5). Shine's (1988) data on *S. flagellum* produced a regression line with slope 0.018 and intercept -1.47 (n = 42) both of which lie outside the confidence intervals determined here. The inclusion of unfertilised ova in litter size did not substantially alter the strength (or significance) of this, or any other, association. Litter size was the only variable that was significantly correlated with both RCM measures ($P < 0.0001$). There were significant positive correlations between maternal SVL and litter-averaged mass ($P = 0.006$) but not litter-averaged SVL ($P = 0.036^*$). A weak positive correlation was found between maternal size and both measures of RCM ($P < 0.21$). The RCM1 and RCM2 values were generally quite close, with the mean difference being 0.076 ± 0.029 (from 0.012 to 0.154) and both were (not unexpectedly) highly correlated. The contribution of maternal body fluids and foetal membranes expelled during parturition was generally small and did not exceed 2.5 g (mean 1.2 ± 0.74 g; n = 13).

Partial correlation analysis provided similar and consistent interpretations of relationships between variables to those correlations in
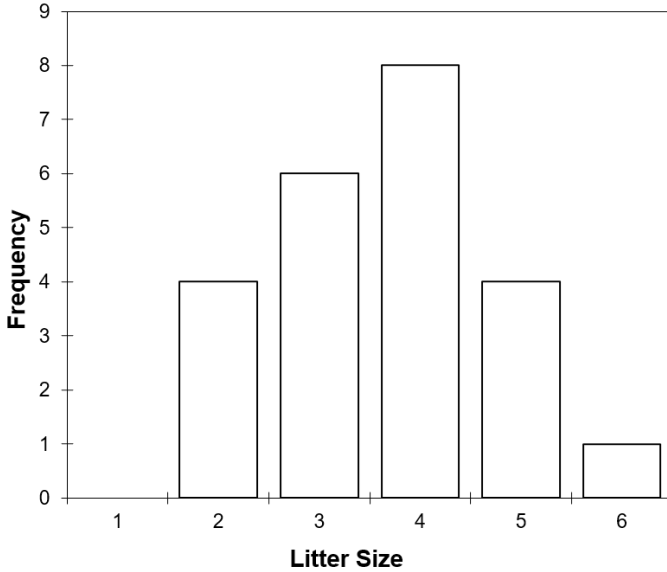
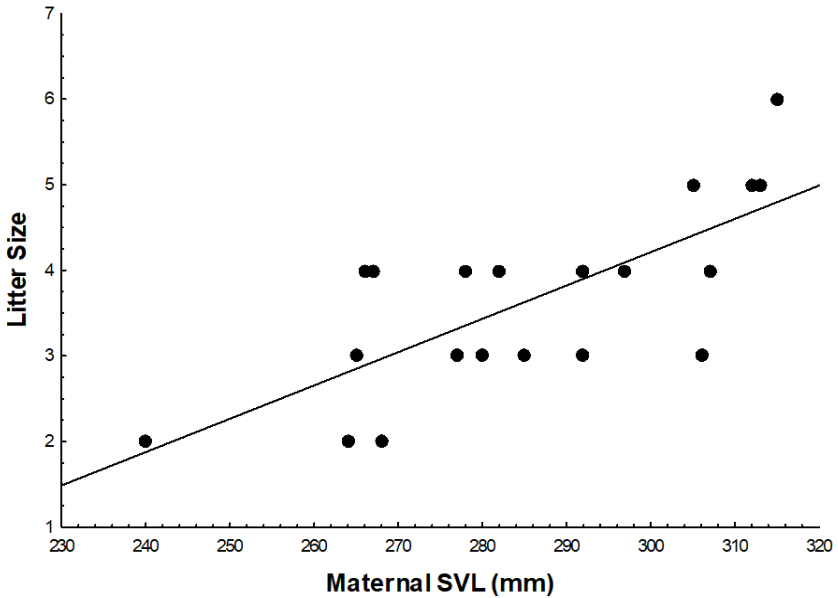**Fig. 4.** Frequency of litter size for 23 litters of the Little Whip Snake *Suta flagellum*.

Fig. 5. Scatterplot of litter size versus maternal snout-to-vent length (SVL in mm) in 23 litters of the Little Whip Snake *Suta flagellum*. OLS (ordinary least squares) regression equation: Litter Size = 0.039 × SVL − 7.464 (see Text for details).

Table 2. Pearson correlation coefficients (*r*) for each pair of reproductive variables in the Little Whip Snake *Suta flagellum*. Abbreviations: Mat SVL = maternal SVL (snout-to-vent length), Neo SVL = litter-average neonate SVL, Neo mass = litter-averaged neonate mass, PrPM = pre-parturient mass, PoPM = post-parturient mass, RCM = relative clutch mass (see Methods for definitions). Bold type indicates significance at the 0.05 level, one asterisk at 0.001 level and 2 asterisks at 0.0001 level.

	Litter Size	Mat SVL	Neo SVL	Neo mass	PrPM	PoPM	RCM1	RCM2
Litter Size	1	**0.739****	0.322	0.277	0.549	0.049	**0.877****	**0.789****
Mat SVL		1	**0.484†**	**0.607***	**0.918****	0.816	0.306	0.303
Neo SVL			1	**0.782**‡**	**0.622†**	0.392	0.427	0.341
Neo mass				1	**0.827***	**0.479**	0.417	0.434
PrPM					1	**0.827***	0.372	0.326
PoPM						1	−0.202	0.224
RCM1							1	**0.982****
RCM2								1

‡ Both variables were first log-transformed
† While p < 0.05, result was deemed non-significant by FDR procedure (see Methods)

Table 2. The relationship between litter size and neonate size (SVL and mass) was examined while controlling separately for maternal size variables (SVL, PrPM and PoPM) but no significant association was found ($r = -0.038$ to 0.105, 16 df, $P > 0.67$).
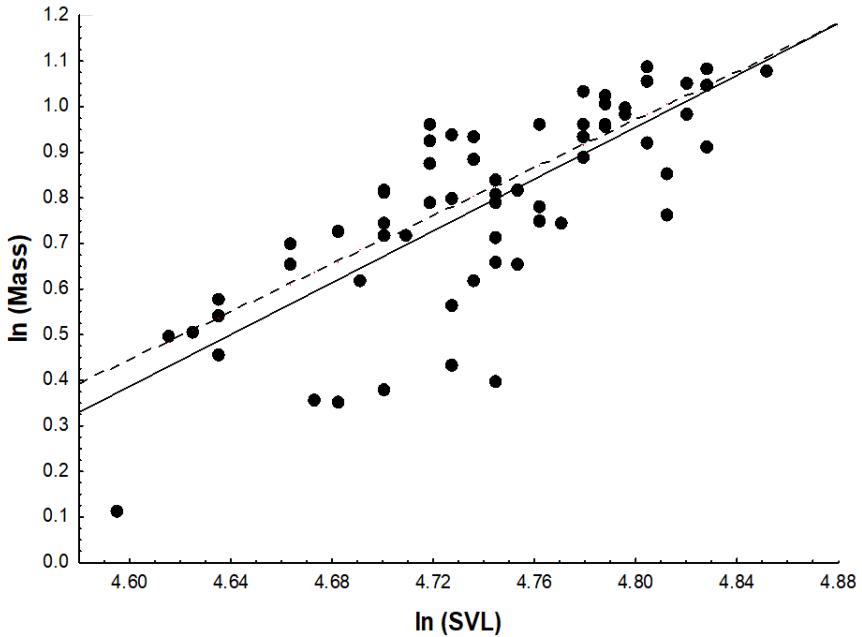
Neonates
Sex, size and stillborns
Data on male and female neonate sizes are given in Table 3. The sex ratio was not significantly different from unity ($\chi^2 = 0.014$, 1 df, $P = 0.811$; n = 70). Both sexes were represented in each litter (n = 22), except for one litter of 2 females. Three litters contained one (n = 1) or two (n = 2) individuals that were considerably smaller in either SVL, mass or both compared to siblings (i.e. runts; these are evident as 'outliers' below the regression lines in Fig. 6). The mean neonate SVL was 114.7 mm (n = 70) and when compared to the mean adult SVL of grasslands populations of the species (282 mm; Turner 2019), it represented 41% of this length. There was a significant correlation between PrPM and litter-averaged mass ($P = 0.0005$) but not litter-averaged SVL ($P = 0.023*$). Nine neonates from 3 litters were stillborn (11%; 9 of 84). Of these, 4 were ectopic and attached to large yolk sacs but were apparently normal in appearance with no externally visible abnormalities while another was severely deformed. In one litter all 4 apparently full-term neonates were stillborn. Severe congenital deformities occurred in just two litters (see Turner 1998).

SVL was controlled when comparing body size variables between male and female neonates since it was highly correlated with both HL and mass ($r = 0.647$, 61 df, $r = 0.782$, 62 df respectively; $P < 0.0001$ for both); SVL was also significantly correlated with tail length in females ($r = 0.693$, 32 df, $P < 0.0001$, n = 34) but not in males ($r = 0.165$, 34 df, $P = 0.335$, n = 36). The only variable in which a significant difference was found between males and females was TL (ANCOVA $F_{1,67} = 158.1$, $P < 0.0001$; HL $F_{1,60} = 0.29$, $P = 0.592$; mass $F_{1,61} = 0.93$, $P = 0.339$; Table 3). Male neonates had significantly longer tails than females. As a proportion of SVL, TL constituted 0.173 ± 0.0203 in males and 0.130 ± 0.0079 in females and these were significantly different (Mann-Whitney $U = 12.5$, n = 34/38, P (1-tailed) < .0001). This compares with the mean proportions 0.189 and 0.135 obtained for adult males and females respectively (see Turner 2019). There was overlap in the range of male and female TLs from 16 to 18 mm range while for the ratio of TL to SVL the overlap was between 0.140 and 0.145 but more than 75% of both the male and female ratios were outside this range (Fig. 7). The overall mean HL was 7.34 mm (n = 63) and mean mass was 2.25 g (n = 64). CV values indicate that HL and mass exhibited the least (5.1%) and most (20.0%) variability in neonates respectively. The natural logarithm of both neonate SVL and neonate mass were significantly and positively

Table 3. The mean SVL (snout-to-vent length), TL (tail length), HL (head length) (in mm) and mass (in g) for male and female neonate *Suta flagellum*. For each variable, the mean, 1 standard deviation (s.d.), minimum and maximum values, and sample size (n) are given. SVL is compared between the sexes using Student's *t*-test (with unequal variances) while ANCOVA is used to compare TL, HL and mass between sexes with SVL as the covariate with probabilities (*P*) in the last row.

		SVL (mm)	TL (mm)	HL (mm)	Mass (g)
Male					
	Mean	113.69	19.83	7.33	2.24
	s.d.	6.378	2.035	0.39	0.422
	Min. – Max.	101–126	16–25	6.64–8.08	1.16–2.95
	n	36	36	31	32
Female					
	Mean	115.79	15.09	7.34	2.25
	s.d.	6.777	1.334	0.364	0.481
	Min. – Max.	99–128	12–18	6.52–7.94	1.12–2.97
	n	34	34	32	32
	P	0.187	0	0.592	0.910

Fig. 6. Scatterplot of the natural logarithm of mass versus snout-to-vent length (SVL) in neonate Little Whip Snakes *Suta flagellum* with OLS (ordinary least squares) regression line (solid) ln(mass) = 2.84 × ln(SVL) − 12.68 and Theil–Sen regression line (broken) ln(mass) = 2.64 × ln(SVL) − 11.70 shown (see Text for details).
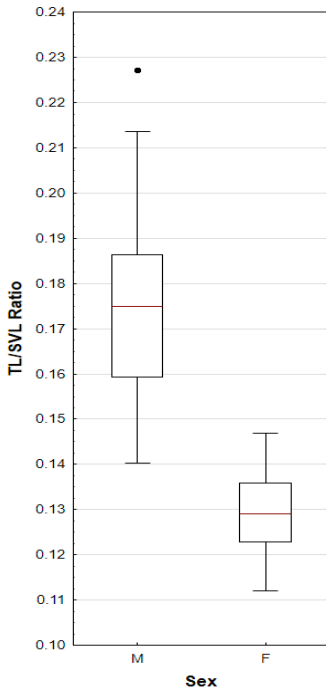
Fig. 7. Box and whisker plot of the ratio of tail length (TL) to snout-to-vent length (SVL) male (n = 38) and female (n = 34) neonate Little Whip Snakes *Suta flagellum*. A single outlier is indicated by a solid circle.

correlated (Table 2) and had a OLS regression equation: $\ln(\text{mass}) = 2.84 \times \ln(\text{SVL}) - 12.68$ (CI's: slope 2.246 to 3.437, intercept -15.4952 to -9.8434, $F_{1,62} = 90.63$, $P < 0.0001$). As there were outliers evident in the plot (Fig. 6), the Theil-Sen regression line was also computed: $\ln(\text{mass}) = 2.64 \times \ln(\text{SVL}) - 11.70$ with both the slope and intercept within the CI's of the OLS regression line.

Appearance
Neonates were pre-slough in appearance, being quite dull compared to adults. They were uniform matt chocolate brown dorsally, with a matt black 'cap' covering the nape, head, and some of the snout. The ventral surface had a milky pale bluish appearance, (a consequence of its translucence) and several of the larger in-ternal organs were visible. Adults of the species are characterised by the presence of a braided or variegated dorsal pattern (Cogger 2018), but this pattern was not obvious in neonates prior to their first slough. Following the first slough, the dorsal ground colouration and braided pattern became apparent, as did individual differences in the pattern of the black head pigment on the hood and snout (see Turner 2023). The glossy (rather than matt) appearance of both dorsal and ventral scales seen in adults also became apparent after the first slough. The ventral surface of the neonates remained translucent even after the first (and subsequent) sloughs but gradually became opaque through the deposition of ventral ground pigment. Black mottling of the ventral surface (as seen in some adults) was discernible but not always conspicuous in some neonates. Approximately 25% of neonates exhibited abnormal ventral/subcaudal scales (16 of 64 from 10 litters) compared with 35% (across all size classes) in grasslands populations (Turner 2021).

Behaviour
Most neonates when handled within hours of birth would evacuate their cloaca, producing an odourless, clear, slightly viscous exudate often tinged with faint yellow. No uric acid precipitate was excreted suggesting that nitrogenous wastes were eliminated via maternal circulation. When handled up to 3 days after birth, neonates typically produced only a very faint odour rather than the strong pungent odour characteristic of adults, despite exhibiting all other elements of the adult defensive display (see Turner 2022). The strong adult odour was, however, produced after this time and prior to both feeding and sloughing. This would indicate that the odours are not a product of some chemical constituent of prey items but rather the result of metabolic processes. The fact that over-wintering juveniles and adults in the field produce such odours, despite not having fed possibly for months, is consistent with this observation (pers. obs.). Although there were instances when neonates had aggregated beneath refuges, usually in direct body contact, there was no consistent tendency to aggregate

either together or with the parent female on the day of birth. Most commenced feeding prior to their first slough with several neonates feeding within 24 hours of birth, but more usually after 2 days. Neonates housed together ate siblings on 2 occasions, but within 24 hours had regurgitated them; following these incidents neonates were always housed separately.

Neonates first sloughed after 7 to 14 days following birth (mean 11.3 ± 1.76 days, mode = 12, n = 38; Fig. 8). Neonates from the same litter all sloughed within 2 days of each other. An unusually long period prior to sloughing in one litter (18 days) was likely due to the inadequate provision of water (and was thus excluded from the analysis).

Post-Parturient Females
Behaviour
Post-parturient females were not observed to exhibit any protective reaction or form of behaviour that might be interpreted as parental care. The action of removing neonates by hand within minutes of parturition only elicited the normal self-protective response in females, which was to seek cover. The basking behaviour of gravid females observed prior to parturition ceased on the day of parturition and no post-parturient females were ever observed basking, either partially exposed, or in the open. Instead, females stayed beneath cover throughout the day, emerging only at night to feed. All females that were offered food within 24 hours of parturition accepted it (n = 11). Sloughing in females typically occurred 2 weeks after parturition (n = 16).
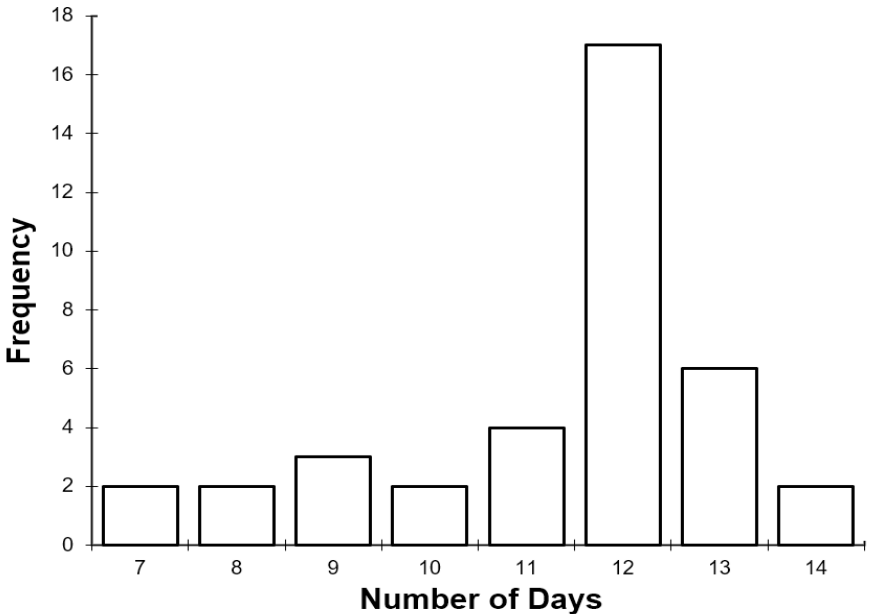

Fig. 8. Frequency of the number of days to first slough in neonate Little Whip Snakes *Suta flagellum* (n = 38).

Appearance

Many post-parturient females exhibited a rather conspicuous abdominal skin fold ('baggy' skin) along the upper flank of the posterior third of the body, presumably due to the skin in this region being stretched whilst gravid (Fig. 3c). The skin fold was observed to persist for one to 2 weeks in some females but more usually the skin became taut within several days of parturition. In one female which produced a litter with a high RCM, the skin fold persisted for more than 3 months despite weekly feeding. A second feature that characterised post-parturient females was a palpable (and often clearly visible) 'hollow' abdominal region. This was evident in some females up to several weeks after parturition. There was a significant negative correlation between the occurrence of these features and RCM ($r=-0.738$, $P=0.015$, $n=9$; categories: both features evident, one feature evident, no features evident). Females that produced high RCM litters generally exhibited both features whereas those with lower RCM either exhibited the features to a lesser extent or not at all.

Female condition was examined in relation to reproductive status and RCM in a small sample. Those females that produced young had positive residual scores (0.51 to 1.34; n = 5) while those females that did not produce offspring (but had mated) had negative residual scores (-0.36 to -1.23, n = 7); one female that did not produce offspring had a residual score close to zero (0.04). Two females that fed substantially after mating, gaining 17 and 25% of their body mass over a 2½ month period, still failed to produce young despite having mated. Two females that produced high RCM2 litters (0.821 and 0.807) and had negative residual scores at next mating (later in that year) subsequently failed to produce young. These results suggest that females need substantial weight gains following parturition to reproduce again the following year.

Discussion

The positive relationship between maternal size and litter size in *S. flagellum* has been recorded in numerous squamate species, though in some there appears to be no relationship (King 1989). Some studies on squamates have demonstrated a trade-off between litter size and offspring size after controlling for maternal size (e.g. Schwarzkopf 1992; Duffield and Bull 1996; Rohr 2001). In the case of *S. flagellum* there was no relationship between litter size and offspring size, despite controlling maternal size. The mean litter size of 3.74 (range 2 to 6) determined in this work is similar to that obtained by Shine (1988): 3.55 (range 1 to 7). The estimated size at birth in *S. flagellum* determined by Shine (1988) based on the smallest field-collected individual (SVL 102 mm) and full-term oviductal young (SVL 110 mm) falls within the range found in this work (SVL 99 to 128 mm) as do neonate measurements from single litters described in Fyfe (1980) and Fyfe and Booth (1984).

A comparison of neonate size amongst *Suta* species indicates that despite substantial differences in mean adult size, neonate size is rather conservative. *Suta dwyeri* neonate size is considerably larger than that of *S. flagellum*, with a mean SVL of 139 mm (*vs* 115 mm) and a slightly larger mass of 2.52 g (vs 2.25 g), though the *S. dwyeri* sample size was small (n=7; Shine 1978). The head length of both species was identical and, given that both feed principally on skinks, this may reflect a certain minimum head size necessary to consume (adult) skink prey. Neonate *Suta nigriceps* from a single litter of 4 had SVLs in the range 108 to 122 mm and mass in the range 1.53 to 1.89 g (Bush 1992) which are generally similar in size to neonate *S. flagellum*, despite adults attaining much larger sizes (see Shine 1988). *Suta gouldii* adults attain significantly greater lengths than *S. flagellum* and neonates are stated to have SVL 140–160 mm and mass 2.0 to 2.5 g (Bush et al. 1995), although Shine (1988) determined the SVL of near full-term oviductal young to lie in the range 103–125 mm and the smallest field-caught specimen to be 115 mm which are both similar to *S. flagellum*. Fyfe (1980) and Fyfe and Booth (1984) report neonate *S. flagellum* with total lengths of approximately 140 mm and 130 to 150 mm, which is consistent with the total lengths determined in this study (means: 134 mm male, 131 mm female); furthermore, they noted a difference in the tail lengths of

male and female neonates, with lengths of 15 and 10 mm respectively (cf. 20 and 15 mm; Table 3 this work). Jenkins and Bartell's (1980) stated size at birth of *S. flagellum* as 70 to 80 mm is almost certainly in error, even if these are SVLs rather than total lengths (as implied).

Many adult male snakes typically have longer tails, relative to body length, than female snakes (King 1989) and within the genus *Suta* sexual dimorphism in adult tail length (as indicated by subcaudal scale counts) is evident in most (possibly all) species (Maryan et al. 2020). Sexual dimorphism in neonate snakes is, however, a rare phenomenon (Shine 1993) and appears to have been reported only in several species of Australian elapids *Acanthophis antarcticus* Johnston 1987; cf. Barnett and Gow 1992; *A. praelongus* Webb, Christian and Fisher 2002; *Pseudechis butleri* Fitzgerald and Mengden 1987. Sexual dimorphism in the TL to SVL ratio has been found in adults in the elapid genera *Simoselaps* and *Vermicella* and may also extend to juveniles (Clarke and How 1995). The sexual dimorphism in tail length of neonate *S. flagellum* (Turner 1999) and the accentuation of this dimorphism as snakes mature makes it possible to accurately determine the sex of individual *S. flagellum* of any size without the need for invasive techniques (such as probing). Whether sexual dimorphism in tail size or shape is present in neonates of other *Suta* species appears to be undocumented, but subcaudal scale counts of some species (that include all stages of maturity) would indicate that it is likely in at least some species (see Maryan et al. 2020).

Relative clutch mass data are not available for many Australian elapid species, and even in those species for which it is, sample sizes are often small (n < 5) (see White et al. 1995; Annable 1996; Greer 1997). What is clear is that within species, RCM values are highly variable, and the values obtained in this work are no exception, varying as much as fourfold (depending on the measure). The mean RCM2 value of 0.52 is very close to the average obtained by Greer (1997) from multiple individuals and species of elapids, and indicates that the mean reproductive mass of female *S flagellum* amounted to about half of their post-parturient mass. Furthermore, RCM in *S. flagellum* was only weakly and positively correlated with maternal SVL, in

contrast to the significant negative correlation found in both *Pseudechis porphyriacus* and *Notechis scutatus* (Shine 1977). White et al. (1995) presented data on the reproductive output of *Drysdalia coronoides* (n = 3) revealing some high RCM1 values (max. 1.26) with non-overlapping RCM1 and RCM2 values, in contrast to the broadly overlapping ranges for *S. flagellum* (see also Lazell 2003).

The results of this work have confirmed results obtained from field studies of *S. flagellum*. In particular, the timing of mating, the occurrence of gravid females and parturition in captivity is entirely consistent with field observations as well as the occurrence of post-parturient females and neonates in the local populations (Valentic 1993a, b; Turner 2019; unpublished data). The captive observations of inactivity, maintenance of open postures and diurnal basking of gravid females, both singly and in aggregations, have all been directly observed in the field (Turner 2001). The timing of parturition in late summer/early autumn in *S. flagellum* is the general trend for viviparous Australian elapids that inhabit temperate regions (Shine 1991; White et al. 1995). By contrast Fyfe (1980) and Fyfe and Booth (1984) recorded parturition in 2 captive bred snakes in September, and recorded a field aggregation, including neonates and a post-parturient female, in the same month. Shine's (1988) examination of museum specimens across the species range indicated parturition in late summer. However, he recorded 'several puzzling exceptions' to the general trend in 3 female *S. flagellum* with large follicles in mid-winter, consistent with September parturition. Variability in female reproductive cycles within (or between) populations of *S. flagellum* was, however, not evident in this work nor in a field study (Turner 2019), indicating that parturition in *S. flagellum* populations near Melbourne typically occurs from February through to March.

The gestation period of 128 to 151 days recorded in *S. flagellum* is consistent with the very limited data recorded in other Australian live-bearing elapids: 110 through to 161 days (4 species; Greer 1997). The only other published records describe a single captive breeding of *S. flagellum*, but the dates on which mating was observed are contradictory, resulting in gesta-

tion periods of either 99 or 123 days (Fyfe 1980; Fyfe and Booth 1984; the quoted figures of 109 and 121 days are both in error). The mean gestation period of *S. flagellum* determined in this study was 142 days, and this period occupies approximately 60% of the time that the species is known to be active and feeding in the field (September through to April inclusive; Turner 2019). This would limit reproduction to a single litter annually.

Gravid female elapids are known to cease feeding some time prior to parturition (Greer 1997), though exceptions do exist. Cessation of feeding usually occurs in the latter stages of gestation but there is considerable variability (Shine 1979; Greer 1997 and references cited therein; Annable 1996; Lazell 2000, 2003). The observation that some captive (and wild) gravid female *S. flagellum* fed through the entire gestation period is atypical but appears to also occur in the White-lipped Snake *Drysdalia coronoides* (Shine 1981), and may be related to the short period of time between parturition and the onset of cool conditions prohibiting feeding that both species experience in the field (Greer 1997). The habit of gravid females confining their movements to a particular refuge (see Turner 2001) is likely to result in limited feeding opportunities since *S. flagellum* feed principally on small skinks which they appear to seek actively beneath ground cover (Fyfe and Booth 1984; Shine 1988; pers.obs.). Furthermore, the difficulties that gravid female *S. flagellum* had in performing certain physical movements, albeit unnatural ones, compared to non-gravid females suggests that their natural movements might be hampered or constrained to some extent by their reproductive mass, and this might also result in limited movements and feeding, particularly in the latter stages of gestation.

Acknowledgements

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Possible evidence of spatial memory in an Eastern Water Skink *Eulamprus quoyii* (Dumeril and Bibron 1839) in Cooranbong, New South Wales

Observations

Early on a warm summer afternoon, a subadult Eastern Water Skink *Eulamprus quoyii* (Dumeril and Bibron 1839) was observed crawling across a west-facing brick wall at a height of about 1 m. This is a common enough observation for this species in Lake Macquarie, New SouthWales. As it came close to a blueberry bush that was growing close to the wall, it was looking at the ripe fruit hanging at the end of a horizontal branch, about 300 mm long, growing parallel to, and about 150 mm from, the wall. The Skink was unable to reach the fruit, but it had a strategy to achieve this purpose. It moved towards the vertical main stem and found a small branch growing towards the wall. It climbed across this branch and about 75 mm up the main stem to the branch with the fruit on it. By now the fruit would have been completely out of sight to the skink because of the high density of the short-petioled, alternate leaves growing laterally along the branches. The Skink continued to crawl along this branch with some difficulty (Eastern Water Skinks have no adhesive ability). The branch was only about 3 mm wide, and the Skink had to use the claws on its hind legs to prevent itself from falling off. By the time it reached the end of the branch the Skink was hanging down at an angle of about 45°. Even at this point it may not have been able to see the fruit because the fruit was hanging below the leaves. The Skink then bent its head down below the leaves and twisted sideways to grab a ripe, glaucous blueberry, ignoring an unripe adjacent berry. At this point I dashed to get my camera, but the Skink was gone when I returned about one minute later, and I presume it fell off and scuttled away.

Comments

The Eastern Water Skink is a medium-sized skink, with adult snout–vent length often exceeding 100 mm. It is commonly found in eastern Australia, often near waterways. These Skinks are viviparous (Cogger 2014), giving birth to up to as many as 6 neonates in early summer (pers. obs.). They are omnivorous, although predominantly carnivorous, feeding largely on a range of arthropods

Fig. 1. Eastern Water Skink *Eulamprus quoyii*.

such as crickets, cockroaches, centipedes and spiders, but also tadpoles and small skinks, including adult *Lampropholis delicata* and also their own neonates (pers. obs.). Like other skinks, they have a parietal third eye, which may be used in directional behaviours (Foà, et al. 2009). They are active hunters, spending a lot of time searching crevices etc. for food. In winter they might find a refuge under a rock or in dense vegetation or deep litter for several months, possibly emerging on a warm day even in mid-winter (pers. obs.).

This lifestyle requires significant brain power, and several studies have been done on lizards to assess their more advanced cognitive abilities such as spatial learning and memory (e.g. LaDage, et al. 2017 and references therein).

These abilities were clearly demonstrated by *Eulamprus quoyii* in the above observations.

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Beetle mania: flowers as food source and rendezvous points for beetles

Australia is home to about 30,000 beetle species, which display a great variety of shapes, colours, and behaviours (Lawrence and Britton 1991). Beetles vary from the generally sombre dung beetles whose lives revolve around smelly droppings, to the colourful and iridescent jewel beetles that visit attractive flowers (Hawkeswood 1978; Lawrence and Britton 1991). However, flowers are not treats exclusive to jewel beetles, as several other species visit floral plants to feed on nectar or pollen, besides using them as rendezvous places (Lawrence and Britton 1991; Hawkeswood and Turner 2008).

We present here a few examples of the variety of beetle species associated with flowers. We observed and photographed the behaviour of beetles in flowers in urban and suburban areas of Sydney during casual observations from December 2020 to October 2023. During the observations in daylight hours, we used 'ad libitum' (typical field notes) and 'sequence' (interactions observations) samplings (Altmann 1974), appropriate for infrequent or unpredictable events. Our observational sessions lasted 3–10 minutes, during which we documented the visitors to

flowers and their behaviour, with a 70–300 mm lens digital camera.

An eye-catching beetle species well suited to feed on nectar from flowers is Long-nosed Lycid Beetle *Porrostoma rhipidius*, whose long mouthparts allow it to reach nectar in flowers of various shapes, including those of Paper Bark *Melaleuca* sp. (Fig. 1). Not so gifted, but nonetheless able to take nectar from flowers, is Plague Soldier Beetle *Chauliognathus lugubris*. This beetle feeds on nectar from various flowers, including those from the Daisy family—Asteraceae (Fig. 1). Flower chafers owe their common name to the habit of visiting flowers to feed on nectar, favouring eucalypts and other gums. One attractive species is Punctate Flower Chafer *Neorrhina punctatum*, which is illustrated here feeding on nectar of Water Gum *Tristaniopsis laurina* (Fig. 2). Another flower chafer which visits the same flowers is Fiddler Beetle *Eupoecila australasiae* (Fig. 2), so-named because of the violin-shaped green contours on the elytra (wing cases). Flower chafers are peculiar among beetles in that they fly with their wing cases closed, whereas most beetles lift their elytra clear of the body while flying.

Fig. 1. Long-nosed Lycid Beetle *Porrostoma rhipidius* feeding on nectar of Paper Bark *Melaleuca* sp. (left). Note long mouthparts within the flower. Plague Soldier Beetle *Chauliognathus lugubris* feeds on nectar of an unidentified species of Asteraceae—Daisy and Sunflower family (right).

Fig. 2. Punctate Flower Chafer *Neorrhina punctatum* feeds on nectar of Water Gum *Tristaniopsis laurina* (left). Note beetle's head touching flower stamens. Fiddler Beetle *Eupoecila australasiae* forages on Water Gum flowers (right).

However, flowers are used by beetles for reasons other than feeding. As flowers may attract 2 or more beetle individuals (both females and males), this food source also serves as a rendezvous point on which the beetles can feed and mate. For instance, Bean Weevils *Bruchidius* sp. feed on nectar and mate in flowers of Forest Bindweed *Calystegia marginata*. Several of these small beetles may aggregate within the flower and exit, dusted with pollen (Fig. 3) and, very likely, they have mated under the cover of the tube-shaped flower. Other beetle species, such as clerid beetles *Eleale illaetabilis*, mate while feeding on nectar, here illustrated by flowers of Tick Bush *Kunzea ambigua* (Fig. 3).

Jewel beetles are renowned for their vivid colours and iridescence, for which they have a special place among more than one beetle enthusi-

ast ('beetle maniacs'). Most jewel beetle species feed on nectar or pollen, but sometimes they eat flower parts, and there are species that are leaf-eaters. Besides feeding on flower resources, jewel beetles mate on this gathering place, such as Pea Flower Beetle *Ethonion reichei* couple seen on a Large Bronze Bush-pea *Pultenaea ferruginea* flower (Fig. 4). Their large eyes are use-

ful for finding flowers, as well as potential mates. A soldier beetle which visits various flowers for twofold purposes is Sydney Soldier Beetle *Chauliognathus sydneyanus*, which mates and feeds on nectar of several plant species, here illustrated by Tick Bush *Kunzea ambigua* (Fig. 4).

The beetle species shown here, and others, usually contact the reproductive parts (anthers

Fig. 3. Bean Weevils *Bruchidius* sp. feeding on nectar and mating on a flower of Forest Bindweed *Calystegia marginata* (left). Note pollen adhered on the beetles. Clerid beetles *Eleale illaetabilis* feeding on nectar, and mating on, Tick Bush *Kunzea ambigua* flowers (right).

Fig. 4. A couple of Pea Flower Beetles *Ethonion reichei* mating on Large Bronze Bush-pea *Pultenaea ferruginea* flower (left). Couples of Sydney Soldier Beetle *Chauliognathus sydneyanus* mating and feeding on nectar of Tick Bush *Kunzea ambigua* flowers (right).

and stigmas) of the visited flower, and pollen adheres to their body parts, rendering them pollinators of several species of Australian plants (Hawkeswood 1978; Armstrong 1979; Williams and Adam 1994). The minimal damage that beetles may do while eating flower parts is more than compensated by their pollinating services. Pollination is one of the most common mutualistic interactions among organisms, even in urban and suburban settings (Sazima and Sazima 2022). Watching the regulating ecosystem service beetles provide while visiting flowers is within the reach of beetle maniacs or any person interested in gorgeous creatures and their attractive food sources.

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Red Wattlebird *Anthochaera carunculata* catching and eating Honey Bees *Apis mellifera*

At Monash University Clayton campus, beside the JMR (Jock Marshall Reserve) Nature Walk, there is a eucalypt (Fig. 1) with a hive of Honey Bees *Apis mellifera* in one of its branches (Fig. 2). Bees exiting the hive leave very quickly, while those coming back often hover for a few moments, as though awaiting their turn to enter, thus unwittingly putting themselves in danger of being captured by a predator.

Sometimes, my husband (Jurrie) and I have watched a Red Wattlebird *Anthochaera carunculata* (Fig. 3) perch on a higher branch of this tree, then swiftly swoop down to catch an unsuspecting Bee approaching the hive entrance. The bird returned to its perch before swallowing the Bee. With their load of nectar and/or pollen, Bees returning to the hive would make a more nutritious snack than those leaving.

Unlike Rainbow Bee-eaters *Merops ornatus*, which rub bees against a perch to remove the sting and venom glands (Birdlife Australia website 2024a), the Wattlebird appeared to kill the Bees by crushing them in its bill before swallowing them, somehow managing to avoid being stung. Mueller (1991: 234) noted similar behaviour of Red Wattlebirds near a beehive, stating that the birds 'squashed the bees in their bill and swallowed them. No precautions were taken in dealing with the bee's sting.'

It is well known that, in addition to nectar, insects form part of the Red Wattlebird's diet (e.g. Birdlife Australia website 2024b). However, JMR is the only place where I have seen a Red Wattlebird catching and eating Honey Bees.

Acknowledgement

Thank you to Jurrie Hubregtse for supplying his photos of a Honey Bee at the hive entrance, and a Red Wattlebird.

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Fig. 2. A Honey Bee *Apis mellifera* at entrance to hive in branch of eucalypt in Jock Marshall Reserve, Monash University Clayton campus. Photo Jurrie Hubregtse.

Fig. 1. The eucalypt in Jock Marshall Reserve, Monash University Clayton campus.

Fig. 3. A Red Wattlebird *Anthochaera carunculata* at Jock Marshall Reserve, Monash University Clayton campus. Photo Jurrie Hubregtse.

2023 Australian Natural History Medallion

Maureen Christie

The 2023 Australian Natural History Medallion has been awarded to Maureen Christie for her contribution to conservation of shorebirds.

Presentation of the Medallion was made at the FNCV hall in Blackburn on 20 November 2023, by Associate Professor Robert Day, as nominee of the President of the Royal Society of Victoria. Following the presentation, Maureen spoke on the subject of beach-cast marine algae fishery.

Maureen has focused much of her working life on shorebird ecology and conservation. Her research on these subjects has taken the form of field surveys, banding, organising and running expeditions, establishing long-term data projects, and the co-supervision of students. Her efforts to enthuse others on the subject include founding the Friends of Shorebirds SE Inc. (FoSSE) and extensive work on the group's committee; involvement in kindred organisations; and providing advice to government departments. Maureen's work has greatly increased the scientific and popular knowledge about the natural history of the shorebirds that frequent South Australia. She has contributed also to conservation through information, fieldwork, and by shaping South Australia's fisheries policy.

Maureen has conducted fieldwork across both inland and coastal South Australia, often 'calling in' to Lake Torrens or Lake Eyre (a mere 1,200 km drive from home!), during her annual 7,500+ km return road trips to/from Broome WA. Those trips were undertaken in order to participate with the Australasian Wader Studies Group, in catching and banding migratory shorebirds. This project has revealed sites of international significance in the East Asian–Australasian flyway, has been instrumental in discovering the breeding grounds of the Ruddy Turnstone in Siberia and the migration route of the Grey Plover through China, as well as its breeding grounds in the Russian Arctic.

At the same time, Maureen has pursued a hectic shorebird-dominated fieldwork schedule across southern South Australia and Victoria.

She regularly attends meetings, public education events and outings with the FoSSE and the Victorian Wader Studies Group. Among a number of significant projects in which Maureen has been involved over the last decade, is her leading of teams to catch and satellite track Grey Plovers in South Australia's St Vincent Gulf. This work has revealed the remarkable migration flights of this species via South East Asia, China and Russia, to the Arctic Circle. Moreover, her work has highlighted the importance of the tidal flats north of Adelaide as a conservation site of international importance. Media stories and public interest in her work coincided with the proclamation of this area as the 'Adelaide International Bird Sanctuary'.

Maureen's work has shaped South Australia's fishery policy on the harvesting of beach wrack. She challenged the policy at the SA Administrative Appeals Tribunal and negotiated an agreement to ensure adequate protection of

FNCV President Maxwell Campbell pictured with the 2023 Australian Natural History Medallionist Maureen Christie. Photo Maryse Hermence.

shorebirds. This has included her significant work in addressing the challenge of mitigating threats to shorebird habitat along the south-east South Australian coastline from beach-wrack harvesting. With a team from FoSSE, local fishermen, the South Australian Government, and the beach-wrack harvesting industry, she worked to achieve effective controls and conditions on harvesting of kelp products, in ways that minimised the impact on prey resources for shorebirds and fish.

There has never been a greater need for citizen scientists to participate in the extensive and often less-recognised work that is required to document the natural history of the unimaginable number of species around us. Such work is essential to conserve both individual species and the stability of the ecosystems that together form the biosphere on which the whole of human existence depends. Maureen is a shining example of a leader in this field and her service has been exemplary.

Maureen's contribution to the understanding and protection of shorebirds, through her significant practical hands-on work, advocacy and support of others, is exceptional. Through her passion, hard work and persistence, she has succeeded in advancing her chosen field, by informing and enhancing conservation efforts, and in disseminating knowledge. She has always generously shared her time, knowledge and skills, and encouraged and supported others in their own pursuits in the study of natural history.

As a volunteer, Maureen has done extraordinary work in both gathering knowledge in rigorous and innovative ways, and the hard work of communicating that knowledge to the public, and to the scientific record for future generations. Importantly, she has also written and disseminated numerous reports and publications, as well as presenting at conferences and schools, and running public education campaigns.

The ANHM Committee was delighted to award the 2023 Australian Natural History Medallion to Maureen Christie.

Maxwell Campbell
Secretary, ANHM Committee,
Field Naturalists Club of Victoria,
1 Gardenia Street,
Blackburn, Victoria 3130.

Australian Natural History Medallion Trust Fund

Donations to the ANHM Trust Fund since 13 September 2021 were gratefully received from the following:

	$		$
Peter Menkhorst	10.00	John Poppins	30.00
Anthea Fleming	30.00	Sue Forster	30.00
Maureen Christie	25.00		

If you would like to contribute to this fund, which supports the Australian Natural History Medallion, donations should be sent to: The Treasurer, Field Naturalists Club of Victoria, 1 Gardenia Street, Blackburn, Victoria 3130. Cheques should be made payable to the 'Australian Natural History Medallion Trust Fund'.

The Medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history.

Maxwell Campbell
Secretary, ANHM Committee,
Field Naturalists Club of Victoria,
1 Gardenia Street,
Blackburn, Victoria 3130.

# Frogs of Victoria: A Guide to Identification, Ecology and Conservation

by Nick Clemann and Michael Swan

Frogs of Victoria is a must-have field guide for Victorian frog lovers. It describes how to identify all 38 native frog species, as well as the one introduced frog and one introduced newt species recorded in Victoria since European settlement.

The guide has 6 chapters as well as Appendices on Wildlife legislation, and an Index of common and scientific names. Notable and exceptional parts of this field guide are the essay and information sections that form the first 5 chapters. These chapters are: Naming and classifying frogs; Biology of frogs; The amphibian fauna of Victoria; Victorian zoogeographic regions and ecosystems, and their frogs; and Conservation of Victorian frogs. These sections reflect the extensive experience and passion that the authors have for amphibians, and the reader is rewarded with a much broader understanding of the evolutionary history and biological diversity of the species, the history of scientific endeavour on this group in Victoria, the threatening process driving amphibian declines, and the immediate need for conservation action to ensure the survival of these extraordinary and beloved species.

The information in these chapters, and in fact within the book as a whole, is not referenced within the text, but there is a 12-page Selected Bibliography at the end of the guide. In this way it is directed at general users such as field ecologists or wildlife managers, rather than academics. The authors are also careful and generous in naming the herpetologists, ecologists, researchers and land managers whose work has contributed to the information in this guide. The clear, interesting writing and detail would make it an excellent read for an enthusiastic amateur.

Chapter 6 contains the species accounts. Each account is 2–3 pages long and includes sections on: common names, synonyms, identification, eggs and tadpoles, similar species, call,
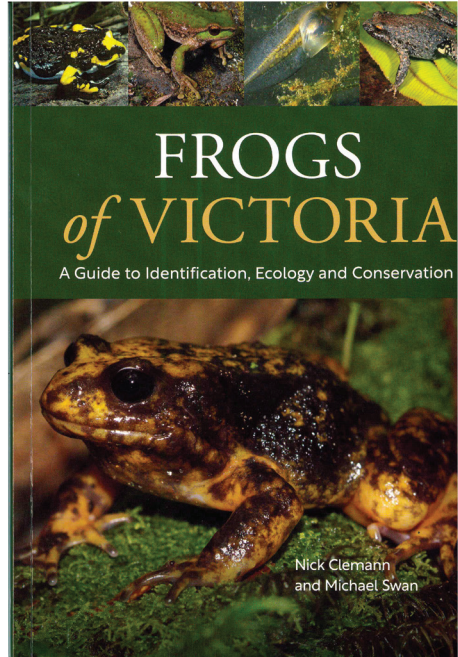
distribution and habitat, biology and conservation status.

The identification section for each species includes major distinguishing features in bold type for ease of identification. Species are illustrated with multiple full colour images, including examples of variable dorsal and ventral coloration, with arrows to indicate specific characters. Species names, location and photographic credits are indicated on each image. Photos in species descriptions are of adults in most cases, with photos of eggs and tadpoles included largely in the Biology of frogs section at the beginning of the field guide. This is explained in the Introduction as being because most tadpoles can be distinguished only

by looking at their mouthparts under a microscope, so are not appropriate characters for use by casual field observers.

There are distributional maps for each species within Victoria showing presence in grid squares across the landscape. The maps also show public land, major roads, cities and towns and have a latitude and longitude grid superimposed on them. The authors state (p. xi) that they 'do not show localities at a fine scale because we do not want to encourage habitat disturbance.' Instead, they include detailed written descriptions of the habitat of each species as well as the distribution of the species in Victoria and across its entire range.

Additional tables are included for species, such as the 'Limnodynastes dorsalis group', to summarise distribution and morphological features of multiple lineages and subspecies.

Overall, there is a substantial amount of information on the morphology, ecology and distribution of each species within the description, including everything from the details of hybrid zones to descriptions of calls. Bibron's Toadlet's call, for example, is described (p. 101) as a 'short, squelchy 'er-ek' repeated every few seconds.'

Dichotomous Keys are a vital part of a good field guide and can make or break the utility of a guide and the enjoyment in its use. Keys are important in higher level understanding of the relationships among the species all the way down to determining what species of frog you can see in your torchlight. In this guide there are keys for each hierarchical juncture, starting with a Key to the Families of Victorian Frogs, dividing the Pelodryadidae from the Limnodynastidae and Myobatrachidae. At each result there is a page number for the key to each order and the figure number for photographs that specifically illustrate the characters used in the key. This is the case for each result, all the way to sub-species level, with the page number of another key or a species description given at each result, facilitating easy movement around the field guide between keys at each level and the individual species descriptions. The detailed descriptions of each decision point in the key is written in clear language with a minimum of jargon, and there is also a glossary of terms at the back of the book that explains some of the less familiar terms.

The book is of a size and weight (under 1 kg) to fit into a backpack (perhaps along with the companion volume; Robertson and Coventry's *Reptiles of Victoria*!), for bushwalking or field work and is a modest price for a guide of this level of detail and expertise.

The authors have brought years of expertise and passion to this work and I highly recommend it.

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One hundred and one years ago

Bird Notes

During the last six months many northern birds that rarely come south have appeared in the lightly-timbered country around the eastern suburban areas. It is quite apparent that the severe drought now raging throughout Australia has caused a general migration of birds towards the sea coast.

As early as 14th October a White-necked Heron, *Notophoyx pacifica,* appeared on Gardiner's Creek, where it remained for a few days, and then suddenly disappeared. However, it was subsequently found dead with a rifle bullet through its neck. This was an unfortunate occurrence, as this was probably the bird that had been visiting that locality for years past.

During the same month a small flock of White-browed Wood-Swallows settled in some box saplings. Here they nested freely in the *Bursaria spinosa* and *Acacia armata* bushes, and only left the district at the end of January. A solitary Masked Wood-Swallow was observed in the above flock when first noticed, but a week later this bird greatly exceeded the White-browed in numbers. They made but a brief stay, and not a bird remained after the end of November.

Four Nankeen Night-Herons, *Nycticorax caledonicus,* all in cinnamon-coloured plumage, were flushed from some dense tea-tree scrub bordering the Gardiner's Creek. Though these birds are regarded as nocturnal, they are almost equally as alert during the daytime as their congener, the White-fronted Heron.

The beautiful Regent Honey-eater, *Meliphaga phrygia,* which comes south at irregular periods, was noted on 22nd November. Other birds soon became aware of this bird's arrival owing to its pugnacious habits. Any bird that happened to come into close quarters with the Regents was furiously attacked and driven some distance away. In all, three pairs frequented the locality for nearly three months, when they gradually disappeared.

Both the Brown, *Cinclorhamphus cruralis,* and Rufous, *Cinclorhamphus rufescens,* Song-Larks arrived during October, and remained till the end of December and early February respectively. The former bird frequented the open grasslands, and only perched on fences on very rare occasions. The Rufous Lark spent most of its time in trees or singing in the air. The female is barely more than half the size of the male. Stubble Quail, *Coturnix pectoralis,* appeared more plentiful than in previous years, but this may be accounted for by the luxuriant growth of grass that existed in the district during the spring months. When the grass dried the birds became scarce, and eventually the whole of them, disappeared. One particular pair had reared a brood by the end of November, and the young ones had just left the nest when I came unexpectedly upon them. The old bird, who was with them, immediately made a short flight, and the young concealed themselves so well that they could not be disturbed or found.

On two separate occasions a Black-shouldered Kite, *Elanus axillaris,* was seen disturbing Starlings. They were probably different birds, as one was seen in November and the other in January. Their white plumage harmonizes so well with the grey atmosphere that they become almost invisible at a short distance away.

Probably the rarest bird seen during the time under review was the Yellow-plumed Honey-eater, *Ptilotis ornata.* This bird was seen only once, and, although frequent searches were made, I could never locate it again. It is readily distinguished from the White-plumed Honey-eater, *Ptilotis penicillata,* which it greatly resembles, by its streaked breast and prominent yellow plumes.

In addition to the migratory birds, the locality was well represented with numerous stationary species. Undoubtedly last season proved extremely rich, not only in ornithology, but in botany and entomology.—D. DICKISON. East St. Kilda.

From *The Victorian Naturalist* **XL***, 12-13, May 1923*