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1 **VARIATION IN SIZE AND CONDITION OF NEONATE PYGMY BLUETONGUE**

2 **LIZARDS, *TILIQUA ADELAIDENSIS*.**

3

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8

9 **Abstract**

10 Phenotypic variation among offspring of individual animals is an important life-history trait. In  
11 viviparous lizards, it could result from genetic variation of individuals and also differences in  
12 environments experienced by mothers during gestation. We investigated variation in phenotype  
13 and survival of neonate pygmy bluetongue lizards, *Tiliqua adelaidensis*, over three sampling  
14 years. We explored changes in body condition, using body size residuals as an index, and body  
15 size (snout-vent length (SVL) and mass) of neonates. For litters that were captured with their  
16 mothers, we hypothesised that body condition and size of offspring are influenced by the  
17 condition and size of their mothers, presence of mothers in the burrow and litter size. We found  
18 that there were significant variations in body condition and mass of neonates among years. There  
19 was no significant relationship between neonate body condition, mass and SVL and post-partum  
20 body condition of their mothers. Results revealed that females with higher SVL produced larger  
21 litters. None of the analyses showed any effect of mother's presence on neonate body condition,  
22 SVL or mass. Neither was there any effect of observed litter size on these parameters. Our  
23 findings have important conservation implications for this endangered species, given that the aim  
24 of conservation managers is to encourage conditions that promote optimum body condition and  
25 fitness in offspring in order to maximise their survival in fragmented habitats.

26

27 **Introduction**

28 Neonate offspring of individual animal species vary in their phenotype as a result of their own  
29 genotypic variation and of variation in the environment experienced by their mothers during  
30 gestation, or by the developing embryo in its egg (Qvarnstrom and Price 2001). The environment  
31 in which the embryo develops can profoundly influence its morphology, behaviour (Burger

32 1989; Du, Shou *et al.* 2003; Hare and Daugherty 2002; Shine, Elphick *et al.* 1997) and postnatal  
33 growth rate (Rhen and Lang 1995). In this paper we explored the role of environmental factors in  
34 influencing phenotypic features that might subsequently affect survival among neonates of an  
35 endangered Australian scincid lizard. Specifically we investigated inter-annual variation in  
36 neonate size and condition in the viviparous pygmy bluetongue lizard, *Tiliqua adelaidensis*, and  
37 looked for factors that might explain this variation.

38 In viviparous lizards, annual variation in neonate body condition could be attributed to the  
39 different environmental conditions experienced by gravid females during embryonic  
40 development in each year (Lourdais, Shine *et al.* 2004; Reinhold 2002; Wapstra 2000). Climatic  
41 conditions, especially the temperature experienced by gravid female lizards (Hubert 1985) can  
42 influence the duration of gestation (Atkins, Swain *et al.* 2007) and the phenotype and fitness of  
43 offspring (Bernado 1996; Mousseau and Fox 1998; Olsson, Wapstra *et al.* 2002). Under warmer  
44 conditions, increased basking opportunities and higher food availability for gravid female  
45 lizards can increase the fitness and survival of their offspring (Bernado 1996; Itonaga, Jones *et*  
46 *al.* 2012; Massot and Clobert 1995; Olsson, Wapstra *et al.* 2002; Shine 1980; Shine and Harlow  
47 1993; Sorci and Clobert 1997; Wapstra 2000). For example, Itonaga *et al.* (2012) showed that  
48 females of the Australian scincid species *Pseudemoia entrecasteauxii*, when given extended  
49 basking opportunities with higher food availability during gestation, produced larger offspring  
50 with larger fat reserves and a higher sprint speed. All of these factors are expected to contribute  
51 to higher fitness. Similarly, Wapstra (2000) showed that female *Niveoscincus ocellatus* lizards  
52 with longer access to thermal basking conditions gave birth significantly earlier than those with  
53 shorter basking opportunities and they also gave birth to larger offspring in better body  
54 condition.

55 After birth, any variation in survival in neonate lizards among years could result from different  
56 opportunities to survive and grow in each year. Differences in the available microhabitat may  
57 have a direct effect on survival of neonates. Some microhabitats provide better refuges against  
58 predators or supply higher quality food (Forsman 2000; Fox 1978; Martin and Lopez 1998). Fox  
59 (1978) showed that home ranges of surviving juvenile *Uta stansburiana* had more access to food  
60 and shelter sites compared to non-survivors. However, individual neonate phenotype may affect  
61 survival more profoundly than local heterogeneities in microhabitat quality. Body size at birth  
62 has an important impact on fitness of juveniles (Blanckenhorn 2000; Dmitriew 2011) with larger  
63 juveniles having survivorship advantage over small ones (Ferguson and Fox 1984). For example,  
64 Civantos and Forsman (2000) found that larger *Psammodromus algirus* juveniles survived better  
65 than smaller juveniles. However, there is a trade-off between growth rate and energy storage or  
66 body condition in young lizards (Forsman and Lindell 1996). Larger individuals may benefit  
67 from better body condition but rapid growth and better body condition may reduce survival due  
68 to increased energy demands for locomotion (Pond 1978) and from a decrease in speed (Garland  
69 1985)

70

71 In many studies of lizards, body condition of neonates has been used as a predictive measure of  
72 future fitness. Body condition is a reflection of the mass per unit body length of an individual  
73 lizard and is often used as an indicator of food intake rate, energy storage and general health  
74 (Civantos and Forsman 2000; Forsman and Lindell 1996). Information about the longer-term  
75 reproductive recruitment for an endangered lizard species is often difficult to acquire directly,  
76 but growth rates and body conditions indices among neonates are valuable indicative parameters  
77 that are relatively more easily derived over a shorter time frame. Here, we use body condition

78 and body size (snout-vent length and mass) of neonate pygmy bluetongue lizards and their  
79 mothers to investigate factors affecting variation in their condition over the study period.  
80 *Tiliqua adelaidensis* is the smallest member of the genus *Tiliqua* and is currently listed as  
81 endangered under the *Australian Environment Protection and Biodiversity Conservation Act*  
82 *1999*. It is a viviparous Australian member of the family Scincidae. All known populations of the  
83 species are restricted to a few isolated fragments of remnant native grassland in a small area in  
84 the mid-north of South Australia. Individual lizards occupy burrows constructed by lycosid and  
85 mygalomorph spiders (Fellows, Fenner *et al.* 2009; Hutchinson, Milne *et al.* 1994). Litters of one  
86 to four neonate pygmy bluetongue lizards are born between late January and mid February  
87 (Hutchinson, Milne *et al.* 1994). Neonates briefly share the natal burrow with their mother and  
88 siblings, but independently leave the burrow, usually between one and five weeks after birth.  
89 Sometimes, the mother leaves the burrow before the neonates disperse (Milne, Bull *et al.* 2002).  
90 Pygmy bluetongue lizards feed by ambushing invertebrate prey that pass by the burrow entrance,  
91 and the more occupants in the burrow the fewer opportunities for prey capture by each  
92 individual. In that case, dispersal away from the natal burrow may reduce competition among  
93 siblings or between mother and offspring.

94

95 The aims of this study were (i) to provide parameters of neonate size and condition for  
96 conservation managers to explain how populations respond to annual changes in environmental  
97 conditions, and (ii) to derive background information relevant to understanding annual  
98 recruitment dynamics in this species. To achieve these aims we (i) explored the variation in  
99 body condition, SVL and mass of neonate pygmy bluetongue lizards over three sampling years,  
100 and (ii) investigated relationships between neonate body condition, SVL and mass and the

101 relative clutch mass (RCM) of their mothers. We predicted that females in better body condition  
102 would contribute a higher proportion of their body mass to their clutches. Additionally we  
103 considered some indirect behavioural influences on neonate fitness, asking whether there were  
104 differences in neonate phenotypes between those that did or did not stay with their mother or that  
105 did or did not stay with siblings. We made no specific predictions for these questions recognising  
106 that there could be benefits of remaining in a secure burrow with related conspecifics, balanced  
107 by costs from increased competition for the invertebrate prey close to the burrow.

## 108 **Materials and Methods**

### 109 *Study site and field methods*

110 The study site was the “Tiliqua” property of the Nature Foundation of South Australia,  
111 previously described as Site 2 (Fenner and Bull 2007), and was located about eight kilometres  
112 from Burra in South Australia (33° 42’S, 138° 56’E) in a remnant patch of native grassland. The  
113 area has hot, dry summers and cool, moist winters. The long-term average annual rainfall at  
114 Burra is 431mm and normally ranges between 300 and 500 mm. Table 1 summarises the rainfall  
115 and temperature data in each of four years. For the three years of our study (2009 – 2011) and the  
116 one year preceding our study, annual rainfall was the highest in 2011 (561.4 mm) and lowest in  
117 2008 (327.6 mm). The rainfall during late summer and early autumn (Jan – April), the months  
118 when neonates are born and start to grow, was highest in 2011 (193.4 mm) and lowest in 2009  
119 (48.8 mm). Total winter-spring and early summer rainfall (June-December), the period leading  
120 up to the birth of neonates in summer, was highest in 2009 (370.5 mm) leading up to the birth of  
121 neonates in 2010 and lowest in 2008 (274.5 mm) leading up to the birth of neonates in 2009.  
122 The average annual temperature over the study period was highest in 2009 (22.2 °C) and lowest in  
123 2010 (21.2 °C). The average daily temperature over the winter-spring- early summer period

124 (June-December) was highest in 2008 (18.6°C), and lowest in 2010 (17.5°C). Average  
125 temperature in the summer months (January-April) was highest in 2010 (28.2°C) and lowest in  
126 2011 (26.0°C).

127 TABLE1 ABOUT HERE PLEASE

128 We sampled 116 neonate lizards over three years 2009 – 2011 from mid January to early March  
129 in each year. Our searching effort of 34 -36 days within that period was the same each year and  
130 covered the same six week period that included the time from when litters were first detected  
131 each year to when lizards normally became inactive with the approaching winter (Milne, Bull *et*  
132 *al.* 2002). The mean snout-vent length (SVL) of neonate pygmy bluetongue lizards is less than  
133 55 mm (Milne, Bull *et al.* 2002), and we used 55 mm as an upper SVL limit to distinguish  
134 neonates from sub-adult and adult lizards.

135 Lizards were captured using the fishing method as previously described by Milne (1999). We  
136 deduced that most neonates were captured in their natal burrows, either because an adult female  
137 was also present in the burrow, or because 2 – 4 neonates were found together. Genetic studies  
138 on mother-offspring relatedness in pygmy bluetongue lizards have shown that females captured  
139 with neonates in a burrow are almost always mothers and offspring, and litters found in the same  
140 burrow are almost always siblings (Schofield, Gardner *et al.* 2013). Some neonates begin  
141 dispersing from the natal burrow within a week after birth and by 5 weeks most of the neonates  
142 have left the natal burrow (Milne, Bull *et al.* 2002). Therefore, the number of neonates described  
143 as a litter in this study was not necessarily the complete litter size, since some young may already  
144 have dispersed from the burrow at the time a litter was detected (Table 2).

145 In some cases females leave their intact litters and disperse to another burrow soon after giving  
146 birth (Schofield, Gardner *et al.* 2013), and in this study we found some litters without an adult



147 female present. For each lizard, we recorded the date of capture and measured the mass, snout to  
148 vent length (SVL), and total body length (TBL). Lizards were weighed on a field balance to the  
149 nearest 0.01 g, and were given a unique toe clip identification marking, and then released back to  
150 their burrows. Marking was used to prevent multiple observations of the same individuals.

151 TABLE 2 ABOUT HERE PLEASE

152

### 153 *Analysis*

154 Neonate body condition was calculated from the residuals of the linear regression between  
155 natural log-transformed mass and natural log-transformed SVL for the complete sample of  
156 neonate lizards. Although there has been debate about the validity of various indices of body  
157 condition (Green 2001; Schulte-Hostedde, Zinner *et al.* 2005) in our analysis, there was a  
158 significant linear relationship between ln mass and ln SVL of the neonates ( $R^2=0.158$ ,  
159  $F_{1,102}=19.12$ ,  $P<0.001$ ) (Fig.1), an appropriate condition to justify the use of this index  
160 (Bradshaw and De'ath 1991; Green 2001; Peig and Green 2010).

161 The analyses were designed to investigate variation in body condition, SVL and mass among  
162 neonate individuals over the six week late summer and autumn period when neonates could be  
163 sampled each year, and to determine whether those three parameters varied among the three  
164 sampling years. For those neonates that were captured with siblings, we used mean values per  
165 litter for each parameter under investigation to ensure independence of data points. Because  
166 neonates were captured from January to March, and because they may have altered their body  
167 condition during growth in the period between when they were born and when they were  
168 captured and measured, we included the day of the year (after Jan 1) when the lizard was  
169 captured as a covariate. Analysis of covariance (ANCOVA) was performed on the body

170 condition indices per litter of neonates, with year as the factor and day of capture as the  
171 covariate. We also investigated growth in snout-vent length (SVL) and mass per litter, by  
172 comparing neonates captured at different times from January to March over three sampling  
173 years. There were no recaptures of neonates within a year in our study. We assumed that sizes of  
174 neonates captured later in the season would reflect a period of growth since birth.

175 On a subset of 23 litters, where both mother and offspring neonates (range 1-3 neonates per  
176 litter) were found together, we investigated whether post-partum maternal body condition was  
177 related to neonate body condition, SVL or mass. We hypothesised that females with better body  
178 condition would have produced offspring with better body condition or larger litters with greater  
179 overall mass. For those litters, we performed three Pearson's correlation tests between post-  
180 partum body condition of mothers and a) the mean body condition of neonates in the litter, b) the  
181 mean SVL of neonates in the litter SVL, and c) the mean mass of neonates in the litter. Similarly  
182 we performed Pearson's correlation tests comparing post-partum body condition, mass and SVL  
183 of mothers with total litter mass and RCM. We also carried out one-way ANOVAs on mean  
184 body condition, SVL and mass of mothers with litter size (1-3 young) as a factor to investigate  
185 whether different numbers of young in a litter came from mothers of different sizes.

186 In addition, we compared the mean body condition, SVL and mass of neonates in litters that  
187 were sampled with their mothers, to those that were found without an adult female present. This  
188 analysis might suggest, if there were a positive association, that the presence of mothers helps  
189 neonates to achieve better body condition, or, if there were a negative association, that mothers  
190 and their co-habiting offspring compete for prey (or alternatively that neonates in better body  
191 condition are more likely to disperse earlier) (Le Galliard, Ferriere *et al.* 2003). Analysis of  
192 covariance (ANCOVA) was conducted with body condition of neonates as the dependent factor,

193 year and presence or absence of mothers as factors, and day of capture as a covariate. The same  
194 analyses were performed with neonate SVL and mass per litter as dependent variables.  
195 We also examined the differences in body condition, SVL and mass of neonates in litters of  
196 different sizes to determine any role of competition among neonates in the same burrow. We  
197 performed ANCOVA analysis with mean body condition of neonates in the litter as the  
198 dependent variable, the number of neonates in the litter (1-3) and sampling year as factors, and  
199 day of capture as a covariate. The same analyses were executed on SVL and mass of neonates in  
200 the litter.  
201 We used SPSS version 22 to conduct analyses in this study. Data were checked for normality  
202 and are presented with error bars of one standard error where appropriate.

203

204

FIGURE 1 ABOUT HERE PLEASE

## 205 **Results**

206 We collected a total of 116 neonate pygmy bluetongue lizards from 84 litters over the study  
207 period (Table 2). Of those, 37 neonates (23 litters) were captured with their mothers in their  
208 natal burrows, while 79 neonates (61 litters) were found in burrows without an adult lizard  
209 present. Mean detected litter size was 1.58 (SE= 0.15; range 1-3). The mean neonate SVL was  
210 44.6 mm (SE=0.2) and mean neonate mass was 2.7g (SE= 0.07). Mean relative clutch mass  
211 (RCM) was 0.29 and varied between 0.13 and 0.84. The lower values may not be true measures  
212 of RCM if some of the litter members had already dispersed before the litter was measured; the  
213 first litter of the year was detected on January 26 in 2009, on February 10 in 2010, and on  
214 January 17 in 2011.

215

216 Analysis of covariance (ANCOVA) tests showed significant variation in body condition and  
217 mean mass among years in neonate pygmy bluetongue lizards (Table 3). Neonates had the  
218 highest body condition and mass in 2011 and the lowest in 2010 (Figure 2(a), (b)). Day of  
219 capture did not have an effect on the body condition or mass.  
220 Results also revealed that SVL increased with days into the season. Lizards that were captured  
221 later in the season were longer (Figure 3) but not heavier. The results were consistent across  
222 years (no significant year x day of capture interaction; Table 3).

223

224 TABLE 3/ FIGURE 2 &3 ABOUT HERE PLEASE

225

226 The presence of mothers in the maternal burrow did not significantly influence the body  
227 condition, mass or SVL of neonate litters (Table 4). Similarly those three parameters were not  
228 found to be influenced by detected litter size (Table 5), with results consistent over the three  
229 sampling years (Table 5).

230 TABLE 4&5 ABOUT HERE PLEASE

231

232 Pearson's correlation tests revealed no significant relationship between post-partum body  
233 condition of mothers and mean body condition of their litters, mean litter mass or SVL (Table 6).

234

235 There was a significant difference in the mean female SVL among litters of different sizes (Table  
236 7; Figure 4). Post hoc comparisons using Tukey HSD test indicated that the mean SVL of  
237 females with three or more young ( $M=97$ ,  $SD=6.0$ ) was significantly higher than mothers with

238 one or two young in their litter. Body condition and mass of mothers did not vary among those  
239 detected with litters of different sizes.

240 TABLE 6&7 ABOUT HERE PLEASE

241 Neither total litter mass nor RCM were significantly correlated with mother's body condition,  
242 SVL or body mass (Table 8).

243

244 TABLE 8 ABOUT HERE PLEASE

245

## 246 **Discussion**

247 Our first aim was to provide parameters for conservation managers to explain how populations  
248 respond to annual changes in environmental conditions. We found significant variation in the  
249 body condition of neonate pygmy bluetongue lizards over the three sampling years. Neonates  
250 had the lowest body condition in 2010 and the highest body condition in 2011 (Fig.2a).

251 Although we have insufficient temporal or spatial replicates for a rigorous analysis, we comment  
252 below on some possible mechanisms for the trends we observed.

253 Variation in the body condition could be attributed to the different environments experienced by  
254 gravid females during embryonic development in each year (Lourdais, Shine *et al.* 2004;  
255 Reinhold 2002; Wapstra 2000). Climatic conditions, especially the temperature experienced by  
256 gravid female lizards (Hubert 1985) can influence duration of gestation (Atkins, Swain *et al.*  
257 2007) and the phenotype and fitness of offspring (Bernado 1996; Mousseau and Fox 1998). In  
258 our study, summer in 2010 was preceded by a cold and wet spring. Females may have had less  
259 basking opportunities prior to and during their gestation periods, leading to later births and to

260 neonates with lower body condition. This may have impacted on the fitness of their offspring in  
261 that year. Pygmy bluetongue lizards normally give birth by mid to late January (Hutchinson,  
262 Milne *et al.* 1994), but births were unusually late in 2010, with the first litters not detected until  
263 February 8. This delay in parturition may have had an adverse effect on the body condition of  
264 offspring that year. Past studies have shown that viviparous lizards can delay parturition if  
265 subjected to unfavourable environmental conditions (Atkins, Swain *et al.* 2007). Although the  
266 delay might reduce overall fitness, it might still ensure that offspring are born under more  
267 favourable conditions for their subsequent survival (Olsson and Shine 1998; Shine and Olsson  
268 2003; Swaine and Jones 2000). Climatic and environmental variation among years may also  
269 influence the body condition and size achieved by female lizards. One of our results showed  
270 females with longer SVL could produce larger litters. However those litters did not have greater  
271 overall mass in our study. Our finding is consistent in part with that of Milne and Bull (2002)  
272 who found that larger pygmy bluetongue females produced larger litters with greater overall  
273 mass. A study by Brandt and Carlos (2011) also found a positive association between mother  
274 size and offspring size in Tropidurinae lizards. Maternal size and age has been related to  
275 offspring size in other taxa such as fish (Kindsvater, Rosenthal *et al.* 2012) and birds (Parker and  
276 Begon 1986). One possible interpretation of the pattern for larger body sizes later in the year is  
277 that larger babies were born later, that is, there is a tradeoff between gestation period and  
278 offspring size.

279

280 Another possible explanation for the variation among years in neonate body condition and size  
281 could be that neonates had different opportunities to survive and grow in each year. Our results  
282 showed a consistent pattern across the three years for significantly longer SVL of neonate lizards

283 captured later in the season (Figure 3). We interpreted this to indicate lizards were increasing in  
284 length through natural growth. An alternative interpretation, because we were not recapturing  
285 individual lizards, is that neonate lizards were not growing over the last few weeks of the lizard  
286 activity period after they are born, but that there was differentially higher survival of longer  
287 lizards over the first few weeks. A lack of growth may result from a relative shortage of the  
288 invertebrate prey late in the summer. This interpretation might explain why mass of neonates did  
289 not change among captures at different times within the sampling period. However, mean mass  
290 of neonates was significantly different among years. This may be because of differences in food  
291 availability, in basking opportunities, or in microhabitat conditions for either neonates after they  
292 have been born or for their mothers before the birth. Our data do not allow us to differentiate  
293 among these explanations, but suggest strong difference in one or more of that set of conditions.

294

295 Our second aim was to derive background information relevant to understanding annual  
296 recruitment dynamics in this species. Specifically we hoped to find trends that would indicate  
297 how various maternal and neonate behaviours affected those neonates. One problem with our  
298 analyses is that we have tried to infer recent past conditions from snap shot observations of  
299 lizards. Thus, although we located some litters or individual neonates without females, we had  
300 no data on how long they had been separated from their mothers. And if we had found  
301 differences in size or body condition between litters with or without mothers present,  
302 interpretation would have been speculative. Thus if we had showed that neonates with mothers  
303 present were larger or in better condition, this may have been explained by mothers assisting  
304 growth of neonates in some way, or by mothers or litter mates differentially forcing dispersal of  
305 the weakest litter members, In fact our analyses showed no impact in any year of the presence or

306 absence of mothers in the maternal burrows, or of the number of litter mates sharing the burrow.  
307 The only conclusion that can be derived is that we found no evidence to suggest neonate growth  
308 was influenced by burrow sharing, and that apparently, during the early weeks of neonate  
309 development, competition for insect prey passing the burrow entrance did not influence the  
310 growth and body condition of litters of different sizes.

311 In summary, our study found significant variation in the body condition of neonate pygmy  
312 bluetongue lizards over three sampling years. This finding has important conservation  
313 implications for this endangered species, given that the aim of conservation managers is to  
314 encourage conditions that promote optimum body condition and fitness in offspring in order to  
315 maximise their survival. Future studies will need to consider long term effects of body condition  
316 on survival of neonate pygmy bluetongue lizards, and how changing climatic conditions affect  
317 the fitness of neonate lizards.

318

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324 (approval no. E206) and in compliance with the Australian Code of Practice for the Use of  
325 Animals for Scientific Research.

326

327



328

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479 **Table 1.** Rainfall and temperature for Burra region in each of four years 2008 - 2011.

Year	Rainfall (mm)			Temperature (C°)		
	Annual	Jan-Apr	June-Dec	Annual	Jan-Apr	June-Dec
2008	327.6	45.6	247.8	21.5	18.6	27.3
2009	428.1	48.8	370.5	22.2	18.45	27.8
2010	539.2	83.8	357.8	21.2	17.54	28.2
2011	561.4	193.4	331.5	21.4	19.58	26

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484 **Table 2.** Number of neonate *Tiliqua adelaidensis* captured from Jan – March in each of three  
 485 years 2009-2011.

Year	NEONATE LIZARDS			NEONATE LITTERS		
	<i>N lizards</i>	<i>N with mother</i>	<i>N without mother</i>	<i>N litters</i>	<i>N with mother</i>	<i>N without mother</i>
2009	23	7	16	20	6	14
2010	44	19	25	35	13	22
2011	49	11	38	29	4	25
<b>Total</b>	<b>116</b>	<b>37</b>	<b>79</b>	<b>84</b>	<b>23</b>	<b>61</b>

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489 **Table 3.** Results of the analyses of covariance of body condition, SVL, and mass of neonate  
 490 pygmy bluetongue lizards, with sampling year as a factor and day of sampling as a covariate.

491 P values in bold indicate results that are statistically significant at  $P < 0.05$ .

	Body condition			SVL			Mass		
	<i>df</i>	<i>F</i>	<i>P</i>	<i>df</i>	<i>F</i>	<i>P</i>	<i>df</i>	<i>F</i>	<i>P</i>
Year	2	3.825	<b>0.026</b>	2	2.587	0.637	2	3.123	<b>0.05</b>
Day of capture	1	3.393	0.069	1	6.377	<b>0.014</b>	1	1.415	0.238
Year x Day of Capture	2	1.799	0.172	2	0.384	0.682	2	1.05	0.355
Error	78			78			78		

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496 **Table 4.** Results of the analyses of covariance of body condition, SVL, and mass of neonate  
 497 pygmy bluetongue lizards with sampling year and mother presence or absence as factors and  
 498 day of sampling as a covariate.

499 P values in bold indicate results that are statistically significant at  $P < 0.05$ .

	Body condition			SVL			Mass		
	<i>df</i>	<i>F</i>	<i>P</i>	<i>df</i>	<i>F</i>	<i>P</i>	<i>df</i>	<i>F</i>	<i>P</i>
Year	2	3.897	<b>0.025</b>	2	1.221	0.301	2	2.857	<b>0.062</b>
Day of capture	1	1.493	0.226	1	1.779	0.186	1	1.057	0.307
Mother presence	1	0.389	0.535	1	2.187	0.143	1	0.010	0.920
Year x Day of Capture	2	1.886	0.159	2	1.029	0.362	2	1.600	0.209
Mother presence x year	2	0.387	0.681	2	0.601	0.616	2	0.085	0.919
Mother presence x Day of capture	1	0.306	0.582	1	1.107	0.336	1	0.002	0.964
Error	74			74			74		

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502 **Table 5.** Results of the analyses of covariance of body condition, SVL, and mass of neonate  
 503 pygmy bluetongue lizards in the litter with sampling year and litter size as factors and day of  
 504 sampling as a covariate.

505 P values in bold indicate results that are statistically significant at  $P < 0.05$ .

	Body condition			SVL			Mass		
	<i>df</i>	<i>F</i>	<i>P</i>	<i>df</i>	<i>F</i>	<i>P</i>	<i>df</i>	<i>F</i>	<i>P</i>
Year	2	4.246	<b>0.018</b>	2	0.868	0.424	2	3.299	<b>0.043</b>
Day of capture	1	0.013	0.910	1	0.087	0.769	1	0.456	0.502
Litter size	2	1.044	0.357	2	0.673	0.514	2	1.413	0.250
Year x Day of Capture	2	2.689	0.075	2	0.920	0.403	2	1.600	0.209
Litter size x year	3	0.169	0.917	3	0.601	0.616	3	0.516	0.672
Litter size x Day of capture	2	0.975	0.382	2	0.094	0.963	2	1.395	0.255
Error	71			71			71		

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508 **Table 6.** Results of the Pearson's correlation between post-partum body condition of mothers  
509 and mean body condition, SVL, and mass of pygmy bluetongue neonate litters.

	<i>r</i>	<i>N</i>	<i>p</i> -value
Body condition	0.13	23	0.953
SVL	0.030	23	0.890
Mass	-0.044	23	0.843

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513 **Table 7.** Results of one-way ANOVAs comparing mean body condition, SVL and mass of  
514 mother pygmy bluetongue lizards that were detected with litters of one two or three neonates.

515 P values in bold indicate results that are statistically significant at  $P < 0.05$ .

	<i>df</i>	<i>F</i>	<i>P</i>
Body condition	2,18	0.067	0.935
SVL	2,18	4.730	<b>0.022</b>
Mass	2,18	1.472	0.256

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519 **Table 8.** Results of the Pearson's correlation between post-partum body condition, SVL and  
 520 mass of mothers and total litter mass and RCM of neonate pygmy bluetongue lizards.

	Total litter mass			RCM		
	<i>r</i>	<i>N</i>	<i>P</i>	<i>r</i>	<i>N</i>	<i>P</i>
Body condition	0.05	21	0.826	-0.67	21	0.773
SVL	0.28	21	0.218	0.13	21	0.553
Mass	0.25	21	0.268	0.04	21	0.986

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525 **Figure legends**

526 **Figure 1.** Relationship between body mass and snout-vent length in neonate pygmy blue tongue  
527 lizards ( $R^2=0.158$ ). (There are overlaps of data points in the figure.)

528 **Figure 2.** Mean (SE) (a) body condition, and (b) mass per litter in each sampling year.

529 **Figure 3.** Mean snout-vent length per litter as a function of the date of sampling (days after Jan  
530 1).

531 **Figure 4.** Mean (SE) snout-vent length (SVL) of mothers of different litter size (1-3).

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