

# MITE INFESTATIONS IN AUSTRALIAN SKINKS: SEASONAL, GEOGRAPHICAL AND ECOLOGICAL VARIATION.

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## ABSTRACT

Lizards often have aggregations of the larvae of trombiculid mites in their axillae ("armpits"). In some lizards, these axillae are invaginated and are referred to as mite pockets. There has been substantial debate on the evolution and adaptive significance of mite pockets. However, very little work has been done on the basic patterns in mite occurrence, such as geographical, seasonal and size variations. I recorded mite numbers in the axillae of six species from three genera of Australian skinks (*Carlia*, *Cryptoblepharus* and *Ctenotus*). In tropical species that experience warm, moist conditions during summer, mite larvae were more abundant in summer than in winter. In *Carlia vivax*, larger lizards had more mites ( $R^2 = 0.10$ ,  $P = 0.04$ ,  $n = 41$ ), but this was not the case in the other species I examined. Mite numbers overall were similar in left-hand-side versus right-hand-side axillae, but species differed significantly in this respect. The functional significance of this species-specific asymmetry remains unclear. There was no difference in mite-load between males and females during summer in the one species examined for this aspect, *Carlia gracilis*.

## INTRODUCTION

The axillary regions of lizards often have aggregations of the larvae of trombiculid mites. The larval stage is the only parasitic one of the four developmental stages: egg, larva, nymph and adult (Sasa, 1961). The common name for members of the mite family Trombiculidae is chigger (Sasa, 1961).

In some lizards, the axillary regions have evolved to form invaginations called mite pockets (Arnold, 1986). Invaginations also occur in other protected areas of lizards, such

as the sides of the neck, groin and post-femoral region (Arnold, 1986). These sites have a good blood supply, and the larvae attach themselves to the host at these points, feeding on cellular debris and tissue fluid (Arnold, 1986). Once the larvae are engorged, they drop off and return to the soil to complete maturation (Sasa, 1961).

There are two alternative hypotheses about why mite pockets have evolved in lizards. Arnold (1986) suggested that the pockets have evolved as adaptations to ameliorate damage caused by the parasites, by concentrating the larvae in one place. In contrast, Bauer *et al.* (1990) argued that mite pockets have evolved as a result of unknown selective forces, and are facultatively exploited by the larvae of mites with no evidence to suggest that pockets ameliorate the damage caused.

Subsequent studies on mite pockets have mostly supported the hypothesis put forward by Arnold (1986). Goldberg and Holshuh (1992) found that increased exposure to mite infestations caused increasingly severe reactions in the mite pockets of the iguanid *Sceloporus jarrovi* (Yarrow's Spiny Lizard). By concentrating them in the pockets, the damage caused to the lizard is localised (Goldberg & Holshuh, 1992). This evidence supports the ectoparasite damage limitation hypothesis put forward by Arnold (1986).

Salvador *et al.* (1999) attempted to determine whether pockets reduce the damage caused by ectoparasites. The work was done in relation to ticks rather than mites, but the results are relevant here. The experimental study was carried out on the lacertid *Psammotomus algirus*, which has nuchal pockets. Salvador *et al.* (1999) found that when parasite loads are low, the pockets are beneficial by concentrating the parasites in areas where

interference with functions related to fitness are reduced. However, heavier loads resulted in infestations in other areas, such as the ears. Lizards with heavy loads and nuchal pockets blocked experimentally had reduced home ranges (restricted movement patterns) and were seen over a shorter period of time (interpreted as being due to higher mortality). These data militate against Bauer *et al.* (1990)'s argument that pockets are not beneficial to lizards. However, it is possible that the experimental blockage of nuchal pockets using glue may have caused the reduction in home ranges.

Goldberg and Bursey (1993) studied the duration of attachment of mites in *Sceloporus jarrovi*. The duration was highly variable, although mites may remain attached in mite pockets for longer periods of time than elsewhere.

Much of the work done on mite pockets has focussed on their evolution and adaptive significance. However, little work has been carried out on basic patterns in mite occur-

rence, such as geographical, seasonal and size variations. No definitive work is available on the presence or absence of sex differences in mite-load, although Salvador *et al.* (1999) observed that during the mating season, males were more frequently infested with ticks than were females and juveniles.

My study was on mites in the axillary regions of lizard species in the family Scincidae, a reptile lineage on which very little work has been done in this respect. Arnold (1986) examined potential hosts from several sites in northern Queensland. He found that the great majority of skinks carrying mites were from the genus *Carlia*, and these mites were found in the axillary region.

My research was aimed at broadening the knowledge of mite infestations in the axillary regions of lizards, and particularly in Australian skinks. Susceptibility of skinks to mites in different habitats, seasonal variation in mite infestation rates and the relationship between snout-vent length and mite-load was investigated. The possibility of a correlation

**Table 1: Habitat and distribution of animals examined for each species studied. (Qld = Queensland; NSW = New South Wales; NT = Northern Territory). Data from Cogger (2000).**

Species	Distribution of animals examined	Habit	Habitat
<i>Carlia tetradactyla</i>	Eastern Australia, specimens examined from the western slopes of NSW	Ground dweller	Dry sclerophyll forest
<i>Carlia vivax</i>	Along Qld coast overlapping into northern NSW	Ground dweller	Seasonally dry open sclerophyll forest and tall woodland
<i>Carlia gracilis</i>	Northern part of NT	Ground dweller	Seasonally dry open sclerophyll forests
<i>Ctenotus essingtoni</i>	North coast of NT and Qld	Ground dweller	Seasonally dry tropical woodlands and coastal dunes and shrublands
<i>Carlia rubrigularis</i>	Rainforests of north-eastern Qld	Ground dweller	Openings in rainforest
<i>Cryptoblepharus plagiocephalus</i>	Virtually Australia wide, except for east and south-east (only specimens from the NT examined)	Primarily arboreal	Tropical to temperate woodlands

between mite-load and sex of the animal within the season of greatest infestation was also considered.

## MATERIALS AND METHODS

Four species of *Carlia* (*C. gracilis*, *C. rubrigularis*, *C. tetradactyla* and *C. vivax*), one species of *Ctenotus* (*C. essingtoni*) and one species of *Cryptoblepharus* (*C. plagiocephalus*) were chosen for the study. Preserved specimens were obtained from the Australian Museum. The species were chosen on the basis of their different distributions and habitats (Cogger, 2000 and Table 1).

General inspection showed that mites were concentrated in the axillae, only occurring on other parts of the body, such as ears and eyes, when infestation levels (number of mites) were very high. For all six species, each specimen was examined for mites, and total numbers were recorded in both the left and right axillary regions. The snout-vent length (SVL) was recorded for animals with mites. The total number of specimens of each species examined was noted, and the dates of collection were recorded for each specimen. Dates were converted into Julian dates (numbers from one to 365) and divided into winter and summer. April 16th to October 15th was defined as winter and October 16th to April 15th was defined as summer. While the different species may experience different lengths of seasons, the overall patterns are covered within each six month period.

*Carlia gracilis* was examined in greater detail due to the larger sample size and time restrictions. The SVL was recorded for all specimens, both with and without mites, and the sex of each animal with mites was also recorded.

A Pearson's Chi-Squared ( $\chi^2$ ) test was used to determine whether there was a significant association between the presence or absence of mites and season. A least squares regression analysis was carried out to determine whether there was a significant correlation between SVL and total mite-load (total

number of mites). A sign test was carried out to find out whether there was a significant level of asymmetry in mite infestation between the left and right axillary regions for animals with mites. A two-sample t-test was carried out within the season of greatest infestation to determine whether there was a significant difference in the total mite-load between males and females within this season.

## RESULTS

### Seasonal variation in mite-load

There was a significant seasonal variation in frequency of mite infestation in three of the species examined: *Carlia vivax*, *C. gracilis* and *Ctenotus essingtoni*. There was a significantly greater proportion of lizards infested with mites in summer than in winter (Table 2). Results for two other species, *C. rubrigularis* and *Cryptoblepharus plagiocephalus*, came close to being significant. *Carlia tetradactyla*, on the other hand, showed no significant seasonal variation. However, as only two specimens had mites in their axillae (see Table 2), significant differences could not be detected.

### Correlation between mite-load and SVL

*Carlia vivax* showed a significant positive correlation between mite-load and SVL ( $R^2 = 0.10$ ,  $P = 0.04$ ,  $n = 41$ ). *Carlia gracilis* ( $R^2 = 0.07$ ,  $P = 0.07$ ,  $n = 51$ ) (Fig. 1) and *Ctenotus essingtoni* ( $R^2 = 0.10$ ,  $P = 0.14$ ,  $n = 24$ ) came close to showing a significant correlation. However, *C. rubrigularis* ( $R^2 = 0.06$ ,  $P = 0.23$ ,  $n = 28$ ) and *Cryptoblepharus plagiocephalus* ( $R^2 = 0.04$ ,  $P = 0.36$ ,  $n = 23$ ) showed no significant correlation between mite-load and SVL. Most animals have few mites, but some individuals have large numbers (Fig. 1).

### Difference between mites in left and right axilla

There was no significant difference between the number of mites in the left and right axillae of individual species: *C. vivax* ( $P = 0.10$ ,  $n = 37$ ), *C. rubrigularis* ( $P = 0.45$ ,  $n = 7$ ), *Carlia gracilis* ( $P = 0.88$ ,  $n = 42$ ), *Cryp-*

*toblepharus plagiocephalus* ( $P = 1.0$ ,  $n = 19$ ) or *Ctenotus essingtoni* ( $P = 0.79$ ,  $n = 14$ ). There were insufficient data to carry out the test for *C. tetradactyla*.

### Variation in mite-load with sex

Mite-loads (number of mites per animal) in *Carlia gracilis* did not vary significantly between males and females in the season of greatest infestation, summer ( $t = -0.60$ ,  $P = 0.56$ ,  $n = 22$ ).

## DISCUSSION

### Seasonal variation in mite-load

There was an association between mite-load and season for *Carlia vivax*, *C. gracilis* and *Ctenotus essingtoni*, but not for the other taxa examined. This interspecific difference may be due to the different distributions and habitats of the species, as suggested by Arnold (1986) and Zippel *et al.* (1996): mites are most likely to be found in warm, moist environments. *Carlia vivax* and *C. gracilis* live on the ground in seasonally dry open sclerophyll forests with a grass understorey and *C. essingtoni* lives on the ground in seasonally dry tropical woodlands. All these habitats are dry during the winter when there is a reduced amount of rainfall and temperatures are cooler. However, during summer, they are warm and moist, creating a favourable environment for mite development and maturation (Sasa, 1961).

There was no significant seasonal variation in *Carlia rubrigularis* and *Cryptoblepharus plagiocephalus*, although both show a tendency towards summer as the season of greatest mite infestation. There are several plausible explanations for the lack of a significant seasonal variation. *Carlia rubrigularis* lives in rainforests, while *C. plagiocephalus* lives in tropical to temperate woodlands. Unengorged larvae tend to conceal themselves in shaded areas (Sasa, 1961), which may be plentiful in these habitats, reducing mite densities and the chance that a lizard will pick them up. It may also be possible that this group of mites is less suited to rainforests (not

addressed in literature), and thus the low levels of infestations during both seasons. Alternatively, it may be because conditions are more uniform through out the year in rainforests and tropical areas, resulting in aseasonality. In addition, *C. plagiocephalus* is more arboreal than the other species examined, spending less time on the ground, making them less vulnerable. While there are plenty of crevices in trees, wind can get into them, drying them out, and the mites are probably terrestrial, although there is no definitive evidence for this.

*Carlia tetradactyla* on the other hand is a southern species from the Sydney region. In this area, the temperature is often cool in winter and hot and dry in summer, perhaps creating a poor environment for mites. In summer, only two specimens out of 86 had mites resulting in a very low frequency of infestation (0.023). By comparison, all other species examined are distributed further north, from northern NSW to Qld and the NT, where the summers are warm and moist.

Seasonality in mite-load appears to be due to the biology of the mites themselves. Most trombiculid mites exhibit exceptional seasonal fluctuation, especially of the larval stages (Sasa, 1961). Warm and moist conditions are optimal for development and maturation of mite larvae (Sasa, 1961). Mite infestations are therefore most likely to occur when the environment is suitably warm and moist, that is, during summer in northern Australia.

### Correlation between mite-load and SVL

Goldberg and Holshuh (1992) observed that all age groups (and therefore size groups) of *Sceloporus jarrovi* were infected with mites but did not test for a correlation between mite-load and SVL. *Carlia vivax* showed a significant correlation between mite-load and SVL ( $P = 0.04$ ), however, the model explains very little of the variation ( $R^2 = 0.10$ ). Similarly, in *C. gracilis*, where the P-value ( $P = 0.07$ ) approaches significance, the model explains very little of the variation ( $R^2 = 0.07$ ).

The low coefficients of determination may possibly be due to the random attachment of mites to a host, regardless of size of the individual and therefore the size of the axillary area available to mites (Fig. 1). For example, one female, summer-caught specimen of *Carlia gracilis* had a SVL of 39.5mm with just one mite. By contrast, a second female, summer-caught specimen of *C. gracilis* had a SVL of 35mm with a total mite-load of 47. Another feasible explanation is that the variation is due to shedding; individuals with few mites may have recently shed while those with many mites may be about to shed (G. Shea, pers. comm.).

#### **Difference between mites in left and right axilla**

Individual species did not deviate significantly from 50:50 in left and right axillae. Similarly, no asymmetry was found between the left and right axillae in the Yarrow's Spiny Lizard, *Sceloporus jarrovi* (Goldburg & Bursey, 1993).

#### **Variation in mite-load with sex**

According to Salvador *et al.* (1999), males were more frequently infested during the mating season than were females and juveniles. This difference was attributed to higher concentrations of testosterone in males during this time. However, frequencies of infestation were not quantified. In addition, the difference may have been due to the greater activity levels in breeding males seeking out females, resulting in more frequent encounters with mites. I did not find any significant difference in mite-load during summer (the season of greatest infestation) between males and females in the species *Carlia gracilis*.

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**Table 2: Seasonal variations of mite infestations in different scincid species.**

Species	Number of animals with mites (Proportion of total)		$\chi^2$	P-value
	Winter	Summer		
<i>Carlia tetradactyla</i>	0/72 (0.000)	2/86 (0.023)	1.70	0.20
<i>C. vivax</i>	6/141 (0.043)	28/97 (0.289)	28.43	0.00
<i>Ctenotus essingtoni</i>	6/76 (0.079)	14/19 (0.737)	39.58	0.00
<i>C. gracilis</i>	27/209 (0.129)	16/27 (0.593)	34.46	0.00
<i>C. rubrigularis</i>	17/179 (0.095)	10/57 (0.175)	2.76	0.10
<i>Cryptoblepharus plagiocephalus</i>	15/166 (0.090)	6/33 (0.182)	2.44	0.12

**Figure 1: Relationship between total number of mites and snout-vent length in *Carlia gracilis*.**

