

**Leaf selection by the leaf-curling spider
Phonognatha graeffei (Keyserling) (Araneoidea:
Araneae)**

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Summary

The leaf-curling spider *Phonognatha graeffei* installs a curled leaf retreat near the hub of its vertical orb-web. The resident spider remains within the retreat, emerging only to capture prey caught in the web. The weight of the leaf used for the retreat often exceeds that of the spider, and larger spiders use heavier leaves than smaller spiders. Laboratory experiments revealed that the spiders prefer to use moist, green leaves rather than drier, brown leaves for their retreats. The latter leaves are harder to curl without breaking, and require more silk to bind into the characteristic tubular retreat.

Introduction

An orb-weaving spider exposed at the central hub of the web may be vulnerable to predation by birds and wasps, and a variety of behaviours including bouncing on, or dropping off, the web (e.g. Tolbert, 1975; Hoffmaster, 1982) are thought to have evolved in response to this form of predation. Some orb-weaving spiders, such as *Eriophora*, avoid predation by remaining exposed on the web at night and spending the day concealed in vegetation (e.g. Edmunds, 1990; Herberstein & Elgar, 1994). Other spiders, including *Zygiella x-notata* (Clerck), build more permanent webs, but remain concealed within a silk retreat located adjacent to the web. The spider monitors the presence of prey with a single thread that runs from the retreat to the central hub (Bristowe, 1958). Finally, a number of spiders incorporate a retreat into the web; *Cyrtophora hirta* L. Koch builds a silk retreat just above the central hub of its horizontal orb-web (Elgar *et al.*, 1983), while the retreat of adult *Fecenia* sp. is a curled leaf located above the conical web (Robinson & Lubin, 1979). These retreats may provide some degree of protection from both predators and the elements (see also Jackson, 1986).

The Australian leaf-curling spider *Phonognatha graeffei* (Keyserling) curls or folds a leaf, binding it with silk and attaching it to the hub of its vertical orb-web (Fig. 1). Occasionally, objects other than leaves may be used as retreats, including snail shells, pieces of paper (Main, 1976; McKeown, 1969) and even cigarette butts. Both females and immature males place leaf-retreats in their webs, but when males reach sexual maturity they cease to construct webs and instead cohabit with either immature or mature females (Fahey & Elgar, ms). The spider remains within the leaf-retreat during the day, some-

times placing its first pair of legs on the hub of the web, and usually only ventures further out of the leaf-retreat at night. This behaviour is consistent with the view that the retreat provides protection from both the elements and predators (but see Martin, 1995).

Leaves used as retreats by *P. graeffei* are almost always desiccated. Our attempts to replicate leaf retreats by rolling desiccated leaves invariably resulted in the leaf cracking or breaking; but spider retreats were always unbroken. In this study, we examine whether *P. graeffei* selects certain kinds of leaves for its retreat, and highlight the consequences of such leaf selection.

Methods

We collected spiders and their leaf-retreats from parks within the suburbs of Hawthorn, Greensborough and Parkville, Melbourne, during March and April 1995. We weighed, to the nearest 0.1 mg on an electronic balance, both the spider and leaf retreat and then removed the spider and weighed the leaf separately.

Fifty spiders were released singly into separate perspex frames (50 × 30 × 10 cm) at the base of each of which we placed a “green” and a “brown” leaf. Green leaves had just been picked from a young eucalypt tree, and brown leaves were collected from the base of the same tree. We then recorded, over the next five days,



Fig. 1: A leaf retreat in a web of *Phonognatha graeffei*. The legs of the resident spider protrude from the entrance to the retreat and rest on silk threads that are attached to the hub of the orb-web.

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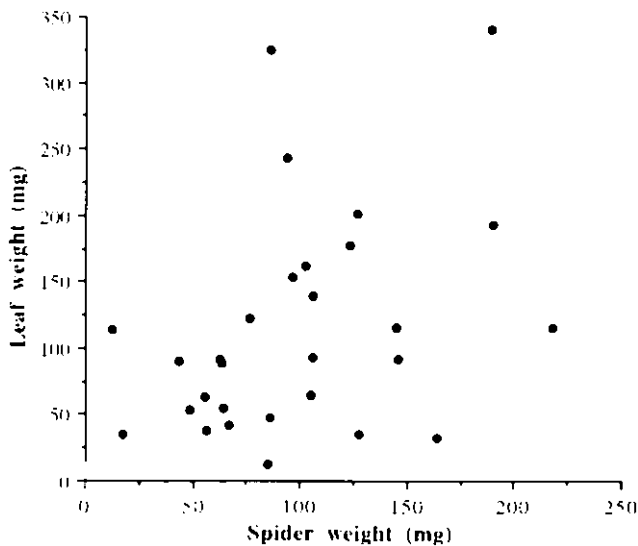


Fig. 2: The weight of the leaf retreat incorporated into the web of female *P. graeffei* is significantly correlated with the weight of the resident spider ($r=0.373$, $n=30$, $p<0.05$).

whether the spiders had built webs, and which type of leaf was used as a retreat.

We also recorded, from a sample of 15 of the above spiders, the weight of silk used to bind the two kinds of leaves. The leaf retreat was detached from the web and the spider was removed from the leaf retreat. The leaf was weighed to the nearest 0.1 mg on an electronic balance, and then all of the silk was removed from the leaf before weighing it again.

Results

In general, large spiders used larger leaves than small spiders; there was a significant positive correlation between the weight of the spiders in our sample and the weight of their leaf retreats (Fig. 2). Smaller spiders appear to be constrained to use lighter leaves, whereas there is greater variation in the weight of the leaf used by heavier spiders. Many spiders incorporated leaves that were heavier than themselves; one spider, weighing 86.2 mg used a leaf weighing 325.1 mg, representing almost 4 times her weight. However, the mean weight of spiders in this sample (98.7 mg, $SD=50.3$, $n=29$) was not significantly less than the mean weight of the leaves (114.8 mg, $SD=83.3$) used for their leaf retreats ($t_{paired}=1.09$, NS). Our measurements of the weight of leaves used by the spiders probably underestimate their weight when they were initially selected and incorporated into the web because some desiccation would have taken place.

Thirty-three of the 50 spiders collected from the field and placed in the perspex frames constructed a web with a leaf retreat. These spiders showed a significant preference for green leaves; 73% of the spiders used green leaves for their retreats, compared with 27% of the spiders that used brown leaves ($\chi^2=6.82$, $p<0.01$).

The spiders curl the leaf by spinning silk between the edges of the leaf; the silk contracts as it loses moisture, thereby curling the leaf. Once the leaf is fully curled, the

spider seals any gaps with additional layers of silk. The two leaf types varied in the degree to which they were curled by the spiders: 78% of the spiders that selected green leaves ($n=24$) curled the leaf into a fully tubular retreat, compared with 17% of the spiders that used brown leaves ($n=9$; Fisher's exact probability=0.002). Typically, spiders that did not fully curl the leaf spun silk across it, producing a semi-cylindrical retreat. Consequently, significantly more silk was used to bind and seal brown, desiccated leaves (mean=1.0 mg, $SD=0.5$, $n=7$) than green, moist leaves (mean=0.4 mg, $SD=0.3$, $n=8$; $t=3.042$, 13 df, $p<0.01$).

Discussion

This study shows that leaf-curling spiders, *P. graeffei*, select moist, green leaves in preference to dry, brown leaves for their retreats. Although the spiders usually selected a leaf for their retreat before completing construction of the web, the decision process appears to be ongoing: four spiders that initially selected dry, brown leaves subsequently removed them from the web in favour of moist, green leaves. The mechanism of leaf selection is not known but spiders may, like leaf-cutter ants, masticate the leaf in order to estimate its moisture content (see Hölldobler & Wilson, 1990).

One reason why green, moist leaves are selected is that they are more malleable, and hence can be folded or twisted without cracking and breaking. This ensures that the spider can be completely sealed within the leaf. Additionally, less silk is required to bind green than brown leaves. This may be an important consideration because silk is energetically and nutritionally expensive to produce (e.g. Peakall & Witt, 1976).

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References

- BRISTOWE, W. S. 1958: *The World of Spiders*. London, Collins.
- EDMUNDS, J. 1990: Wasp predation on orb web spiders (Araneidae) in Ghana. *Acta zool. fenn.* **190**: 117–122.
- ELGAR, M. A., POPE, B. & WILLIAMSON, I. 1983: Observations on the spatial distribution and natural history of *Cyrtophora hirta* (L. Koch) (Araneae: Araneidae). *Bull. Br. arachnol. Soc.* **6**: 83–87.
- FAHEY, B. F. & ELGAR, M. A. ms: Sexual cohabitation as mate guarding in the leaf-curling spider *Phonognatha graeffei* Keyserling (Araneidae, Araneae).
- HERBERSTEIN, M. E. & ELGAR, M. A. 1994: Foraging strategies of *Eriophora transmarina* and *Nephila plumipes* (Araneae: Araneidae): nocturnal and diurnal orb-weaving spiders. *Aust. J. Ecol.* **19**: 451–457.
- HOFFMASTER, D. K. 1982: Predator avoidance behaviors of five species of Panamanian orb-weaving spiders (Araneae: Araneidae, Uloboridae). *J. Arachnol.* **10**: 69–73.
- HÖLLDOBLER, B. & WILSON, E. O. 1990: *The Ants*. Cambridge, Mass., Harvard University Press.

- JACKSON, R. R. 1986: Silk utilisation and defensive behaviour of *Thiania*, an iridescent jumping spider (Araneae: Salticidae) from Malaysia. *N.Z. J. Zool.* **13**: 553–561.
- MAIN, B. Y. 1976: *Spiders*. Sydney, Collins.
- MARTIN, A. A. 1995: The wasp and the spider. *Victorian Nat.* **10**: 177.
- McKEOWN, K. C. 1969: *Australian Spiders*. Sydney, Halstead Press.
- PEAKALL, D. B. & WITT, P. N. 1976: The energy budget of an orb web-building spider. *Comp. Biochem. Physiol.* **54A**: 187–190.
- ROBINSON, M. H. & LUBIN, Y. D. 1979: Specialists and generalists: the ecology and behavior of some web-building spiders from Papua New Guinea. II. *Psechrus argentatus* and *Fecenia* sp. (Araneae: Psechridae). *Pacif. Insects* **21**: 133–164.
- TOLBERT, W. W. 1975: Predator avoidance behaviors and web defensive structures in the orb-weavers *Argiope aurantia* and *Argiope trifasciata* (Araneae, Araneidae). *Psyche, Camb.* **82**: 29–52.

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Biological notes on and population size of *Pachylospeleus strinatii* Šilhavý, 1974 in the Gruta das Areias de Cima, Iporanga, south-eastern Brazil (Arachnida, Opiliones, Gonyleptidae)

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Summary

The population size of *Pachylospeleus strinatii* Šilhavý, 1974 at the Córrego Grande area in the Gruta das Areias de Cima, south-eastern Brazil, was estimated by Petersen's method as modified by Bailey. The captures/recaptures were carried out during May and June 1993 and the population size was estimated at 199.95 individuals (SE 35.74). The possible troglomorphisms are discussed. Based on its endemic cave-dwelling distribution, depigmentation of body and appendages, and large number of segments (4–5) on distitarsus II, it is concluded that *P. strinatii* is a troglobite.

Introduction

In 1974, Šilhavý proposed the subfamily Pachylospeleinae for a new genus and new species, *Pachylospeleus strinatii*, based on material collected by Pierre Strinati from Gruta das Areias de Cima. This species, the first gonyleptid troglobite known, showed according to Šilhavý (1974) depigmentation of the body and appendages, reduced eyes, long legs and a high number of segments on distitarsi I–II. All these characters (except the last) are usually considered as specialisations of harvestmen restricted to cave life (Goodnight & Goodnight, 1960).

P. strinatii was recorded in the Gruta das Areias de Cima, Gruta das Areias de Baixo and Ressurgência das Areias das Águas Quentes (cited as *Pachylospeleus* sp.) by Trajano (1986, 1987). These caves are located in the same system and are crossed by the same stream. The fauna of Areias cave was listed by Gnaspini & Trajano (1994) and Trajano (1987).

The Gruta das Areias de Cima is the best known Brazilian cave and has the largest number of troglobites

described hitherto in this country. Besides *P. strinatii*, the following troglobites have also been described (Gnaspini & Trajano, 1994): *Pimelodella kroni* (Osteichthyes, Siluriformes), *Katantodesmus* sp. (Diplopoda), *Leptodesmus yporangae* (Diplopoda), *Aegla cavernicola* (Decapoda, Anomura), *Pseudochthonius strinatii* (Pseudoscorpiones), *Trogolaphysa aelleni* (Collembola), *Schizogenius ocellatus* (Coleoptera).

The number of Neotropical species of harvestmen known from caves is very small compared with Nearctic and Palearctic cave faunas. The following Laniatores have been recorded in the Neotropical region: Triaenonychidae, *Pichunchenops spelaeus* (Argentina); Samoidae, *Hoplobunus* spp. (Belize and Mexico); Stygnommatidae, *Stygnomma* spp. (Belize, Ecuador, Jamaica and Venezuela); Phalangodidae, *Spaeleoleptes spaeleus* (Brazil); Agoristenidae, *Vima* spp. and *Phalangozea bordoni* (Venezuela). All of these groups show depigmentation, and some of them show hypertely of the appendages and reduced eyes (Goodnight & Goodnight, 1971, 1973, 1977; Maury, 1988; Muñoz-Cuevas, 1975; Rambla, 1969, 1976, 1978; Soares, 1966).

The aim of this study is to present biological data on the population of *P. strinatii* in the Gruta das Areias de Cima and to increase our knowledge of Neotropical cavernicolous harvestmen.

Material and methods

The Gruta das Areias (24°35'20"S - 48°42'05"W, Iporanga County, São Paulo State, Brazil) is located in Subtropical Humid Forest between the Tropical Atlantic Domain and Araucaria Forest Domain (Ab'Saber, 1977). The climate is subtropical humid without a dry season (Monteiro, 1973 in Trajano, 1991), with an annual mean temperature between 18 and 19°C. The cave has a length estimated at 3,260 m and is located in limestone of the Açungui group in the north of the Speleological Province Vale do Ribeira (Karmann & Sánchez, 1986). It has a Y outline and two different streams, one running throughout most of its length (the Areias stream), and the other on the Y apex (the Córrego Grande stream) (Fig. 1). The Córrego Grande sinks into the ground (from the surface) for about 200 m