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SHORT COMMUNICATION

Maternal care in the Neotropical harvestman *Liogonyleptoides tetracanthus* (Opiliones: Gonyleptidae)

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Abstract. We describe post-ovipositional maternal care in *Liogonyleptoides tetracanthus* Mello-Leitão 1932 (Gonyleptinae) and experimentally evaluate the protective role of this behavior against egg predation under laboratory conditions. Females laid 138.8 eggs on average and remained close to the clutch during the entire day. Eggs hatched after 11–15 days and nymphs dispersed from maternal protection after one to two days. Most of the experimental clutches left unattended were entirely consumed by conspecifics in 2–3 days. There was no reduction in egg number in the clutches protected by females. Although biological data are scarce, there are cases of egg hiding, paternal and maternal care within the subfamily Gonyleptinae. This diversity of forms of parental care is unusual when compared to other gonyleptid subfamilies, and future systematic revisions of the polyphyletic Gonyleptinae should include parental care as a potential source of phylogenetic information.

Keywords: Egg-guarding, cannibalism, evolution, Gonyleptinae, post-ovipositional parental care

Many species of harvestmen in the suborder Laniatores exhibit post-ovipositional parental care (Machado & Raimundo 2001). Maternal care, in particular, is widespread among Neotropical representatives of the superfamily Gonyleptoidea, in which female egg-guarding has evolved at least seven times independently: once in the stygnopsid *Hoplobunus boneti* (Goodnight & Goodnight 1942), at least once in the closely related cranaid genera *Phareicranaus* Roewer 1913 and *Santinezia* Roewer 1923, once in the cosmetid *Erginulus clavotibilialis* (Pickard-Cambridge 1905), once in the gonyleptid *Neosadocus maximus* (Giltay 1928), at least once in the Pachylinae (Gonyleptidae), once in the ancestor of the Bourguyiinae (Gonyleptidae), and once in the ancestor of the Goniosomatinae (Gonyleptidae) (see references in Machado & Macías-Ordóñez 2007 and Hunter et al. 2007). Here we provide additional observation of maternal care in the previously unstudied genus *Liogonyleptoides* Mello-Leitão 1925 (Gonyleptidae) and experimentally evaluate the protective role of maternal care against egg predation under laboratory conditions.

We collected 24 individuals of *L. tetracanthus* (Mello-Leitão 1932) at the edge of an Atlantic Forest fragment near the city of Sooretama, state of Espírito Santo, south-eastern Brazil. We brought the individuals to our laboratory at the Universidade de São Paulo, São Paulo, Brazil, and placed them in two terraria (40 × 90 cm base, 20 cm height) containing soil, rocks and small pieces of wood. Each terrarium received 12 individuals (four males and eight females) that were individually marked on their dorsal scute with colored dots of enamel paint and fed *ad libitum* with canned dog food. Climatic conditions in the laboratory were: 21–24° C, 61-80% rel. humidity, and 12:12 h L:D cycle (lights on at 06:00 h). We conducted behavioral observations at 1–6 day intervals in January–April 2010. Behavioral samplings consisted of scans conducted three times a day: morning (09:00–11:00 h), afternoon (13:00–14:00 h), and night (20:00–23:00 h). In each scan (''point sampling'' sensu Martin & Bateson 1994), we recorded: a) the presence of clutches in the terraria, b) the presence of a guarding female close to each clutch, and c) the presence and behavior of any other individual near each clutch. We also made continuous records (sensu Martin & Bateson 1994) of all relevant behavioral observations, such as agonistic interactions between individuals, ovipositions, and egg predation events. Continuous records lasted from 1 to nearly 30 min, depending on the duration of the behaviors we were observing. In addition, we photographed half of the 12 clutches 3–5 days after oviposition and used these photographs to count the eggs. In the remaining cases, eggs were laid deep inside cavities of rocks and wood so that it was not possible to photograph or to count them.

We evaluated the protective role of maternal care against egg predation through an experiment in which we removed five guarding females from their clutches between January and March. Two females were removed from one terrarium (one on January 21st and the other on March 2nd), and three were removed from the other also on different dates (on February 25th, March 8th and 25th). At the moment we removed these females, at least two other females in each terrarium were also guarding eggs, and we used those females as controls in our experiment. The clutches from which we removed the females were 4–5 days old, and we monitored them daily for 6 days or until all eggs were consumed. We also monitored the control clutches and counted the total number of eggs in each of them after 6 days of experiment. At the end of April, when the experiment was already finished, several individuals (males and females) died due to unknown reasons in both terraria, and we resumed our observations. We deposited voucher specimens of males and females in the arachnological collection of the Museu de Zoologia da Universidade de São Paulo (MZSP), state of São Paulo, Brazil.

Twelve of 16 *L. tetracanthus* females laid eggs in the laboratory during the four months of observations. Eggs were laid in single large clutches inside cavities of rocks ($n = 9$) and wood ($n = 3$), and females did not cover the eggs with debris or mucus, but remained guarding them (Fig. 1). The clutches had 138.8 ± 59.6 eggs (mean ± SD, $n = 6$ clutches), which were light cream in color when recently laid (Fig. 1), but darkened during embryonic development. During most of the day, guarding females stayed prostrate on the eggs or at the side of their clutches with legs II or IV touching the eggs (96% of 149 scans; Fig. 1). We observed guarding females away from their clutches in only three occasions. In all these cases, they left the eggs unattended to search for food at night. Embryonic development lasted 11–15 days. After egg hatching, guarding females remained with the hatched nymphs until they dispersed, which generally occurred one to two days after eclosion. Hatched nymphs did not feed while under maternal protection, but attacked and cannibalized other nymphs (including siblings) after dispersion. In one of the clutches there were

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Figure 1.—Guarding female of the harvestman *Liogonyleptoides tetracanthus,* prostrated close to a clutch of recently laid eggs.

four eggs infected by fungus that did not hatch. The guarding female remained on these infected eggs for four days before abandoning them.

Three of the five clutches from which we experimentally removed the guarding females were entirely consumed and two partially consumed by conspecifics in two to three days. We observed no reduction in the number of eggs in the seven clutches that were protected by females. During daylight hours, we observed non-parental individuals (males and females) prostrate near the protected clutches in 33.5% of the scans (n = 149 scans), but we recorded no aggressive interactions by the guarding females. At night, when the individuals were more active, guarding females were generally aggressive when other individuals approached their eggs or nymphs (n = 5 observations). In these situations, guarding females attacked the intruders with the pedipalps, sometimes grasping their legs and carrying them away from the offspring (n = 2).

The oviposition sites used by *L. tetracanthus* females in our terraria are similar to those of the cosmetid *Erginulus clavotibialis* (Goodnight & Goodnight 1976) and most species of Pachylinae exhibiting maternal care (Capocasale & Bruno-Trezza 1964; Juberthie & Muñoz-Cuevas 1971; Elpino-Campos et al. 2001). On the other hand, the lack of debris around the eggs, is a derived trait of Bourguyiinae (Machado & Oliveira 2002), Goniosomatinae (Machado 2002), and Gonyleptinae (Machado & Vidal 2001; this study). Unlike many gonyleptid species in which females care for the offspring, hatched nymphs of *L. tetracanthus* remain under parental protection for only a short period (no longer than five days). In representatives of Bourguyiinae and Goniosomatinae, for instance, newly hatched nymphs remain under maternal protection for up to 14 days (Gnaspini 1995; Machado & Oliveira 1998, 2002).

In species with maternal care, females lay larger eggs than species exhibiting no care (Machado & Raimundo 2001). Heavily yolked eggs may supply more reserves, allowing the young to develop to a larger size inside of the egg prior to hatch. Moreover, nymphs hatched from larger eggs may remain longer under maternal protection, consuming the remaining energetic reserves before dispersing to forage. Therefore, we hypothesize that interspecific differences in the time of nymph dispersion may be related to egg size, so that nymphs hatched from relatively small eggs are likely to disperse faster than nymphs hatched from relatively large eggs. Given that maternal care has evolved many times independently within the suborder Laniatores (Machado & Macías-Ordóñez 2007; Hunter et al. 2007), this hypothesis can be tested in the future using a comparative approach.

Our captive experiment showed that female presence has an important protective role against predation in *L. tetracanthus*. Conspecifics, the only predators present in the terraria, consumed entire clutches within a few days. Similar results have already been described in the wild for a variety of neotropical harvestmen, including the gonyleptids *Acutisoma longipes* Roewer 1913, *Bourguyia trochanteralis* (Roewer 1930), and *Serracutisoma proximum* (Mello-Leitão 1922) (see references in Buzatto et al. 2007). Eggs of *L. tetracanthus* may also be attacked by fungi and, although fungus-infected eggs did not develop, guarding females do not eat or remove such eggs from their clutches. Field experiments with *A. longipes* demonstrated that guarding females are also unable to protect eggs against fungal attack (Machado & Oliveira 1998). Only one harvestman species, the paternal *Zygopachylus albomarginis* Chamberlin 1925, is known to control egg fungal attack (Mora 1990). Although the ability to control fungus infection on the eggs is probably rare in harvestmen (Machado & Raimundo 2001), it is common in centipedes (Brunhuber 1970) and millipedes (Kudo et al. 2011) with parental care.

In its current systematic definition, the Gonyleptinae includes 142 species (Kury 2003), and three forms of parental care have been described for species of the subfamily. Females of *Mischonyx cuspidatus* (Pereira et al. 2004), *Parampheres albimaculatus* and *P. ronae* (Stanley 2011) hide their eggs on the soil, under fallen trunks, or among the leaf litter. Males of *Neosadocus* sp. and *Gonyletes saprophilus* guard eggs and early hatched nymphs (Machado et al. 2004). Lastly, *Neosadocus maximus* (Machado & Vidal 2001) and *L. tetracanthus* (this study) exhibit maternal care. Although biological data are scarce, such diversity of forms of parental care in the Gonyleptinae is unusual when compared to other subfamilies of Gonyleptidae. In most harvestmen, species belonging to the same genus or even the same subfamily exhibit the same form of parental care (e.g., Nazareth & Machado 2009). Since the Gonyleptinae is almost certainly a polyphyletic group (Kury & Pinto-da-Rocha 2007), and most of the genera are not correctly diagnosed and delineated, future systematic revisions should include the forms of parental care as a potential source of phylogenetic information. Therefore, additional information on the reproductive biology of a wider sample of species is extremely valuable for both behavioral and systematic studies.

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