

SHORT COMMUNICATION

NOTES ON THE FORAGING BEHAVIOR OF THE BRAZILIAN CAVE HARVESTMAN *GONIOSOMA SPELAEUM* (OPILIONES, GONYLEPTIDAE)

Flávio H. Santos and Pedro Gnaspini: Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Caixa Postal 11461, 05422-970 São Paulo, SP, Brazil. E-mail: fhsantos@usp.br and E-mail: gnaspini@ib.usp.br

ABSTRACT. *Goniosoma spelaeum* (Mello-Leitão 1932) hide in caves during the day and leave periodically after dusk to forage, moving mainly vertically (towards the canopy). When stopped, individuals of all developmental stages often showed the behavior of cleaning appendages. To hunt, some specimens remained for several hours in a static posture with all legs spread out, radially disposed. In a less frequently used hunting position the body is used as a “web” i.e., the animal is supported by two opposing leaves, leaving its body between them, while legs II are kept free in the air and moving constantly. The first position possibly increasing the chance of meeting a possible prey by creating a larger area of contact, and the second especially by intercepting flying insects. Food items observed being taken in nature include: noctuid lepidopterans, tipulid and nematoceran dipterans, ascalaphid neuropterans, and isopods. They also infrequently use their chelicerae to chew on the rim of leaves and/or pieces of moss, with no ingestion of plant matter. Therefore, this behavior is probably related to drinking.

Keywords: *Goniosoma*, hunting behavior, foraging behavior, Opiliones, Gonyleptidae

The cave harvestman *Goniosoma spelaeum* (Mello-Leitão 1932) is one of the best-studied laeateorean species, in several aspects: reproductive behavior and development (Gnaspini 1995), population ecology (Gnaspini 1996), defensive behavior (Gnaspini & Cavalheiro 1998), and morphometrics (Gnaspini 1999). Using the classification of cavernicolous animals proposed by Schinner-Racovitza (Racovitza 1907; see also Gnaspini & Hoenen 1999), *G. spelaeum* can be considered a strict troglone, since the individuals must leave the cave in order to forage, but must come back to the cave to breed and for shelter (Gnaspini 1996). It is restricted to caves of the Ribeira Valley in southeastern Brazil. Six nymphal stages have been recognized by Gnaspini (1995), in addition to a short larval stage and the adult stage. Its longevity was estimated to be > 40 mo.

These harvestmen hide in caves during the day and after dusk leave periodically to forage (Santos & Gnaspini, unpublished). Gnaspini (1996) recorded the food items used by *G. spelaeum* in the field (lepidopteran larvae and adults, tipulid dipterans, and ascalaphid neuropterans) and in the laboratory (banana, cooked carrot, cooked sugar beet, chopped *Tenebrio obscurus* larvae, ham, and cream cheese). On this basis the species was considered omnivo-

rous with a tendency to feed on invertebrates. However, little is known about the foraging behavior of the species, which is the aim of the present note.

We observed the nocturnal foraging behavior of *G. spelaeum* during four field trips to Barra Bonita cave, located at Parque Estadual Intervales (Ribeira River Valley, São Paulo, Brazil), carried out in different seasons (13–20 May, 06–16 July, 05–10 November, all in 1997 and 19–26 January 1998). Voucher specimens are deposited at “Museu de Zoologia da Universidade de São Paulo” (MZSP).

To allow individual recognition, all harvestmen were individually marked. We first made a round spot at the scutum using commercial ink correction fluid (Papermate “Liquid Paper Correction Pen NP10”), and then we added a number, written with a 0.1mm china ink pen (Tombow “Fineliner WS-X0-01-1”). The facts that marked animals were recaptured more than one year later and that they normally left the cave even in the same day that they were marked indicate that this marking method did not affect harvestmen survival or behavior.

The forest vegetation above the main cave entrance (up to 10 m in distance and 2 m in height) was sampled, mainly during the hours when the harvestmen leave the cave towards the epigeal environment (from 1700–2000 h), and occasionally

during their return to the cave environment (from 0300–0700 h). In addition, a given tree located close to the entrance and frequently used by the harvestmen to reach the canopy (see Gnaspini 1996) was climbed by means of a rope. Using the rope, the vegetation up to 20 m above the ground and around 6 m in diameter could also be sampled.

After leaving the cave entrance, specimens of *G. spelaenum* ($n = 97$) primarily moved vertically (towards the canopy), without a large horizontal distribution of individuals, as has also been reported for *Mitopus morio* (Fabricius 1799) (see Adams 1984). The largest horizontal distance walked was about 5 m. They walked through up to three main paths, as already noted by Gnaspini (1996), who suggested that the animals chemically mark and/or memorize their ways in and out the cave. However, we should stress that, if some kind of chemical marker is used, it seems to be individual (and not a single one used by several specimens) because different harvestmen moving towards the same given tree used different paths.

When stopped, either at their hunting places or at occasional stops while walking towards the canopy, individuals of all developmental stages often showed the behavior of cleaning appendages (“leg-threading,” see Edgar 1971). As expected, as they are considered to be essentially sensorial, the harvestmen spent the largest time cleaning legs II. Legs II were cleaned by pulling them directly between the cheliceral claws, whereas the other appendages were either cleaned directly by the chelicerae or indirectly by legs II (they first rubbed legs II on the appendage to be cleaned and afterwards cleaned legs II as mentioned before). Time spent for cleaning varied between 15–30 min in each event ($n = 11$). Cleaning behavior has also been recorded for *Leiobunum* spp., but only after the harvestmen had consumed a meal (Edgar 1971). Capocasa & Bruno-Trezza (1964) stated that harvestmen have many tactile sensorial hairs, which are more abundant on legs I and II. On the other hand, Edgar (1963) has shown that the number of sensillar organs (mainly proprioceptor organs) did not vary much among legs, at least when comparing legs II with the other legs. In any case, the cleaning behavior is probably related to the maintenance of sensorial receptors and would enhance the effectiveness of these organs to detect food and/or the sex of conspecifics (Edgar 1971).

We have confirmed the suggestion (Gnaspini 1996) that the hunting place of *G. spelaenum* is located in the tree and/or bush vegetation above the cave, mainly in the crown of the canopy, at about 20 m above the ground. No vertical stratification related to harvestmen age was observed on the vegetation, individuals of all ages have been found at different heights. In addition, the main factor influencing the beginning of hunting behavior of the

harvestmen seems not to be the height, but the fact that the animal has reached the top of the plant it climbed. On the other hand, while climbing the vegetation, these harvestmen use an exploratory behavior like that described for *Leiobunum* spp. (Edgar 1971). Therefore, during climbing they occasionally find a food item which they promptly take, suggesting an opportunistic feeding habit which includes consuming dead or dying animals.

To hunt, *G. spelaenum* adopts a static posture with all legs spread out, radially disposed. Legs I are kept straight forward, together with the pedipalps, while legs II are raised straight upwards, laterally disposed in relation to the body and perpendicular to the substrate. This position is observed in individuals of all ages ($n = 31$). It is possible that this posture increases the chance of meeting possible prey by creating a larger area of contact. Some specimens remained in this position for several hours. Others alternate stillness with some displacements, after which they return to the same position.

In a less frequently used hunting position the body is used as a “web” i.e., the animal is supported by two opposing leaves, leaving its body between them, while legs II are kept free in the air and moving constantly. This position probably increases the chance to find food, especially by intercepting flying insects. We observed a harvestmen in this position intercepting a fly in flight, but the fly was able to flee.

Harvestmen have both chemo- and mechanoreceptors on the legs (Juberthie et al. 1981; Kauri 1989), but prey capture seems to depend on physical contact and the sensorial apparatus may be not sensitive enough to detect possible prey (Phillipson 1960a). The hunting behavior of *G. spelaenum* is similar to that described for *Mitopus morio*, (Phillipson 1960a, b) and considering the postures in nature it is possible that *G. spelaenum* also depends on physical contact with the prey to start capture movements. We should mention that *Leiobunum vittatum* Say 1821 also depends on physical contact to find and recognize mates and/or mating rivals (Macías-Ordoñez 1997). Furthermore, Guffey et al. (2000) found what they interpreted to be typical innervation of chemoreceptors attached to sensillae not recognized as typical chemoreceptors (sensilla chaetica without pores, as expected) on legs of *Leiobunum nigripes* (Weed 1892).

On the other hand, some additional laboratory observation suggested that *G. spelaenum* and other harvestmen can detect prey by chemoreception since they find it very quickly (*G. spelaenum* took 30–50 seconds to reach the food placed 45 cm away) without physical contact (F.B. Oliveira pers. comm.). Perhaps closed places lead to a great concentration of chemicals, facilitating faster detection of prey. It is also possible that food items used in the laboratory (such as ham, cream cheese, and liv-

er spread) may have a stronger smell than natural items, facilitating their detection.

Because the animals cited above (Phillipson 1971; Macías-Ordoñez 1997; Guffey et al. 2000) belong to the suborder Palpatores and those studied here belong to the Laniatores, we could not discard the possibility that there are sensorial differences between them. We are presently conducting studies to check for chemoreceptors in the legs and to test food detection at distance among laneatoreans.

Our observations about the diet of *G. spelaeum* are unfortunately few, allowing only a qualitative analysis. In addition to the food items noted by Gnaspi (1996), mentioned above, we observed the use of noctuid moths ($n = 4$), nematoceran dipterans ($n = 1$) and isopods ($n = 1$). We should stress that only noctuids were included in the diet during the warmer months (November and January), whereas the variety of items increased during the colder months (May and July). Dipterans and lepidopterans had been previously recorded as food items and seem to be thoroughly used both by the laneatoreans; *Pachyloidellus goliath* (Acosta et al. 1995) and *Goniosoma longipes* (Machado et al. 2000) and the palpatoreans; *M. morio* (Phillipson 1960a; Cannata 1988), *Leiobunum* spp. (Bristowe 1949; Edgard 1971), *Oligolophus tridens* (C. L. Koch 1836) *Oligolophus agrestis* (Meade 1855) and *Phalangium opilio* (Linnaeus 1758) (Bristowe 1949). The use of isopods had been recorded only for the palpatoreans *Lacinius ephippiatus* (C. L. Koch 1835), *Leiobunum rotundum* (Latreille 1798), *M. morio*, and *Nemastoma bimaculatum* (Fabricius 1775) (Adams 1984). Finally, the use of earthworms as food items was observed in the laneatoreans *Acanthopachylus aculeatus* (Capocassale & Bruno-Trezza 1964), *Pachyloidellus goliath* (Acosta et al. 1995) and *Goniosoma longipes* (Machado et al. 2000), but was not observed for *G. spelaeum*.

Halaj & Cady (2000) suggested that it is unlikely that palpatorean harvestmen can overcome prey items much larger than themselves. If this also occurs with the apparently armed laneatoreans, larger food items, such as the lepidopterans (which are the main part of the diet of *G. spelaeum*) are probably captured still, dead or dying, while the harvestmen walk upwards to the canopy. However, a *Goniosoma* harvestmen taking prey from a spider has been recorded in the literature (Sabino & Gnaspi 1999). Hence, these harvestmen may be stronger than generally believed. Unfortunately, no case of taking large food items could be observed directly.

After taking a food item, *G. spelaeum* handles it with pedipalps and chelicerae. The handling of large prey with legs I, as noted for *Leiobunum* spp. (Edgar 1971), was not observed. Previous studies have led Gnaspi (1996) to state that individuals of *G. spelaeum* never take food items into their cave shelters. However, we observed some animals with

prey inside the cave regardless of the prey body size.

We also observed that *G. spelaeum* use their chelicerae to chew on the rim of leaves and/or pieces of moss, while walking upwards to the canopy. This was seen infrequently, and no ingestion of plant matter was observed. Therefore, we believe that the harvestmen were trying to obtain water (and other fluids) from the plants as observed for *Pachyloidellus goliath* (Acosta et al. 1995). We did not observe cannibalism among *G. spelaeum*, but we noted scavenging on conspecifics.

There seem to be large differences between the diet observed in nature and in the laboratory, as already reported for *Leiobunum* spp. (Edgar 1971), as well as the strategies used to find food. From the large number of food items both in natural and laboratory conditions, it seems that harvestmen accept a larger variety of food items in the laboratory. For instance, plant matter is commonly accepted in the laboratory, but this was never observed in nature for *G. spelaeum*, although the use of plants has been reported for some harvestmen species (see Machado & Pizo 2000). Based on the food items used in nature by *G. spelaeum*, we classify this species as a generalist carnivore with a highly opportunistic diet. However, when also considering its diet in the laboratory (see Gnaspi 1996), the species should be considered a generalist omnivore with a preference to carnivory.

ACKNOWLEDGMENTS

We thank Fundação Florestal de São Paulo for allowing studies and the use of facilities at Parque Estadual Intervales. We also thank the editors and an anonymous referee for valuable comments. This study is part of a project supported by a M.Sc. fellowship from FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo), # 95/8949-0, Brazil, for the senior author, and partially by FAPESP research grant # 00/04686-4 for the junior author. The junior author also has a research fellowship from CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico), # 300326/94-7, Brazil.

LITERATURE CITED

- Acosta, L.E., F.E. Pereyra & R.A. Pizzi. 1995. Field observations on *Pachyloidellus goliath* (Opiliones, Gonyleptidae) in Pampa de Achala, province of Córdoba, Argentina. *Bulletin of the British Arachnological Society* 10:23–28.
- Adams, J. 1984. The habitat and feeding ecology of woodland harvestmen (Opiliones) in England. *Oikos* 42:361–370.
- Bristowe, W.S. 1949. The distribution of harvestmen (Phalangida) in Great Britain and Ireland,

- with notes on their names, enemies and food. *Journal of Animal Ecology* 18:100–114.
- Cannata, L. 1988. Observations sur les opilions de la tourbière du Cachot. *Bulletin de la Société Neuchateloise des Sciences Naturelles* 111:67–70.
- Capocasale, R. & L. Bruno-Trezza. 1964. Biología de *Acanthopachylus aculeatus* (Kirby, 1819) (Opiliones; Pachylinae). *Revista de la Sociedad Uruguaya de Entomología* 6:19–32.
- Edgar, A.L. 1963. Proprioception in the legs of phalangids. *Biological Bulletin (Woods Hole)* 124:262–267.
- Edgar, A.L. 1971. Studies on the biology and ecology of Michigan Phalangida (Opiliones). *Miscellaneous Publications, Museum of Zoology, University of Michigan* 144:5–64.
- Gnaspini, P. 1995. Reproduction and postembryonic development of *Goniosoma spelaum*, a cavernicolous harvestman from southeastern Brazil (Arachnida: Opiliones: Gonyleptidae). *Invertebrate Reproduction and Development* 28:137–151.
- Gnaspini, P. 1996. Population ecology of *Goniosoma spelaum*, a cavernicolous harvestman from south-eastern Brazil (Arachnida: Opiliones: Gonyleptidae). *Journal of Zoology* 239:417–435.
- Gnaspini, P. 1999. The use of morphometric characteristics for the recognition of species among Goniosomatine harvestmen (Arachnida, Opiliones, Gonyleptidae). *Journal of Arachnology* 27: 129–134.
- Gnaspini, P. & A.J. Cavalheiro. 1998. Chemical and behavioral defenses of a neotropical cavernicolous harvestman: *Goniosoma spelaum* (Opiliones, Laniatores, Gonyleptidae). *Journal of Arachnology* 26:81–90.
- Gnaspini, P. & S. Hoenen. 1999. Considerations about troglomorphic habit: the cave cricket model. *Mémoires de Biospéologie* 26:151–158.
- Guffey, C., V.R. Townsend, Jr. & B.E. Felgenhauer. 2000. External morphology and ultrastructure of the prehensile region of the legs of *Leiobunum nigripes* (Arachnida, Opiliones). *Journal of Arachnology* 28:231–236.
- Halaj, J. & A.D. Cady. 2000. Diet composition and significance of earthworms as food of harvestmen (Arachnida: Opiliones). *American Midland Naturalist* 143:487–491.
- Juberthie, C., A. Lopez & L. Juberthie-Jupeau. 1981. Sur l'équipement adeno-sensorial du pédipalpe de l'opillion troglophile *Sabacon paradoxum* Simon (Palpatores, Sabaconidae). *Proceedings VIII International Congress of Speleology* 810–811.
- Kauri, H. 1989. External ultrastructure of sensory organs in the subfamily Irumuinae (Arachnida, Opiliones, Assamiidae). *Zoologica Scripta* 18: 289–294.
- Machado, G. & M.A. Pizo. 2000. The use of fruits by the neotropical harvestman *Neosadocus variabilis* (Opiliones, Laniatores, Gonyleptidae). *Journal of Arachnology* 28:357–360.
- Machado, G., R.L.G. Raimundo & P.S. Oliveira. 2000. Oliveira. Daily activity schedule, gregariousness and defensive behaviour in the Neotropical harvestman *Goniosoma longipes* (Opiliones: Gonyleptidae). *Journal of Natural History* 34: 587–596.
- Macías-Ordoñez, R. 1997. The mating system of *Leiobunum vittatum* Say 1821 (Arachnida: Opiliones: Palpatores): resource defense polygyny in the striped harvestman. *Lehigh University, Ph.D. Dissertation*.
- Phillipson, J. 1960a. A contribution to the feeding biology of *Mitopus morio* (F.) (Phalangida). *Journal of Animal Ecology* 29:35–43.
- Phillipson, J. 1960b. The food consumption of different instars of *Mitopus morio* (F.) (Phalangida) under natural conditions. *Journal of Animal Ecology* 29:299–307.
- Racovitza, E.G. 1907. Essai sur les problèmes biospéologiques. *Archives de Zoologie Expérimentale et Générale* 6:371–488.
- Sabino, J. & P. Gnaspini. 1999. Harvestman (Opiliones, Gonyleptidae) takes prey from a spider (Araneae, Ctenidae). *Journal of Arachnology* 27: 675–678.

Manuscript received 7 December 2000, revised 9 November 2001.