Iheringia
Série Zoologia

e-ISSN 1678-4766
www.scielo.br/isz

Museu de Ciências Naturais

Article

The hard task of a short-tailed mouse opossum (*Monodelphis*) to prey a harvestman (Arachnida: Opiliones)

Nilton C. Cáceres & Isadora E. Fluck

Departamento de Ecologia e Evolução, CCNE, Universidade Federal de Santa Maria, 97105-900 Santa Maria, RS, Brazil. (niltoncaceres@gmail.com)

Received 2 February 2021
Accepted 12 May 2021
Published 13 August 2021
DOI 10.1590/1678-4766e2021014

ABSTRACT. Despite the great diversity of small insectivorous mammals and the use of scent gland secretions as a defense mechanism by harvestmen, there is no observation about the effectiveness of scent glands against predators such as small mammals. We report a remarkable harvestman defense mechanism against a small-mammal attack. When a harvestman and a mouse opossum confronted each other inside a cage, the harvestman knocked out the mouse opossum two sequential times before it could attack the harvestman. Although it is a unique observation and there is no information about its frequency in nature, this report stimulates the study of agonistic behavior between small, cryptic species, which are difficult to observe in the field.

KEYWORDS. Prey defensive strategy, escape behavior, counterattack, predator attack, Didelphidae.

RESUMO. A difícil tarefa de uma cuíca-de-cauda-curta (*Monodelphis*) para atacar um opilião (Arachnida: Opiliones). Apesar da grande diversidade de pequenos mamíferos insetívoros e do uso de secreções odoríferas como mecanismo de defesa por opiliões, não há registros sobre a eficácia das secreções odoríferas contra predadores como os pequenos mamíferos. Relatamos um notável mecanismo de defesa de um opilião contra um ataque de um pequeno mamífero. Quando um opilião e uma cuíca-de-cauda-curta se confrontaram dentro de uma caixa, o opilião nocauteou a cuíca duas vezes consecutivas antes que ela pudesse atacá-lo. Embora seja uma observação única e não haja informações sobre sua frequência na natureza, este registro estimula o estudo do comportamento agonístico entre pequenas espécies crípticas, difíceis de serem observadas em campo.

PALAVRAS-CHAVE. Estratégia defensiva da presa, comportamento de fuga, contra-ataque, ataque de predador, Didelphidae.

Harvestmen are arachnids that have several defense mechanisms, including camouflage, aposematism, mechanical retaliation (with spiny legs, pedipalps, and chelicerae), autotomy, and release of chemical secretions (Gnaspini & Hara, 2007; Pomini *et al.*, 2010; Souza & Willemart, 2011). Even though there is variation in the chemical nature of the scent gland secretions released by different harvestman species (Hara *et al.*, 2005), the chemical compounds can repel ants, spiders, small frogs, but not large opossums. Therefore, the success of the harvestman scent gland secretions in avoiding predation depends on the predator type (Machado *et al.*, 2005). For example, harvestmen can defend themselves by producing chemical defensive compounds called benzoquinones. Unrealistic dosages of these compounds can be harmful to rats under laboratory experiments that use an amount thought to be much higher than that found in wild harvestmen (Gnaspini & Hara, 2007). In the laboratory, small horned frogs, *Proceratophrys boiei* (Wied-Neuwied, 1825), regurgitate crickets soaked with harvestman secretions in 80% of cases, but 100% of large opossums, *Didelphis albiventris* Lund, 1840, consumed harvestmen (Machado *et al.*, 2005).

Marsupials are small mammals highly diversified in the Neotropics (Gardner, 2008) whose main diet is composed of invertebrates, such as arthropods. Many marsupial species are of small size (less than 100 g in body mass), mainly belonging to the family Didelphidae (Gardner, 2008; Paglia *et al.*, 2012). Small-sized species are usually insectivores or have most of the diet composed of arthropods (Paglia *et al.*, 2012; Santori *et al.*, 2012). The most speciose marsupial group in the Neotropics is the genus *Monodelphis*, with mean body mass ranging from 11 to 90 g, with a few species reaching 180 g (Paglia *et al.*, 2012; Pavan & Voss, 2016; but see also Pavan, 2019). Species of *Monodelphis* are mostly diurnal and terrestrial, being found in forests, savannas, and grasslands (Gardner, 2008; Pavan & Voss, 2016). *Monodelphis dimidiata* (Wagner, 1847) (Fig.1) is one of the largest species of the genus (40 to 84g) and exhibits extreme sexual dimorphism, with males being 50% larger than females (Chemisquy, 2015). However, the species is relatively small compared to the large-sized genus *Didelphis* (500 to 2,700 g; Paglia *et al.*, 2012). Although its diet is poorly known, it relies mostly on arthropods (insects and arachnids), and eventually on mammalian prey, such as small rodents (Busch & Kravetz, 1991).

The interaction between harvestmen and vertebrate predators is rarely observed, and the few reports are derived from laboratory experiments. Some laboratorial experiments manipulated secretions extracted from harvestmen, injecting it in possible offensive agents like other arthropods, flatworms, and rats (*e.g.* Machado *et al.*, 2005; Gnaspini & Hara, 2007; Silva *et al.*, 2018). Therefore, it is unclear how such secretions act in nature leading the harvestman to escape predation as its last line of defense (Gnaspini & Hara, 2007; Pomini *et al.*, 2010). We report for the first time the interaction between a large Gonyleptidae harvestman and a small-sized mouse-opossum, *M. dimidiata*. Both animals were caught just before the manipulation on the nearby forest floor. The effect of harvestman chemical defense on small mammals such as *M. dimidiata* is unknown. Once *Didelphis*, which are larger than *Monodelphis*, had their first attack thwarted by the release of harvestman's secretions, it is expected the effect of such secretions on *Monodelphis* to be even stronger (Machado *et al.*, 2005; Gnaspini & Hara, 2007).

Fig. 1. The mouse opossum *Monodelphis dimidiata* (Wagner, 1847). Photograph by J. J. Cherem.

MATERIAL AND METHODS

Study area. The field observation was performed in the forest edge of the Rio Guarani state park (2,230 ha), located in the west of Paraná state, Brazil (25°26'20.4"S 53°08'28.1"W). The area is covered by the Atlantic Forest, a biome with nearly 600 harvestman species, from which 97.5% are endemic (Pinto-da-Rocha *et al.*, 2005).

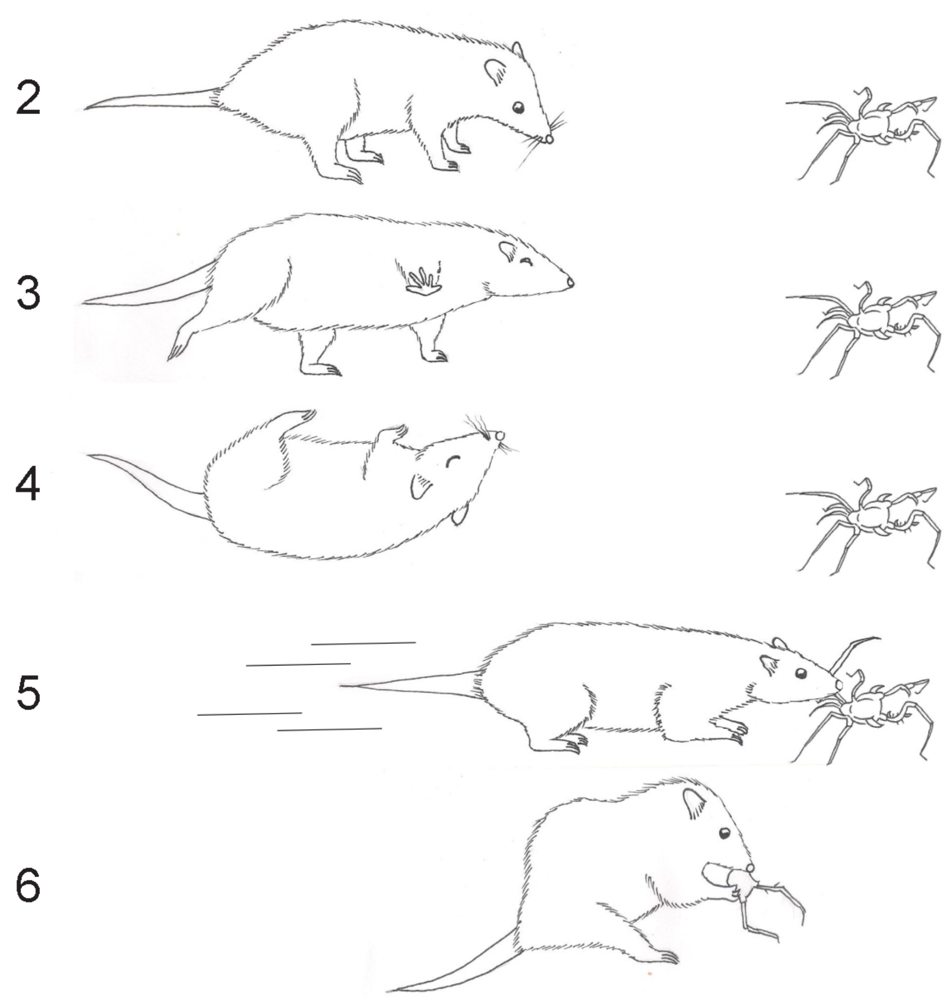
Field manipulation. Both the harvestman and the mouse opossum *M. dimidiata* were captured by hand on the same day (October 11, 1998) in the forest edges of the park. They were inserted in separated cages to rest for some 3 to 4 hours before the manipulation. During this period, *ad libitum* water was given for both individuals and the mouse opossum was fed with fresh worms. The cages where the mouse opossum and the harvestman were placed (30 x 30 cm base; 10 cm high; woody material) could be opened from the above (Supplementary Material Fig. S1). This cage architecture enabled the observer (NCC) to see clearly inside the cage. In the late afternoon, we introduced the mouse opossum in the harvestman cage keeping the door open for observation.

RESULTS

The agonistic interaction began just after the mouse opossum introduction to the harvestman's cage. The opossum assumed an attack position, with legs slightly inflected and head downward oriented to the prey, staying around 9-10 cm from the harvestman (Fig. 2). Both opossum and harvestman were facing each other. Suddenly, few seconds after the opossum introduction to the cage, it staggered side to side and finally it fell sideways on the floor (Figs 3, 4). Although not seen, we recognize that there was a jet of secretion probably on the face of the marsupial through its smell, as commonly succeeds in cases of jet secretion of harvestmen that is difficult to see (ACOSTA *et al.*, 1993). After a few seconds, the marsupial got up and assumed the attack position again in the same place of the first attack attempt. Again, it staggered side to side and fell sideways to the floor. Just after, the opossum got up again and assumed the attack position. From the opossum introduction to the cage until the last attack attempt, less than 30 seconds passed by. Both recuperations of the mouse opossum from the knockout were quick – there was no time of unconsciousness on the cage floor just after the knockouts. The harvestman remained in the same place during all these mouse opossum's movements. After the second scent-gland jet secretion (also recognized by its smell) and the quick recuperation of the marsupial by assuming the attack position for the third time, it began to attack the harvestman by biting its front legs one by one (Fig. 5). After the harvestman became immobilized, without most of its legs, the opossum attacked its body by biting it continuously and ingesting all harvestman's body except for its detached legs (Fig. 6).

DISCUSSION

Although we did not photograph or film this behavioral interaction (because of the lack of equipment for visual recording at the time of the manipulation), we could identify the harvestman by its characteristics. The harvestman used in the manipulation (large size, shorter and stronger legs, general coloration, and the pattern of spiny legs and carapace) was surely recognized as a species of the family Gonyleptidae (G. MACHADO, pers. comm.), which is commonly found in the Atlantic Forest (RESENDE *et al.*, 2012). The family Gonyleptidae is one of the most diversified family of the order Opiliones (KURY, 2000, 2003), being usually found in scats of opossums *D. albiventris* and *D. aurita* (CÁCERES & MONTEIRO-FILHO, 2001; CÁCERES, 2002). Another feature of some specific clades within the family Gonyleptidae is the ability to squirt the gland secretion as a fine jet,



Figs 2-6. Agonistic behavior between a harvestman of the family Gonyleptidae and the mouse opossum *Monodelphis dimidiata* (Wagner, 1847). The interaction starts with the mouse opossum in an attack position, facing the harvestman (Fig. 2), then the marsupial staggers side to side (Fig. 3) and is knocked out (Fig. 4). This sequence of events is repeated two times, until the mouse opossum assumes its third attack position and attacks the harvestman (Fig. 5). The mouse opossum removes the harvestman's legs one by one to then feed on its body (Fig. 6). Image edited in the Inkscape software.

even forward, without mixing it with enteric fluid. Although this fluid is more effective because it is a pure secretion, it is costly to the harvestman (Caetano & Machado, 2013). Once not all harvestmen can squirt effectively a secretion jet from 5 to 10 cm of distance (Gnaspini & Hara, 2007), the fact that our harvestman was ~9-10 cm apart from the marsupial (*i.e.* offending agent) and how the subsequent behavior happened also points to its identification as part of the family Gonyleptidae (more precisely the subfamily Gonyleptinae; G. Machado, pers. comm.). In addition, it was very similar to the Gonyleptinae *Geraeocormobius sylvarum*, which is large-sized, found in the litter, uses jet secretion as defense behavior, and has distribution in the south of Brazil (including the Paraná state) and adjacent Paraguay and Argentina countries (Acosta *et al.*, 2007; G. Machado, pers. comm.).

The staggering and posterior knockout of the mouse opossum two sequential times reveal the power of scent gland secretion of the harvestman. Although we could not see the secretion jet (as reported by Acosta *et al.*, 1993), the literature indicates that some harvestman species throw the jet on the face of the offensive agent (Machado *et al.*, 2005). The different secretion compounds are thought to be irritant to the offensive agent (Gnaspini & Hara, 2007; Pomini *et al.*, 2010), repealing most of them (Machado *et al.*, 2005). The first or second secretion jets from the harvestman's glands happened without a previous attack of the mouse opossum. It suggests that the harvestman was prepared for the attack just after the mouse opossum introduction inside the cage. This indicates that the harvestman probably had experience in escaping predation using this defense due to the precision that it used the scent gland to throw the secretion on the marsupial.

Even after the two knockouts due to the harvestman's defense mechanism, *M. dimidiata* stood up and interspersed with returns to the safety original distance and started to directly and accurately bite each anterior legs of the harvestman. Similarly to *Didelphis* (Machado *et al.*, 2005), only the harvestman's body was consumed by the mouse opossum. However, whereas *Didelphis* uses the harvestman's legs as an aid to feed on its body (G. Machado, pers. comm.), the harvestman's legs were detached one by one before *M. dimidiata* attacked its body. The fact that the harvestman had quite all legs detached from the body before the attack to the carapace suggests that the marsupial species is habituated to this harvestman defense mechanism and had a specific strategy to prey on it.

Due to the extreme sexual dimorphism in *M. dimidiata* (Chemisquy, 2015), and the experience necessary to prey on a large harvestman, it is likely the observed individual was an adult female (40 – 50 g, since males can weigh 84 g; Paglia *et al.*, 2012). Although large opossums (genus *Didelphis*) that eat harvestman reveal some discomfort when ingesting it (Machado *et al.*, 2005), small mammals such as *M. dimidiata* are capable of preying even on small rodents like *Oligoryzomys* and *Calomys* (Brusch & Kravetz, 1991). Even though rodents do not have secretions that cause discomfort for opossums, their body masses vary between 15 and 22g when adult (Hodara *et al.*, 1989; Paglia *et al.*, 2012), being relatively larger comparing to its predator body mass, what would be a disadvantage for predation. Thus, this mouse opossum is specialized in preying on relatively large prey (Blanco *et al.*, 2013), such as rodents and arthropods which could be difficult to prey on, exhibiting different predatory strategies (González & Claramunt, 2000).

Most small mammals are insectivores and harvestmen have an effective weapon for defense against relatively large predators. However, the effect of such mechanism on small mammals as predators remained unclear until now. Although this report was unique and not replicated, it adds knowledge about how effective is the defense mechanism of harvestmen that uses jet secretion directly toward the aggressor, stimulating the study of agonistic behavior between small, cryptic species, which are difficult to observe in nature. Future research can answer how different species of small mammals behave to prey on different species of harvestmen and, from the prey's point of view, how harvestmen have adapted to scape predation by different species of small mammals.

Supplementary Material. Fig. S1. Illustration of the cage where the mouse opossum and the harvestman relied. Image edited in the Inkscape software.

Acknowledgments. NCC has a research fellowship granted by the Brazilian Agency for Scientific Research (CNPq). This research was funded by Brazilian Agency for Scientific Research (CNPq) and COPEL Paraná Company of Energy. We also thank Glauco Machado for his important contributions as a reviewer of this manuscript.

REFERENCES

Acosta, L. E.; Poretti, T. I. & Mascarelli, P. E. 1993. The defensive secretions of *Pachyloidellus goliath* (Opiliones, Laniatores, Gonyleptidae). **Bonner Zoologische Beitraege 44**:19-31.

Acosta, L. E.; Kury, A. B. & Juárez, M. L. 2007. New records of *Geraeocormobius sylvarium* (Acachnida, Opiliones, Gonyleptidae), with a remarkable disjunction in northwestern Argentina. **Boletín Sociedad Entomológica Aragonesa 41**:303-306.

Blanco, R. E.; Jones, W. W. & Milne, N. 2013. Is the extant southern short-tailed opossum a pigmy sabretooth predator? **Journal of Zoology 291**(2):100-110.

Brusch, M. & Kravetz, F. O. 1991. Diet composition of *Monodelphis dimidiata* (Marsupialia, Didelphidae). **Mammalia** (Paris) 55(4):619-621.

Cáceres, N. C. 2002. Food habits and seed dispersal by the white-eared opossum, *Didelphis albiventris*, in southern Brazil. **Studies on Neotropical Fauna and Environment 37**(2):97-104.

Cáceres, N. C. & Monteiro-Filho, E. L. 2001. Food habits, home range and activity of *Didelphis aurita* (Mammalia, Marsupialia) in a forest fragment of southern Brazil. **Studies on Neotropical Fauna and Environment 36**(2):85-92.

Caetano, D. S. & Machado, G. 2013. The ecological tale of Gonyleptidae (Arachnida, Opiliones) evolution: phylogeny of a Neotropical lineage of armoured harvestmen using ecological, behavioural and chemical character. **Cladistics 29**:589-609.

Chemisquy, M. A. 2015. Peramorphic males and extreme sexual dimorphism in *Monodelphis dimidiata* (Didelphidae). **Zoomorphology 134**(4):587-599.

Gardner, A. 2008. **Mammals of South America: marsupials, xenarthrans, shrews, and bats**. Chicago, The University of Chicago Press. 690p.

Gnaspini, P. & Hara, M. R. 2007. **Defense mechanisms.** *In*: Pinto-da-Rocha, R.; Machado, G. & Giribet, G. **Harvestmen: The Biology of Opiliones.** Cambridge, Harvard University Press, p. 374-399.

González, E. M. & Claramunt, S. 2000. Behaviors of captive short-tailed opossums, *Monodelphis dimidiata* (Wagner, 1847) (Didelphimorphia, Didelphidae). **Mammalia 64**(3):271-286.

Hara, M. R.; Cavalheiro, A. J.; Gnaspini, P. & Santos, D. Y. 2005. A comparative analysis of the chemical nature of defensive secretions of Gonyleptidae (Arachnida: Opiliones: Laniatores). **Biochemical Systematics and Ecology 33**(12):1210-1225.

Hodara, V. L.; Espinosa, M. B.; Merani, M. S. & Quintans, C. 1989. *Calomys laucha* (Rodentia, Cricetidae): growth and breeding in laboratory conditions**. Laboratory Animals 23**(4):340-344.

Kury, A. B. 2000. **Classification of Opiliones**. Museu Nacional/UFRJ website. Available at <http://www.museunacional.ufrj.br/mndi/Aracnologia/opiliones.html>. Accessed on August 2020.

Kury, A. B. 2003. Annotated catalogue of the Laniatores of the New World (Arachnida, Opiliones). **Revista Ib**érica de **Aracnología 7**:5-337.

Machado, G.; Carrera, P. C.; Pomini, A. M. & Marsaioli, A. J. 2005. Chemical defense in harvestmen (Arachnida, Opiliones): do benzoquinone secretions deter invertebrate and vertebrate predators? **Journal of Chemical Ecology 31**(11):2519-2539.

Paglia, A. P.; Fonseca, G. A. B.; Rylands, A. B.; Herrmann, G.; Aguiar, L. M. S.; Chiarello, A. G.; Leite, Y. L. R.; Costa, L. P.; Siciliano, S.; Kierulff, M. C. M.; Mendes, S. L.; Tavares, V. C.; Mittermeier, R. A. & Patton, J. L. 2012. Annotated Checklist of Brazilian Mammals. **Occasional Papers in Conservation Biology**, No. 6. Arlington, Conservation International. 76p.

Pavan, S. E. 2019. A revision of the *Monodelphis glirina* group (Didelphidae: Marmosini), with a description of a new species from Roraima, Brazil**. Journal of Mammalogy 100**(1):103-117.

Pavan, S. E. & Voss, R. S. 2016. A revised subgeneric classification of short-tailed opossums (Didelphidae: Monodelphis). **American Museum Novitates 3868**:1-44.

Pinto-da-Rocha R.; da Silva M. B. & Bragagnolo, C. 2005. Faunistic similarity and historic biogeography of the harvestmen of southern and southeastern Atlantic Rain Forest of Brazil**. Journal of Arachnology 33**(2):290-299.

Pomini, A. M.; Machado, G.; Pinto-da-Rocha, R.; Macías-Ordóñez, R. & Marsaioli, A. J. 2010. Lines of defense in the harvestman *Hoplobunus mexicanus* (Arachnida: Opiliones): Aposematism, stridulation, thanatosis, and irritant chemicals. **Biochemical Systematics and Ecology 38**(3):300-308.

Resende, L. P. A.; Pinto-da-Rocha, R. & Bragagnolo, C. 2012. The harvestmen fauna (Arachnida: Opiliones) of the Parque Estadual Carlos Botelho, and the Floresta Nacional de Ipanema, São Paulo, Brazil. **Biota Neotropica 12**(4):146-155.

Santori, R. T.; Lessa, L. G. & Astúa, D. 2012. *In*: Cáceres, N. C. ed**. Os marsupiais do Brasil: biologia, ecologia e conservação**. Campo Grande, Ed. UFMS, p. 383-404.

Silva, M. S.; Willemart R. H. & Carbayo, F. 2018. Sticky flatworms (Platyhelminthes) kill armored harvestmen (Arachnida, Opiliones) but are not immune to the prey's weapons. **Journal of Zoology 306**(2):88-94.

Souza, E. S. & Willemart, R. H. 2011. Harvest-ironman: heavy armature, and not its defensive secretions, protects a harvestman against a spider. **Animal Behaviour 81**(1):127-133.