SHORT COMMUNICATION

FEEDING IN *MAXCHERNES IPORANGAE* (PSEUDOSCORPIONES, CHERNETIDAE) IN CAPTIVITY

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

ABSTRACT. The feeding behavior of the cave pseudoscorpion *Maxchernes iporangae* Mahnert & Andrade 1998 was studied in the laboratory. We also investigated aspects such as preference and frequency. Nymphs are more active in prey capture. Cannibalism is uncommon. The frequency of feeding of adults was about once a month, with an increased rate for females during the reproductive period.

Keywords: Pseudoscorpiones, feeding behavior, feeding frequency, Chernetidae, *Maxchernes*

Pseudoscorpions are predators of other arthropods. The organisms consumed by pseudoscorpions kept in captivity included larvae and adults of *Drosophila* sp. (Gilbert 1951; Levi 1953; Goddard 1976), Isoptera (Brach 1978; Hahn & Matthiesen 1993a), Collembola (Wood & Gabbutt 1979a, 1979b; Johnson & Wellington 1980), Psocoptera (Levi 1948, 1953), and larvae and adult of cucujid and tenebrionid beetles (Levi 1948, 1953). Information about pseudoscorpion prey and predators can be found in Jones (1975).

Chthoniidae, Neobisiidae and some related families masticate the prey with their chelicerae; at the same time the food is digested by a fluid from the oral cavity. Later, the digested contents are ingested (Gilbert 1951; Weygoldt 1969). Other groups (e.g., Olpiidae, Garypidae, and all Cheliferoidea) use the chelicerae to make a hole in the body wall of the prey, through which an enzymatic fluid is injected. The digested contents are then ingested (Feio 1942; Gilbert 1951). After digestion, the ingested material that has not been used is transformed into crystals, probably guanine (Gilbert 1952), which is stored in the rectal pocket and excreted from time to time. A comprehensive review of the digestive tract and nutrition of pseudoscorpions is given in Heurtault (1973).

The present study gives further information about feeding in pseudoscorpions, specifically regarding feeding behavior, preference and frequency in the chernetid pseudoscorpion *Maxchernes iporangae* Mahnert & Andrade 1988, a species living in a subterranean habitat.

Individuals of *Maxchernes iporangae*, which are approximately 2 mm in length when adults (see Mahnert & Andrade 1998), were collected on fru-

givorous bat guano piles from Alambari de Baixo Cave (SP-012, 24°33′15″ S and 48°39′55″ W), situated in the Ribeira River Valley (São Paulo State, Brazil). This species seems to be restricted to this kind of guano in this particular cave (Mahnert & Andrade, 1998; pers. obs.). Collections and observations were made between February 1996 and February 1998.

The pseudoscorpions were placed with guano in small closed containers and transported to the laboratory, where some pseudoscorpions were kept in groups (up to 18 individuals) in transparent plastic boxes (9 cm length x 6 cm width x 2.5 cm height). Others were kept individually in glass Petri dishes (2.5 cm diameter x 1.5 cm height). All containers contained moistened guano or fine sand on the bottom, and were kept under almost constant darkness and at a temperature of 21.0 °C ± 2.0. This temperature is similar to the temperature of the cave inhabited by the species studied. Regarding the use of alternative substrates, we preferred the use of guano. However, this material rots with time and accumulates fungi, needing to be replaced. Because sometimes it was not available at the laboratory, we used fine sand.

In order to analyze the feeding frequency, the pseudoscorpions were fed twice a week. Each isolated adult received one live adult of *Drosophila* sp. (slightly larger than an adult *M. iporangae*). After six hours, the dish was examined. The feeding was considered effective if the pseudoscorpion was found eating the prey. Other items were also offered to adults: psocopterans, tineid moth larvae, psychodid dipterans, collembolans, *Endecous* sp. cricket nymphs (which occur in the same cave as the pseudoscorpions) and isopods (from the same gua-

no piles as the pseudoscorpions). The last two animals were offered to determine if they could be natural prey of *M. iporangae*. The other animals were offered because they were available in the laboratory, although they did not occur in the caves studied. The initial purpose of trying different food items was to maintain the pseudoscorpions in the laboratory, since the cave is located 5 hours from São Paulo, because the original objective of the study was to follow their life cycle. Nymphs were initially offered live *Drosophila* sp. larvae. Later, a dead adult *Drosophila* sp. was left in each Petri dish with nymphs. More than thirty observations on feeding behavior were performed with isolated and/ or grouped pseudoscorpions.

Voucher specimens, collected at the same guano deposit where the type specimens were collected, are deposited at the Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZSP).

Feeding behavior.—Adults of *M. iporangae* moved relatively slower than nymphs and mostly attacked prey by quick movements of the pedipalps when the prey was near. The nymphs attacked prey more readily, pursuing prey over relatively longer distances. Protonymphs were more active in prey capture than later instars. This was also observed for *Paratemnoides minor* (Balzan 1892) (Atemnidae) (see Hahn & Matthiesen 1993a) and is probably related to the larger feeding needs of the young, in order to allow faster growth and development.

Maxchernes iporangae grasped the prey with the palpal chelae and immobilized it with their poison. The time taken to paralyze the prey varied. The time in which the pseudoscorpion kept the prey between the palpal chelae also varied, reaching up to 10 min. In some cases, the grasped drosophilid was immobilized in a few seconds, in others, it took longer. Probably the immobilization time is related to the prey region pierced (Feio 1942), and/or to the prey sensitivity and size. After immobilization, the prey was passed to the chelicerae, where it remained for a variable time, sometimes exceeding 2.5 h. On some occasions, the pseudoscorpions were observed piercing a prey in different positions, a behavior also recorded for *Dactylochelifer latreillei* (Leach 1817) (Cheliferidae) by Gilbert (1951). This behavior allows more efficient utilization of the prey by feeding at multiple points.

During feeding, the prey was held only by the chelicerae, and the palps were kept free and directed laterally, in a characteristic defensive posture, as observed for other pseudoscorpions (Gilbert 1951; Weygoldt 1969). The palps were used to attack other pseudoscorpions that occasionally approached. Individuals of *M. iporangae* were often observed walking with prey held in their palps or even by the chelicerae, until they found a secure or hidden place, where they stopped and started feeding. This aspect, frequently observed in grouped pseudoscorpions, was practically absent among isolated pseudoscorpions. This behavior may represent a response to the recognition of other pseudoscorpions in proximity and may avoid prey theft by another pseudoscorpion.

The sharing of prey by up to three pseudoscorpions was observed among pseudoscorpions kept in groups. On these occasions, the pseudoscorpions were sufficiently separated so that they did not touch each other. However, if some disturbance occurred, such as prey movement or the approach of another individual, the pseudoscorpions became agitated, attacking each other, without releasing the prey and pulling on it, until one individual succeeded in moving off with the prey. The partition of prey was earlier recorded for nymphs and adults of *Paratemnoides elongatus* (Banks 1895) (Atemnidae), however, without aggressive interactions or attempts to take the prey (Brach 1978).

Grooming behavior was often observed. The most important grooming organ is the serrula exterior of the movable fingers of the chelicerae (Weygoldt 1969). In *M. iporangae* the palpal fingers were cleaned by drawing them through the chelicerae; the chelicerae were cleaned by rubbing each other; and the palpal coxae by cheliceral rubbing. The grooming occurred just after the prey was placed in the dish with the pseudoscorpion, during and at the end of feeding, after the prey was released. The grooming of the palpal fingers before feeding, when the prey was placed in the dish, would possibly have the function of improving the capacity of recognition and detection of the prey and its location by using the palpal trichobothria. Such behavior is usual in other species of pseudoscorpions (Weygoldt 1969; Heurtault 1973).

Feeding preference.—When live fly larvae (*Drosophila* sp.) were offered as food to protonymphs of *M. iporangae* that hatched in captivity, only two attacks were observed. The protonymphs only pinched the prey by quick movements of the pedipalps, without taking the prey. The same happened with small collembolans, except on one occasion, when a protonymph grasped and passed it to the chelicerae.

Prey rejection probably was the main cause of the low survival rate (4%) observed among protonymphs, which is considered to be the more active metabolic instar in many species of pseudoscorpions that possess a free protonymph phase (Levi 1948, 1953; Goddard 1979; Hahn & Matthiesen 1993a).

Good survival rates (increased from 4% to 40%) were obtained when dead adult flies were placed in the dishes with protonymphs. Although the prey was large and feeding was rarely observed, the mortality rate of these protonymphs decreased, indicating that the nymphs were probably feeding. In

addition to drosophilids, deutonymphs and tritonymphs accepted other food, such as tineid larvae and psocopterans. Adult pseudoscorpions accepted fly larvae in addition to dead or live adult flies, but, in that case, at a lower frequency than the acceptance of adult flies. Many times they only pinched the prey without grasping it, then rejected the food offered. Other prey accepted were psychodid dipterans, psocopterans and tineid larvae, the later in higher frequency than the former. We should stress that psocopterans and tineid moths are common in guano deposits, even in similar frugivorous bat guano (such as in Casa de Pedra cave—see Gnaspini 1989a, b), but not in this guano pile, so far. Collembolans were not taken, which is probably related to the collembolan's agility. The possible natural prey (*Endecous* nymphs and isopods) were not taken at all.

On one occasion, in the field, a pseudoscorpion was observed dragging a prey with its palp. Both were collected and brought to laboratory where the pseudoscorpion was identified as an adult male and the prey as an early nymph of an undetermined species of seed bug (Heteroptera, Lygaeidae). The occurrence of nymphs and adults of two undetermined species of the family Lygaeidae inhabiting guano piles of frugivorous bats in the Alambari de Baixo Cave was recorded by Gnaspini-Netto (1989a, b). These heteropterans were considered by Gnaspini (1992) to be guanobites, a word used to define organisms which, in caves, inhabit guano deposits exclusively, where they complete their life cycle. Because of the preying event directly observed in the field and because of the probable restriction (considering the cave population) of these bugs to the same guano piles where *M. iporangae* is present (Gnaspini & Trajano 2000), it is probable that these bugs are one (and maybe the principal) of the natural prey of this species. Unfortunately, it was not possible to offer these animals to pseudoscorpions in captivity.

There are few studies concerning feeding preference of pseudoscorpions. Weygoldt (1969) reported that chernetids prefer insects, such as small dipterans, psocopterans and beetles, and that many species can be maintained on drosophilids, as we did with the studied species.

Cannibalism.—Weygoldt (1969) considered cannibalism to be a rare event among pseudoscorpions, and that it would occur among animals kept in captivity without food for a long time, especially considering that older or injured animals could be attacked by others. Considering chernetids, Levi (1953) did not observe cannibalism among individuals of *Lamprochernes minor* Hoff 1949 kept in captivity. On the other hand, considering other Cheliferoidea (in which Chernetidae is included), Levi (1948) observed cannibalism among protonymphs of *Chelifer cancroides* (Linnaeus 1758) (Cheliferidae). Varied results occurred among Atemnidae: *Paratemnoides elongatus* did not show cannibalism (Brach 1978), whereas *P. minor* (Hahn & Matthiesen 1993b) did.

We observed only three cases of cannibalism in *M. iporangae*, all three with alternative food (flies) available. First, a protonymph fed on a second protonymph kept in the same Petri dish. The victim was inside its molting chamber, in a characteristic torpid condition that precedes the molt, thus unable to move or defend itself. On another occasion, an adult female was observed preying on a recently hatched protonymph. Considering that we had 12 breeding females with a total of 118 hatched nymphs, it gives a rate of less than 1% cannibalism. Finally, a female was found feeding on her brood sac, which was previously abandoned outside the nest at an advanced stage of development. Considering that she did not abandon her eggsac to specifically feed upon it (she probably found the eggsac by chance), and that we do not know if females can recognize abandoned brood sacs as their own, we can not even assure that this is a case of intentional cannibalism. The last two cases occurred with adults kept individually (from other adults, but not from their own brood). In general, cannibalism can be considered uncommon in *M. iporangae*, especially considering that (1) it did not occur among adults kept in groups, and (2) it was recorded only three times (ca. 1%) over 310 observations done for *M. iporangae* during this study.

Feeding frequency.—Generally, adult pseudoscorpions of *M. iporangae* ate about once a month. The average number of prey eaten per month was 1.14 ± 0.50 s.d. ($n = 47$). There are few studies on feeding frequency of other pseudoscorpions. For comparison, Levi (1948) reported that adults of *Chelifer cancroides* can feed once or twice a week.

When sexes were analyzed independently, the monthly average feeding frequency of females of *M. iporangae* was 1.27 ± 0.50 ($n = 33$); and of males was 0.83 ± 0.34 ($n = 14$). We observed that 85% of males had a feeding frequency between 0.4–1.19, whereas in 75% of females the frequency was between 0.8–1.99 times a month. Although the confidence interval for feeding frequency of males and females overlap, Mann-Whitney rank sum test ($T = 213.0$, $P = 0.004$) showed that the sexual difference between frequencies is statistically significant. In addition, the monthly average feeding frequency of females after breeding increased to 1.50 ± 0.27 ($n = 11$), but this increase is not significant (overlap of confidence intervals and Mann-Whitney rank sum test—$T = 263.0$, $P = 0.222$). The energy spent for the nutrition of embryos and for the time spent inside nest chambers may be responsible for the increase (although not significant) in feeding frequency of females in the reproductive period. This is also common in other arachnids that

spend some time with their brood without feeding (e.g., laniatorean harvestmen, Gnaspini 1995).

Similarly, an increase in the feeding activity of animals having recently left molting chambers was observed in two cases. The monthly average feeding frequency of a recently molted adult female was 3.7 during the three months subsequent to exiting the molting chamber. The second case is a tritonymph, which increased its feeding frequency to 2.0 also for three months. It is expected that pseudoscorpions increase their feeding frequency after the molt, due to having spent a long time without food. This increase is expected to be larger in early stages because they are more active and feed more frequently (Levi 1948; Hahn & Matthiesen 1993a). The fact that our observations do not agree with this statement is probably due to the extremely low number of cases observed.

An ecological study focusing on this species in the field is presently being conducted by the senior author, including food preferences, and should give additional information that could resolve some unanswered questions.

ACKNOWLEDGMENTS

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