

## NATURAL HISTORY AND SOCIAL BEHAVIOR IN NEOTROPICAL PSEUDOSCORPIONS

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### Summary

Pseudoscorpions (false scorpions) are small arachnids that in a quick look resemble small scorpions, although, without the “tail” having a sting. They have the body divided in cephalothorax and abdomen and six pairs of appendices. Nowadays are known more than 3,200 species of pseudoscorpions in the world, grouped in 425 distinct genera and 24 families. Although widespread through the Earth, they are poor known in terms of biology and behavior, especially in the tropics. In the Amazon forest are expected more than 100 of new species, completely unknown by the science. These animals can live in a wide variety of conditions and environments, like the leaf litter; under the bark of live or dead trees; under stones; cavern walls; on the bat’s guano; and also in extreme conditions like rocky crevices of some coastal regions. Pseudoscorpions are predators of small animals that they found in their territories. The reproductive behavior of pseudoscorpions is also very interesting and curious. Although the fecundation is internal, they do not perform direct transference of spermatozoids. The spermatophore

is a small structure formed by a type of flagpole that is glued in the soil having in the top, in the position of the flag, a small package full of sperm in its interior. This package has appendices that are responsible to attach in the genital opening of the female and to bomb the sperm to the female genital chamber.

The lack of information about the natural history of pseudoscorpions is a grave problem in the comprehension of importance in trophic chains, life histories and biology of this diversified group of arachnids. Indeed, for several decades in the last century natural history studies in almost all taxonomic groups, especially of animals, were neglected by referees of the main journals. Here we will present full data about the biology, development, reproduction and life system of the Neotropical pseudoscorpion *Paratemnoides nidificator*. After this previous presentation we will discuss why these small creatures, *P. nidificator*, live in a type of society and cooperates each other in prey capture? How its life system can be evolved and how are the advantages? The social behavior and causes of its evolution, details of ecology that pointed out this species in direction of sociality will be discussed here as an important issue that can reveal much more than we can figure out about the evolution of eusociality in tropical arthropods.

## 1. Introduction

### 1.1. What we know about the Order *Pseudoscorpiones*?

Like the name suggests, pseudoscorpions (false scorpions) are small arachnids that in a quick look resemble small scorpions, but without the extended metasoma (without the tail and sting). In fact they are very small, not longer than five to eight millimeters (Figure 1).



Figure 1. A solitary tropical pseudoscorpion from the Brazilian savanna. This species belongs to Chernetinae sub-family and probably is a new species that lives under the bark of trees.

Even all arachnids, the pseudoscorpions have the body divided in cephalothorax and abdomen and six pairs of appendices: the chelicerae (associated to the mouth chamber); the pedipalps (like tweezers similar to that from scorpions) and four pairs of legs used to locomotion. Like other arthropods the body is segmented and in this case the segments of cephalothorax are melted giving them an aspect sometimes flat and in other times lumpy. Nowadays are known more than 3,200 species of pseudoscorpions in the world as a whole and they are grouped in 425 distinct genera and 24 families. Although widespread over the Earth, the major part of studies about biology, ecology or simple natural history and taxonomy of pseudoscorpions are concentrated on European, North American and Australian species. Although specialists pointed out South America as belonging to the richest fauna in this group, some researches await more than 150 new species only in Brazil; its pseudoscorpion fauna is almost unknown. Some parts of the Amazonian forest are the most studied regions of Brazil and the initial studies revealed the existence of 75 species.

One can easily perceive that due to its small size the observation of pseudoscorpions in natural conditions is very difficult. However, there are a good group of naturalists working and showing that these animals can live in a wide variety of conditions and environments, like the leaf litter; under the bark of live or dead trees; under stones; cavern walls; on the bat's guano; and also in extreme conditions like the species *Neobisium maritimum* that can live on rocky crevices of some coastal regions of Europe. The beauty can be found in the most unexpected places of nature. Additional facts made the study of pseudoscorpions very difficult: furtive habits, cryptic coloration (camouflage), agility and the use of hidden environments as home. Some of the best known species are cosmopolite and well adapted to urban conditions. A good example is the species *Chelifer cancroides* (Linné, 1758) commonly found in house cracks. This pseudoscorpion discovered a "secure environment" among sheets of old books stored and forgotten in bookcases, a good place to build their silk nests. Opening a book like that some people get scared with the disturbed pseudoscorpions, now running and searching for a place to hide. These occurrences with time ended with people naming and recognizing these animals like Book-scorpions or false-scorpions.

## 1.2. Predatory Behavior and Feeding Habits

Pseudoscorpions are predators of small animals that they find in their territories, as larvae and adults flies (Diptera) and beetles (Coleoptera), springtales (Collembola), mites (Acari), ants (Formicidae) and other false-scorpions too. Due to their small size, these arachnids are limited to attack and prey on animals of also small size, similar to them or preferentially smaller. In fact, pseudoscorpions are in general solitary animals, very aggressive, especially one with each other. In this sense, cannibalism of youngest (infanticide) or of small ones is not rare.

The most important sense to prey location is vibration (mechanoreception). The body of these arachnids, mainly the chelicerae, legs, abdomen apical portions and, mainly, the pedipalps, are covered by long sensorial hairs, the trichobotria. These structures are able to detect a minimal air vibration nearby the predator. Thus so, when a prey moves by the environment, it produces an air disturbance and substrate vibration at the point where it is. These signals act as cues to the pseudoscorpion locate and to direct the

attack. Vision is not an important sense in this world, serving mainly to determine variations between day and night. Several species are blind or can present up to two pairs of composed eyes, or a pair of ocelli, small structures able to detect changes in luminosity. It is possible that pseudoscorpions are also be able to locate and identify prey to chemical signals.

The pedipalps and chelicerae are strong weapons used to capture and subjugate preys. The capture and way to kill are variable according to the suborder. For example, the suborder Epiocheirata did not present poison glands associated to the chaela of pedipalps, as is common in this animal group (taxa). The Epiocheirata species present more delicate pedipalps; they can be long and fine, in some cases short, but rarely robust. In these species the pedipalps are very important in prey manipulation after the capture. The chelicerae are responsible for maceration. In the suborder Iocheirata, the arthropods can present a poison gland associates with both fingers of pedipalps, or in special cases present only in the immovable or in the movable finger, depending on the family; it is a very important taxonomic character to species determination. The Iocheirata species firmly and quickly grasp on the prey with the pedipalps, while they inoculate the poison that has functions both, digestive and paralyzing (neurotoxic and proteolytic).

### **1.3. Reproductive Behavior**

The reproductive behavior of pseudoscorpions is also very interesting and curious. Although the fecundation is internal, they do not perform direct transference of spermatozoids. However, it does not mean that there is no structure to penetration, copulation and to produce the spermatozoid transference. The indirect transference of gametes is a common behavior among arachnids with the exception of Opiliones (Harvestmen) and some Acari. In the case of pseudoscorpions the male produces a small structure that stores the spermatozoid (the spermatophore) that will later be transferred to the female. The spermatophore is a small structure formed by a type of flagpole that is glued in the soil having in the top, in the position of the flag, a small package full of sperm in its interior. This package has appendices that are responsible to attach in the genital opening of the female and to bomb the female genital chamber with the sperm. The morphology of spermatophore is widely varied among species. Thus so, the fit in between the spermatophore and female genital opening is something like a key-lock mechanism, therefore, there is no connection between different species.

In the major part of species of Neobisoidea superfamily it is believed that males never found a female along their whole life. It happens probably due to the natural conditions in what they live, the litter fall. In the forest ground the leaf litter that covers the ground can be compared to an enormous ocean in the point of view of so small creatures like these arachnids. In this taxa, the males put the maximum number of spermatophores in the environment, randomly, and during almost their whole life. Females probably are attracted by chemical signals of these spermatozoid packages, a sensual and irresistible odor. Finding the structure the female puts her body upon it producing the fecundation. The reproductive behavior is very distinct in another superfamily, the Cheliferoidea. These pseudoscorpions generally are found in bark crevices of live and dead trees, under stones and rocky cracks. After finding a female, the male produces an elaborate

repertory of behavioral acts, using mainly his pedipalps; it is courtship. If the female accepts and is receptive to copulate, both will enlase the pedipalps and they will initiate a movement similar to a dance. During the dance the male fixes the spermatophore on the ground and now, he will direct the female to the package that will fit in the female genital opening. The male will grasp the female over the spermatophore for a good length of time to enable the total transference of his genetic material.

#### **1.4. Development, Life Cycle and Parental Care**

Pseudoscorpions are viviparous animals. Egg development and larvae emergence occur still inside the mother's body, where one can find embryos in distinct stages. In the following phase, the embryos or larvae, both names are valid names in this case, are deposited by the mother in the interior of a delicate and membranous sac. This bag is secreted and produced by the reproductive organs and annex glands, having the general appearance of a transparent small sphere of side by side cloves. This special structure is named brood sac and it can be more or less elaborate depending on the species and of the type of glands related in its production.

The brood sac remains attached to the female's genital opening and can be carried under the mother's womb while she walks about searching for food and better shelters through the environment (Figure 2). The embryos are fed by a nutritive fluid produced in the interior of reproductive channels of the mother and thrown inside the brood sac. Larvae do the first molt still inside the sac. During the second molt, in the ecdysis the larvae cut the old cuticulae and the sac opens like it was composed by several capsules. Now the young, named nymphs, yet resembling a small pseudoscorpion go out. The ontogenetic aspects, like developmental time, were investigated in a few species.



Figure 2. Female of the Neotropical pseudoscorpion *Americhernes bethaniae* carrying on a brood sac, full of second instar embryos. The female is building her silk chamber in the bark tree where their brood will develop.

The first described pseudoscorpion was initially classified as an animal belonging to the Acari taxonomic group. For this reason and until nowadays, researchers maintained that the three stages of initial development of pseudoscorpions must receive the same names used in the study of arachnids: Protonymph, Deutonymph and Tritonymph, respectively to the first, second and third instar. Besides size differences, each instar can be differentiated by the clearest exoskeleton in the youngest. The post-embryonic developmental time was studied in detail in a very limited number of species. These studies pointed out that in some North American and European species, like *Chelififer cancroides* Levi 1948, the whole post-embryonic development can delay one year.

### 1.5. Living Together

Living together is not an easy thing to do in nature. Animals living together have to be adapted to share food, space, mates, shelters, and several other resources and possibilities. Perhaps, due to this and other factors, species in general prefer to live alone. We can not say that one life strategy, alone in sociality, is superior. We can say that species were selected through hundreds or thousands of millions of years to live in one or another way, better to each one in each time and space circumstances. Like the great majority of other arachnids, pseudoscorpions are predominantly solitary animals.

Arachnids are known by their aggressive behavior against co-specifics, they can be cannibals or necrophagous. Tolerance, an initial step in the evolution of sociality is almost nonexistent in this group. Some males have problems to control females during the reproduction.

Thus, it is extremely rare to find examples of arachnids, including pseudoscorpions that live together in aggregations or cooperate in some way during their life cycles. However, we have to consider that these animals are small, cryptic, freak and that they scare humans with facility and that there are a reduced number of researchers studying the social behavior of arachnids in the world. In fact, there is only one pseudoscorpion genus where social behavior was described and in the following sections we will present and discuss the case study involving the fascinating *Paratemnoides nidificator*.

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### **Biographical Sketches**

**Everton Tizo-Pedroso** is a biologist, graduate in Ecology from the Federal University of Uberlândia (UFU) in 2007 and developing his doctorate thesis in the Ecology and natural history of tropical pseudoscorpions. He is also member of Biotic Interactions and Behavioral Ecology Research Group from the Brazilian Council of Science and Technology (CNPq) and member of the project sponsored by the Fapemig (Research council of Minas Gerais State) to investigate ecology, diversity and Natural history of pseudoscorpion in the cerrados (tropical savannas) of Minas Gerais, Brazil.

**Kleber Del-Claro** is a biologist with doctorate in Ecology by State University of Campinas (Unicamp) in Brazil. Since 1992 is a teacher at Federal University of Uberlândia (UFU), where between 2003 and 2007 was the coordinator of the graduate program in Ecology. Kleber is the coordinator of the international cooperation agreement between UFU and the University of Missouri, St. Louis (UMSL), USA. He is a researcher from the Brazilian Council of Research, Science and Technology (CNPq) since 1996. At UFU and other Brazilian universities he was instructor of several master and doctoral thesis in ecology and animal behavior developed in the tropics. His scientific history, books and publications are available in: [www.leci.ib.ufu.br](http://www.leci.ib.ufu.br). In 2005 he was the president of the “Frontiers in Tropical Biology and Conservation” meeting, settled in Brazil (Uberlândia), the annual meeting of Association for Tropical Biology and Conservation (ATBC) and supported by the Brazilian Society of Ethology (SBEt, now President for the second time).