Defensive Behaviors in Mygalomorph Spiders: Release of Urticating Hairs by Some Aviculariinae (Araneae, Theraphosidae)

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Abstract. The release of urticating hairs by five species in three genera of Aviculariinae spiders is described. In contrast to other Theraphosidae spiders which shed urticating hairs, in these genera the spiders insert the urticating hairs by direct contact with the potential predators, by rubbing the region with urticating hairs on the skin of the predator. Release and morphology of urticating hairs are associated with spiders’ habitats. Hair-flicking is restricted to burrow spiders, from two distinct phylogenetic lineages – Ephebopus (Aviculariinae) and all Theraphosinae –, whereas contact urticating hairs are found only in arboreal spiders (mostly Aviculariinae). These three groups of urticating hairs seem to have evolved independently.

Key words: mygalomorph spiders, Theraphosidae, Aviculariinae, defensive behaviors, urticating hairs, phylogenetic relationships, spiders’ habitats.

1. INTRODUCTION

The defensive behaviors of mygalomorph spiders include flight (EDMUNDS 1974), threat displays and biting (COOKE et al. 1972). One type of defense, apparently restricted to New World theraphosids, is the release of urticating hairs (COOKE et al. 1972). In the subfamily Theraphosinae these hairs are situated on the dorsum of the abdomen and the spider sheds the hairs using one or both of the hind legs (COOKE et al. 1972). In the genus Ephebopus Simon, 1892 (Aviculariinae), these hairs are found as a distinctive pad on the distal prolatral surface of the pedipalpal femur (MARSHALL & UETZ 1990). To shed these hairs, the spider brings the pedipalps down across the basal segments of the chelicerae (MARSHALL & UETZ 1990). Hair-flicking behavior has never been recorded in other genera of Aviculariinae spiders which have urticating hairs on the abdomen (i.e. Avicularia, Pachistopelma, and Iridopelma – LUCAS et al. 1991), and the mechanism by which these hairs are dislodged is still poorly known (COOKE et al. 1972).

Here we report on the defensive behavior of five species of Aviculariinae in which the spiders insert the urticating hairs by direct contact with the potential predator. We also compare the morphology of urticating hairs, spider’s morphology, defensive behaviors, and habitats of the different types of Theraphosidae and discuss their possible phylogenetic relationships.

2. MATERIALS AND METHODS

Defensive behavior was recorded for the following species and individuals: Aviculariinae - Avicularia avicularia (Linnaeus, 1758) - (n = 10), Avicularia watckenaeri (Perty, 1833) - (n = 5), Avicularia sp. - (n = 5), Pachistopelma rufomgram Pocock, 1901 - (n = 1) and a new genus, to be described - (n = 4); Theraphosinae (sensu RAVEN 1985) – Acantoscurria arex Veillard, 1924 – (n = 6), Vitalius sorocabae (Mello-Leitão, 1923) – (n = 7), Lasiodora klugi (C. L. Koch, 1842) – (n = 6), Grammostola actaeon (Pocock, 1903) – (n = 3) and Theraphosa blomdi (Laterille, 1804) – (n = 3). The spiders were observed in captivity, in the Laboratório de Artrópodos
of the Instituto Butantan, São Paulo, Brasil. The animals are maintained in individual wooden cages with the following dimensions: 26 × 24 × 17 cm. They are fed on newborn mice or crickets each month and water is provided “ad libitum”. Each tested spider was stimulated by touch with forceps or the tip of a finger. We used the “all occurrence sampling” and “sequence sampling” methods for the observations (LÜHNER 1979). Photographic records were taken during the tests in order to observe in greater detail the defensive behaviors.

3. RESULTS

All specimens of Theraphosinae spiders exhibited the usual hair-flicking response using one or both of their hind legs, which were lifted onto the dorsum of the abdomen (cf. COOKE et al. 1972).

In agreement with COOKE et al. (1972), we did not observe hair-flicking among specimens of the species of Aviculariinae tested and attempts to bite were infrequent. Nevertheless, we observed that these spiders remained attached to the substrate with the aid of the well developed claw tufts and directed the abdomen toward the stimulus. This was particularly common when the spider was stimulated frontally or laterally (Fig. 1). In these cases, the spider turned its abdomen completely towards the stimulus and sometimes it rubbed its abdomen against the stimulating object. After touching these docile spiders with the finger, we noted the presence of many hairs over the skin of the finger. A careful examination under a stereoscope microscope showed us the presence of many urticating hairs of the type II of COOKE et al. (1972) fixed by their penetrating tip into the skin. The urticating hairs penetrated the skin slowly, embedding completely after one to two days. This rubbing behavior occurred mainly when the spiders were in the silk nest built on the walls of the cage. When they were out of their web, they usually resort to flight, running across the cage floor or climbing the walls.

4. DISCUSSION

COOKE et al. (1972) suggested that the ventral metatarsal spines of the Theraphosidae play an important role in combing off the urticating hairs, although no comparative study has yet been made. The American subfamily Theraphosinae is the only group with species that possess abdominal urticating hairs and that shed them (COOKE et al. 1972). Theraphosinae spiders have many spines on their legs, whereas other theraphosids have just a few apical spines or their legs are

Fig. 1. The release of type II urticating hairs by an Aviculariinae spider (Avicularia avicularia). A – The spider is stimulated with a pincers laterally. Note that the spider puts down its body and legs near the stimulation object while rises its body and legs of the other side. The fourth leg of the side from where comes the stimulus is put close to the fourth leg of the opposite side. The abdomen is directed towards the disturbing object and B – sometimes is rubbed against it. Drawn from serial photographs.
aspinose (pers. obs.). Among the Theraphosinae the spines are concentrated on the ventral metatarsus IV (pers. obs.), the region of the leg used to scrape the dorsum of the abdomen when the hairs are combed off (Cooke et al. 1972). These spines become erect at the moment of release and many hairs remain attached to the metatarsal spines afterwards (pers. obs.). In contrast, in the Aviculariinae, which were never seen shedding urticating hairs (Cooke et al. 1972), there are normally no leg spines except for a few apical spines in some genera (Raven 1985; pers. obs.). There is a great difference in the morphology and size of the urticating hairs in Theraphosinae and Aviculariinae (Fig. 2). There are three types of abdominal

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**Fig. 2.** Types of urticating hairs in theraphosid spiders. A – Type I urticating hair, found in many Theraphosinae. B – Type II urticating hair, found in the Aviculariinae genera Avicularia, Pachistopelma, Iridopelma and a new genus, to be described. C – Type III urticating hair, found in many Theraphosinae. D – Type IV urticating hair, found in some Theraphosinae. E – Type V urticating hair, found only in species of the genus Ephebopus (Aviculariinae) has no stalk and is attached directly on the spider’s skin by the penetrating tip. PT: penetrating tip; B: barbs; ST: stalk. Drawn from the species Vitalius sorocaber, Avicularia avicularia, Lasiodora sp., Grammostola acteon and Ephebopus marinus, respectively.
urticating hairs in the Theraphosinae, all of them short (type I = 0.2 to 0.6 mm; type III = 0.3 to 1.2 mm and type IV = 0.06 to 0.2 mm), and/or thin, and with many long barbs (Cooke et al. 1972), characteristics which probably aid them in being blown through the air (pers. obs.).

Aviculariinae spiders present two types of hairs. The type V, described by Marshall & Uetz (1990) in the genus *Ephebopus* is short and stout, with many barbs, and it is easily blown through the air (pers. obs.). The type II urticating hair (Cooke et al. 1972) is only found on the abdomen of the genera *Avicularia, Pachistopelma, Iridopelma* (Lucas et al. 1991) and a new genus, to be described. Type II hair is rather stout and longer than the others (0.5 to 1.5 mm) and with many small, scale-like barbs (see Figs. 10–12, in Cooke et al. 1972). Attempts to scrape the type II hair from the spider showed that it is not carried through the air, but falls immediately to the ground instead. Moreover, the type II urticating hair is implanted via a supporting stalk with the penetrating tip directed downwards (i.e., basally), in contrast to urticating hairs type I, III, and IV, which have the penetration tip directed upwards (i.e., distally) (see Fig. 2 and Cooke et al. 1972). The type II penetration tip comprises an area beginning at the point of implantation of the hair on the supporting stalk and tapering towards the tip. It is also slightly curved upwards (see Figs. 11C and 21 in Cooke et al. 1972; pers. obs.).

We propose that type II urticating hairs are released by contact: when the abdomen of the spider is touched, the hairs are pushed onto their posterior (distal) end, and the penetrating tip rises up coming into contact with the touched object (see Fig. 3). Thus, the penetrating tip perforates the skin of a potential predator and, by means of its small barbs, which point backwards, the hair becomes attached. At the same time the hair is loosened from its supporting stalk. This initial penetration by the hairs may be enhanced by the abdominal movements of the spider (Fig. 1).

**Fig. 3.** Schematic representation of the release of the type II urticating hair. **A** – A potential predator (P) is coming into contact with a type II urticating hair (H) attached by its supporting stalk (ST) to the spider’s abdomen (SA). **B** – The predator contacts the spider, the distal part of the hair is pushed down and the penetrating tip (PT) is raised. **C** – The penetrating tip, slightly curved upwards, contacts and perforates the predator’s skin. **D** – The urticating hair, fixed in the predator’s skin by its small barbs (B) pointed backwards, is loosened from the supporting stalk.
We examined the suggestion of Cooke et al. (1972) that Avicularia surinamensis Strand, 1907 uses the urticating hairs indirectly by incorporating them into the silk walls of the retreat, but we did not find urticating hairs in the webs of the tested species of Aviculariinae. However, when newborn mice were offered to the spiders and were rejected by them, we found hundreds of type II urticating hairs in the skin of the dead mice and in the web around them. Although we were unable to determine whether the urticating hairs were involved in the death of the mice, this strengthens our suggestion that some Aviculariinae spiders deliberately bring urticating hairs into contact with disturbing animals.

As observed by Marshall & Uetz (1990), the variety of urticating hairs and their release mechanisms in New World Theraphosidae is remarkable when contrasted with their absence in the spiders of the Old World. Additionally, they seem to have evolved three times. Considering that most of the Theraphosidae subfamilies and its sister-group Paratropidae (Raven 1985; Goloboff 1993) share the absence of any type of urticating hair (pers. obs.), we consider this absence to be a plesiomorphic characteristic. The occurrence of urticating hairs (type V) in the pedipalps of Ephebopus is unique, representing an autapomorphy. There is no reason to consider the type V urticating hair as homologous with that on the abdomen of other Aviculariinae or Theraphosinae, because of its distinct position and pronounced morphological differences. We think it is better to consider them as functional analogues.

It should be considered whether the abdominal urticating hair type II from Aviculariinae and the urticating hairs types I, III, and IV from Theraphosinae are homologous, i.e. if their common ancestor had any type of urticating hair on the abdomen. The differences shown here in the structure and release mechanism of urticating hairs in these two groups suggest their non-homology. Moreover, the existence in Aviculariinae of groups exhibiting the plesiomorphic state (absence of urticating hairs on the abdomen) indicates the possibility of convergent evolution of these structures in the two subfamilies, even if we consider them as sister-groups. Analysis of the phylogenetic relationships among the Theraphosidae subfamilies and genera could confirm this hypothesis of convergent evolution. Concerning the habitats (Cambridge 1986; Cooke et al. 1972; Marshall & Uetz 1990), it is remarkable that we found release of urticating hairs by contact only in a group known to be arboreal – i.e. Aviculariinae except Ephebopus. The burrowing spiders – Ephebopus and all Theraphosinae – shed urticating hairs spontaneously.

Morphological and behavioral differences in the release and type of urticating hairs between burrowing and arboreal spiders seems to be associated with contrasting habitats.

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