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A Morphological Study on the Venom Apparatus of the Spider *Agelena labyrinthica* (Araneae, Agelenidae)*

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Abstract: The morphology of the venom apparatus of the spider *Agelena labyrinthica* was studied using scanning electron microscopy. The venom apparatus, situated in the anterior of the prosoma, is composed of a pair of chelicerae and venom glands. Each chelicera consists of two parts, a stout basal segment covered by hair, and a movable articulated fang. There are regular, parallel fine grooves on the surface of the cheliceral fang. The venom pore is situated on the subterminal portion of the fang. All of the venom glands are the same size and are shaped like long tubes. Each gland is surrounded by bundles of muscular fibers. Venom is produced in the venom glands, and it is carried by a venom duct passing through the chelicera, exiting from the venom pore during muscular contraction.

Key Words: Spider, *Agelena labyrinthica*, venom apparatus, morphology, SEM (scanning electron microscopy).

Agelena labyrinthica (Araneae, Agelenidae) Örümceğinin Zehir Aygıtı Üzerine Morfolojik Bir Çalışma

Özet: *Agelena labyrinthica*, huni örümceğinin zehir aygıtının morfolojisi taramalı elektron mikroskop (SEM) kullanılarak çalışılmıştır. Prosomanın ön kısmında yer alan zehir aygıtı, bir çift keliser ve zehir bezinden oluşmaktadır. Her bir keliser kıllarla kaplı, kuvvetli bir bazal parça ve hareketli bir zehir dişi olmak üzere iki kısımdan oluşur. Zehir dişinin yüzeyinde düzgün, paralel dizilmiş oluklar bulunmaktadır. Dişin ucuna yakın kısmında bir zehir deliği yer almaktadır. Zehir bezinin her biri eşit büyüklükte olup uzun tüp şeklindedir. Bezin etrafı sarmal dizili kas demetleri ile sarılmıştır. Zehir bezinde üretilen zehir, bu kasların kuvvetli bir şekilde kasılmasıyla keliser boyunca uzanarak zehir dişine ulaşan bir zehir kanalı ile taşınır ve zehir deliğinden dışarı verilir.

Anahtar Sözcükler: Örümcek, *Agelena labyrinthica*, zehir aygıtı, SEM (taramalı elektron mikroskop)

Introduction

Spiders (Arthropoda: Arachnida) are an ancient and successful group of invertebrate animals, widely distributed throughout the world. These arthropods have two parts the prosoma and the opistosoma. The prosoma contains the brain, venom glands and stomach (Preston, 1982; Levi and Levi, 1990). Except for Uloboridae and Holarcheae, all spiders have a venom apparatus. In principle, all spiders with any kind of venom apparatus are considered to be "venomous", but this does not mean that all of them are dangerous to human beings. Their venom is toxic to insects, their usual prey. Russell et al. (1973) considered approximately 100 spider species to be actually dangerous to human beings. The European species *Latrodectus tredecimguttatus* and the American species *L. mactans* (black widow spider) are among the most dangerous spider species to human beings (Frontali and Grasso, 1964; Grasso, 1992).

The histology of the *Latrodectus* venom gland and venom components has been investigated by several researchers (Moon and Tillinghast, 1996; Grasso, 1976; Grasso and Pescatori, 1996). It is known that *Latrodectus* venom acts upon neuromuscular transmissions that release the transmitter acetylcholine from the synaptic vesicles and extravesicular agglomerations (Ori and Ikeda, 1998). On the other hand, several authors have established that the toxins of other genera, *Atrax* and *Loxosceles,* act on neuromuscular endings in different ways (Grishin, 1999; Rash and Hodgson, 2002).

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Previous investigators have described the venom apparatus of several venomous animals including snakes, wasps and centipedes (Foelix, 1982; Mebs et al., 1994; Young et al., 2001; Schoeters et al., 1997; Ménez et al., 1990). Snakes have attracted the greatest attention and there have been many investigations into them.

The venom apparatus of spiders consists of a pair of chelicerae and venom glands. The shape and position of the venom gland is different in various species. In the large "tarantulas" the venom glands are quite small and lie inside the chelicerae. In the genus *Atypus* the glands are composite, in *Filistata* they are of a multilobular type and in *Sctodes* they are bilobular (Maretic, 1987).

In *Plesiophirctus collinus* the venom glands are situated dorsally in the basal article of the chelicerae, between the adductor and abductor muscles. The glands are carrot-like in shape. In *Heteropoda venatoria* and *Lycosa indagastrix* the venom glands are situated in the prosoma with the adductor and abductor muscles holding them in position. The glands are sac-like or cylindrical and consist of two lobes (Waller and Phanuel, 1989).

Kovoor and Muñoz-Cuevas (2000) described the structure and histochemistry of the poison glands in *L. tarentula* (*Lycosidae*), four *Peucetia* species and *Oxyopes lineatus* (*Oxyopidae*). All these species show two voluminous gland sacs situated dorsally in the prosoma, over the nervous system. The excretory duct of the gland begins at the base of the chelicerae in *L. tarentula*. It finally opens onto the upper surface of the fang, shortly before the tip.

In many species, both sides of the cheliceral grooves are often armed with cuticular teeth. There are also similar but very small structures on the ventral side of the fang. These act as a buttress for the movable fang. Spiders whose chelicerae are equipped with such teeth mash their prey into an unrecognizable mass. Spiders without such teeth can only suck out their victims through the small bite holes. The number and size of the cheliceral teeth are important diagnostic characteristics for the taxonomist (Foelix, 1982).

However, the functional anatomy of the fangs and venom apparatus of *A. labyrinthica* have not been studied by any researchers. We describe here the morphology of the venom apparatus of *A. labyrinthica* that is widely distributed throughout Turkey (Bayram, 2002).

Materials and Methods

Adult specimens of *A. labyrinthica* of both sexes were collected from Kızılırmak Green Valley in Kırıkkale and were reared in special cages in the Biology Department of Kırıkkale University.

The spiders were dissected under stereo microscope after being narcotzed with ether. The carapax was gently removed and the venom glands were extracted. Then the venom glands were fixed in 3% gluteraldehyde buffered with sodium phosphate (pH 7.2) for 2 h at +4 ºC rinsed in sodium phosphate buffer and post -fixed in 1% osmium tetraoxide in sodium phosphate buffer for 2 h. Samples were dehydrated in a graded ethanol series, and critical point dried. To clean the surfaces the chelicerae and fangs were washed with a stream of isotonic saline solution, and air dried (Moon, 1996). All specimens were mounted onto specimen stubs, coated with a thin layer of gold by a Polaron SC 500 sputter coater, and examined under a JEOL JSM 5600 scanning electron microscope (Bozzola and Russel, 1992).

Results

The venom apparatus of the spider *A. labyrinthica* is located in the anterior of the prosoma. It is composed of a pair of venom glands that produce the venom, venom ducts that carry the venom from its source to the point of delivery and cheliceral fangs that envenomate the prey by pricking it (Figure 1 a,b).

Each chelicera consists of two parts: a stout basal segment and a movable articulated fang. The chelicerae are covered in hairs (Figure 2).

The fang rests in a groove of the basal segment. Both sides of the cheliceral grooves are often armed with marginal teeth. However, no structures resembling small teeth were found on the ventral side of the fang. There are regular, parallel fine grooves on the surface of the cheliceral fang. The fangs possess a ridge, and on the lateral side there is a blade -like structure (Figure 3). The venom pore is situated on the subterminal portion of the fang (Figure 4).

The results obtained by scanning electron microscopy show that the venom glands of *A. labyrinthica* are of equal size, and that they resemble a long tube. Each gland is surrounded by bundles of muscular fibers (Figure 5). The venom produced in the venom gland is carried by a venom duct passing through the chelicera, exiting from the venom pore during muscular contraction.

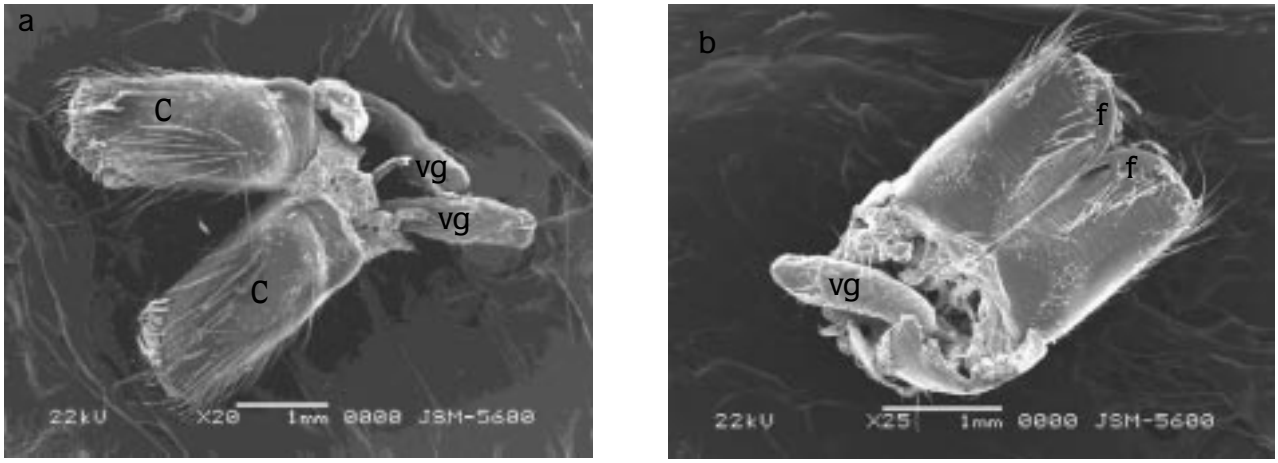

Figure 1. Chelicerae and venom glands of *Agelena labyrinthica.* a) Dorsal view of the chelicerae, showing the venom apparatus. c: Chelicera, vg: Venom gland. b) Ventral view of the chelicerae, f: fang.

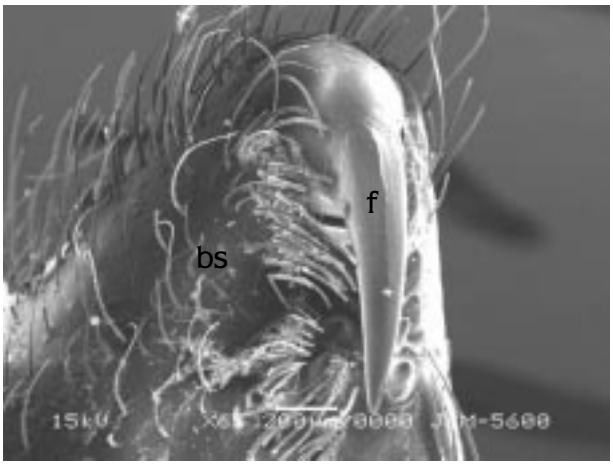

Figure 2. The chelicera (covered in hairs) consists of two parts, a basal segment (bs) and a movable fang (f).

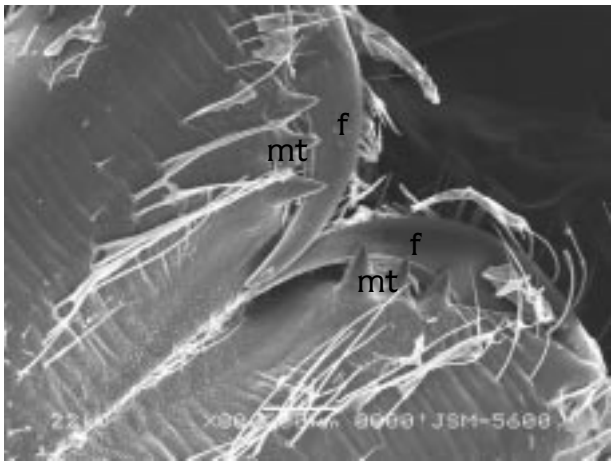

Figure 3. The fangs (f) rest in a groove of the basal segment, showing marginal teeth (mt).

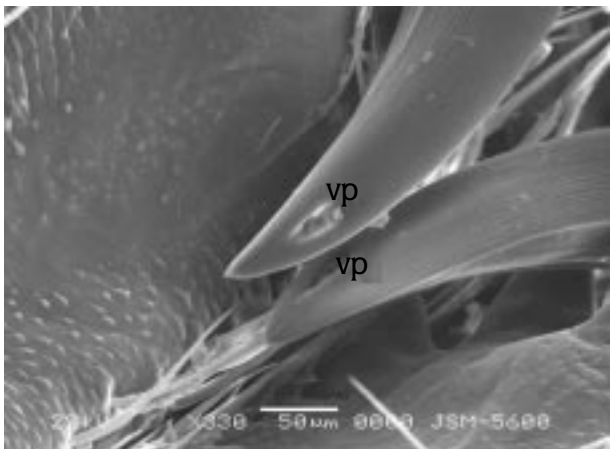

Figure 4. The venom pore (vp) and fine grooves on the surface of the fangs.

Figure 5. Morphological description of the venom gland. The venom gland is tubular and is covered with muscle bundles that completely encapsulate it.

Discussion

The position of the fangs in spiders allows them to be divided into two suborders: Labidognatha and Orthognatha (Foelix, 1982). It has been noted that Labidognatha and Orthognatha move their chelicerae in quite different manners. Labidognatha fangs inject venom perpendicular to the longitudinal axis of the body. Orthognatha fangs are parallel to each other and to the longitudinal axis of the body. The venom apparatus of *A. labyrinthica*, a spider belonging to the suborder Labidognatha, located in the prosoma. These characteristics are found in *Loxosceles intermadia* (Santos et al., 2000) and *A. limbata* (Moon, 1996), both labidognatha spiders. The gross morphology of the venom apparatus of the funnel-web spider, *A. labyrinthica,* is basically similar to those of other kinds of spider (Moon and Tillinghast, 1996; Moon, 1992) and centipedes (Ménez et al., 1990) investigated by several researchers. The venom apparatus is generally composed of a pair of chelicerae and venom glands.

The venom glands of *A. labyrinthica* are paired structures located in the prosoma that communicate with the outside through two ducts that lead into the fangs. Most labidognatha spiders, including *A. labyrinthica,* have relatively large venom glands that extend out of the chelicerae and reach the middle of the prosoma. The shape of the venom glands is different in various species of spider: bulbous in *L. intermedia* (Santos et al., 2000), carrot-like in *Pelesiophirctus collinus*, and sac-like or cylindrical and consisting of two lobes in *Hetropoda venatoria* and *Lycosa indagastrix* (Waller and Phanuel, 1989), whereas the venom glands of *A. labyrinthica* are long and tubular and are surrounded by a layer of muscles that encircle the glands. In addition, blocks of muscle bundles spirally encapsulating the glands can be observed, in contrast to the *L. intermedia* external muscular cells that are branching in morphology (Santos et al., 2000).

In some spiders, the ventral side of the fang is rough. This structure acts as the cheliceral teeth. However, the ventral side of the fang is smooth in *A. labyrinthica*, and there are regular and parallel fine grooves on the fang in *Latrodectus,* which comprises many venomous species as well. A smooth–sided fang is probably a diagnostic characteristic in venomous species. Additional studies are needed to prove this relation.

The tip of the fang is pointed and sharp. It is hollow and has a needle-like structure. It is used for injecting venom as well as for piercing and holding prey. The cutting ridge on both lateral sides allows deeper fang penetration of the prey. *A. labyrinthica*'s fang possesses a ridge on the lateral side with a blade-like structure. We found regular grooves on the surface of the fang. These grooves probably suck up the body fluids of the prey by capillary action.

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