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Functional Morphology of the Venom Apparatus of *Larinioides ixobolus* (Araneae: Araneidae)

[1]Nazife Yiğit, [1]Abdullah Bayram, [1]Tarik Danişman and [2]Zafer Sancak
[1]Department of Biology, Faculty of Science and Arts,
University of Kirikkale, TR-71450 Yahsihan, Kirikkale, Turkey
[2]Department of Biology, Graduate School of Natural and Applied Sciences,
University of Kirikkale, TR-71450 Yahsihan, Kirikkale, Turkey

Abstract: *Larinioides ixobolus* (Thorell, 1873) is widely distributed throughout Middle Europe, Turkey and Middle Asia. The morphology of the venom apparatus of *L. ixobolus* using adult spiders that were collected from Kirikkale (Turkey) were investigated by scanning electron microscopy. The general organization of the venom apparatus of *L. ixobolus* is similar to other spiders' venom apparatus. The venom apparatus, situated in the anterior of the prosoma, is composed of a pair of chelicerae and venom glands. Each chelicera consists of a stout basal and a movable apical (fang) segments. The fang rests in a groove on the basal segment. Both sides of the cheliceral grooves are armed with three marginal teeth. To eject the venom, a venom pore is situated on the subterminal part of the fang. The venom glands of *L. ixobolus* are equal size and they look like a carrot. Each gland is surrounded by bulky muscular layer. Also, the nerve cells can be easily observed on the surface on the venom gland by Scanning Electron Microscope (SEM).

Key words: Spider, *Larinioides ixobolus*, venom apparatus, morphology, Scanning Electron Microscope (SEM)

INTRODUCTION

Spiders are an ancient and successful group of invertebrate animals, widely distributed throughout the world (Levi and Levi, 1990). They are also the largest group of venomous animals, represented by about 40,000 species. 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. About 200 species are actually dangerous to human beings. Their venom is toxic to insects, their usual prey. The known most dangerous spiders belong *Latrodectus* (black widow spiders), *Loxosceles* (violin spiders), *Atrax* (funnel spiders) and *Phoneutria* (banana spiders). *Segesteria*, *Agelena*, *Cheiracanthium*, *Steatoda* and *Lycosa* are known as secondary dangerous spiders (Frontali and Grasso, 1964; Grasso, 1992).

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). 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 multilobular type and in *Sctodes* they are bilobular (Maretiæ, 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 (Ridling and Phanuel, 1989). Kovoor and Munoz-Cuevas (2000) described the structure and histochemistry of the poison glands in *Lycosa 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.

There is a little knowledge on functional morphology of the venom apparatus and venom gland that produced venom. We describe in this study, morphology of the venom apparatus of *Larinioides ixobolus* that widely distributed throughout Middle Europe, Turkey and Middle Asia.

Corresponding Author: Nazife Yiğit, Department of Biology, Faculty of Science and Arts, University of Kirikkale, TR-71450 Yahsihan, Kirikkale, Turkey

MATERIALS AND METHODS

Adult individuals of *Larinioides ixobolus* were collected from Yahsihan-Kirikkale (33°: 31' E, 39°: 50' N, Turkey) on September 2005. The spiders were identified as *L. ixobolus* and then they were reared in special cages and fed with insects (*Drosophila melanogaster*) in the Biology Department of Kirikkale University. In order to dissect, spiders were narcotized with ether. Carapace was gently removed and the venom apparatus were taken for electron microscopic specimens under a stereo microscope (Nikon SMZ800).

Chelicerae and venom glands were fixed in 3% glutaraldehyde buffered with 0.1 M sodium phosphate buffer (pH 7.2) for two hours at +4°C temperature and then rinsed for 12 h in sodium phosphate buffer and postfixed in 1% osmium tetroxide in the same buffer for 2 h. They were then dehydrated in a graded ethanol series. To clean the surfaces of the chelicerae and fangs were washed for 10 min with a stream 100% ethanol. The last stages of dehydration were performed with propylene oxide and acetone. The specimens of venom glands were then dried in the incubator at 30°C overnight. These specimens were coated with a thin layer of gold by Polaron SC 500 sputter coater. The materials were examined at an accelerating voltage of 10 kV under Jeol JSM 6060 LV Scanning Electron Microscope and the electron micrographs were recorded. All materials that investigated are deposited at The Zoological Research Laboratory of Kirikkale University.

RESULTS

The general organization of the venom apparatus of *Larinioides ixobolus* is similar to the other spiders' venom apparatus. The venom apparatus of *L. ixobolus* is situated 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 envenomed the prey by pricking it (Fig. 1).

Each chelicera consists of two parts: a stout basal segment and a movable articulated fang. The basal segments of chelicerae are very stout and strong and covered by hairs. The fang rests in a groove of the basal segment. The fang was getting narrower towards tip. To eject the venom, a venom pore is situated on the subterminal part of the fang. Both sides of the cheliceral grooves are armed with three marginal teeth. These teeth are used for holding and crushing the prey (Fig. 2). The venom pore is situated on the subterminal portion of the fang (Fig. 3).

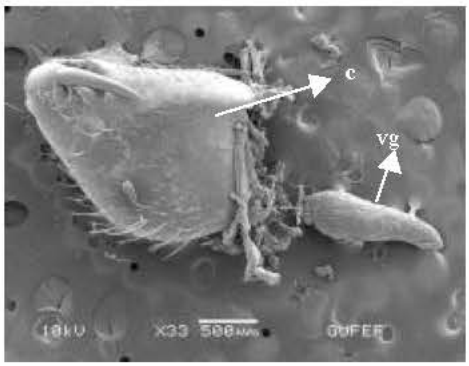

Fig. 1: The ventral view of a chelicera and venom gland of *Larinioides ixobolus*, showing the venom apparatus. c: Chelicera, vg: Venom gland

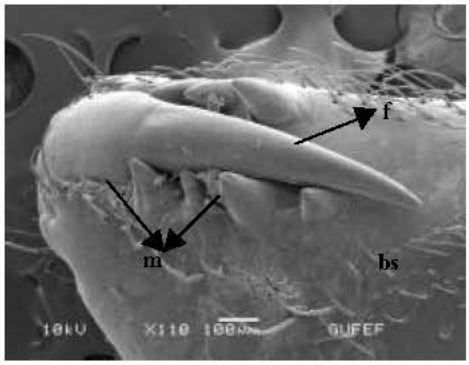

Fig. 2: The general view of the chelicera. The chelicera consists of two parts, a basal segment (bs.) and a movable fang (f). It can be clearly seen that the fangs (f) rest in a groove of the basal segment, showing marginal teeth (mt.)

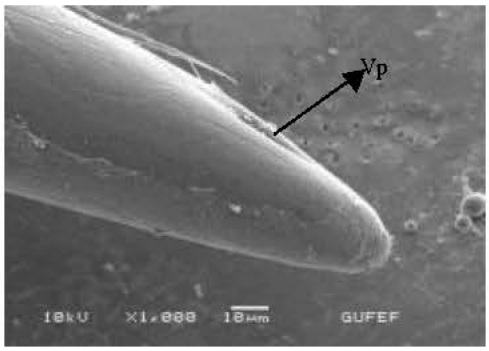

Fig. 3: The view of tip of the fang at higher magnification. The venom pore (Vp) is situated on the subterminal portion of the fang

Fig. 4: Morphological description of the venom gland. The venom gland is look like a carrot and is covered with muscle bundles that completely encapsulate it

Fig. 5: The higher magnification of the distal portion of the venom gland has clearly showed that was distinctive muscle bundles

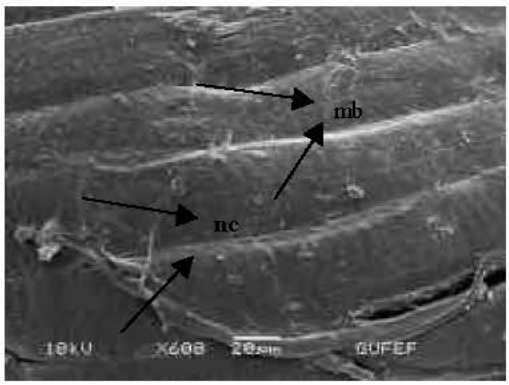

Fig. 6: The nerve cells (nc.) that control the contraction of the bulky muscular layer can be easily observed on the surface on the muscle bundles (mb.)

The results obtained by scanning electron microscopy show that the venom glands of *L. ixobolus* are equal size and they look like a carrot (Fig. 4). The distal portion of the venom gland is narrower than the proximal portion. Each gland is surrounded by bulky muscular layer. These gross muscle bundles spirally covering the venom gland can be easily observed (Fig. 5). The venom, is produced in the venom glands, is exited from the venom pore during the muscular contraction. Also, the nerve cells that control the contraction of the bulky muscular layer can be easily observed on the surface of venom gland by SEM. The nerve cells especially are located the distal portion of the venom gland surface (Fig. 6).

DISCUSSION

The position of the fang is important for spiders. In spiders, the position of the fangs 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 *Larinioides ixobolus*, a spider belonging to the suborder Labidognatha, located in the prosoma. These characteristics are found in *Loxosceles intermadia* (Santos *et al*., 2000) and *Agelena limbata* (Moon, 1996), both labidognatha spiders.

The gross morphology of the venom apparatus of spider, *Larinioides ixobolus*, is basically similar to those of other kinds of spider (Moon and Tillinghast, 1996; Yigit *et al*., 2004). The venom apparatus is generally composed of a pair of chelicerae and venom glands.

Spiders use their chelicerae for defense, seizing prey, carrying egg cocoons, making noise and digging. In many species, both sides of the cheliceral grooves are often armed with cuticular teeth. 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 taxonomist (Foelix, 1982). In *L. ixobolus*, there are three marginal teeth on the both side of the cheliceral groove.

In some spiders, 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. In addition, some spiders' fang possesses a ridge on the lateral side

with a blade-like structure. The tip of the fang of *L. ixobolus* is not very sharpness and do not have the cutting ridge or blade-like structure on lateral side when it compare with other spiders. Similarly, there are not regular and parallel fine grooves on the surface of fang in *L. ixobolus*, but many venomous species as *Latrodectus* and *Agelena* possess these structures (Yigit *et al*., 2004). These grooves probably suck up the body fluids of the prey by capillary action. But additional studies are needed to prove this relation.

The venom glands of *L. ixobolus* are paired structures located in the prosoma. Most labidognath spiders, including *L. ixobolus*, have relatively large venom glands that extend out of the chelicerae and reach the middle of the prosoma. Kovoor and Munoz-Cuevas (2000) described the structure and histochemistry of the poison glands in *Lycosa 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 shape of the venom glands is different in various species of spider: bulbous in *Loxosceles 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* (Ridling and Phanuel, 1989), whereas the venom glands of *L. ixobolus* look like a carrot. The distal portion of the venom gland is narrower than the proximal portion. In addition, blocks of muscle bundles spirally encapsulating the glands can be observed, the muscle bundles spirally covering the gland is prominent. In contrast to the *L. intermedia,* external muscular cells are branching in morphology (Santos *et al*., 2000).

The venom gland of *L. ixobolus* is surrounded by a thick layer of striated muscle which encircles the gland. The contraction of the bulky muscular layer is controlled by the nerve system. The nerve cells can be easily observed on the surface of the venom gland. The nerve cells especially are located the distal portion of the venom gland surface. When the spider is excited, nerve cells produce impulse and then the venom is produced in the venom glands and it is carried by venom ducts passing through the chelicerea, exiting from the venom pore during the muscular contraction.

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