Morphology of the external sense organs on the adult Lycosoides coarctata (Araneae: Agelenidae) inhabiting Assiut Governorate, Egypt.

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Abstract

Spiders are equipped with a large number of sense organs, which respond to various sensory stimuli. The spider's body hair and spines are high sensitive to touch and to vibrations. Spiders can feel a puff of air so gentle that it only stirs one hair. Spiders do not have ears, but have an excellent hearing. They pick up sound vibrations with tiny hairs on their legs and bodies. A spider can "hear" the vibrations of an insect walking along the ground or onto a web. They can tastes and smells with its feet. Scanning electron microscopic studies illustrate the presence of different types of hairs and sensilla on different parts of adult males and females of *Lycosoides coarctata*. There are two stimuli affected to spiders, mechanical and chemical stimuli. Here we focus on the different types of sensilla: the mechanosensory setae, trichobothria, slit sensilla, lyriform organs, trichoid sensilla, sensilla placodea, sensilla styloconica and chemosensory setae. Trichobothria have a cup-like socket and a long hair-like projection. Trichobothria present on all walking legs, pedipalps, chelicerae and are the air movement sensors of spiders.

Introduction

Members of the family Agelenidae (Funnel web spiders) are small to medium sized with a body typically ranging from1/3 to 2/3-inch when full grown, ecribellate spiders, the color with dissimilar shades of brown and grey and dorsal side consists of a reddish-brown folium and a series of pale spots (Koch 1837). Family Agelenidae, represented by 515 species occur worldwide (World Spider Catalog 2022), 72 species in Africa (Keil 1997) and 7 species in Egypt (El-Hennawy 2017). The family Agelenidae was for long time a dumping ground for three-clawed, ecribellate entelegyne spiders, lacking the distinctive characters of better defined groups (Lehtinen 1967). Agelenids build flat, slightly concave brushed sheet webs with a funnel-shaped retreat in a variety of habitats usually in grass and low vegetation but also in caves, buildings and other man-made constructions. They have four pairs of eyes that are roughly the same size. The legs and body are hairy and legs usually have some dark banding. They are often mistaken for wolf spiders (family: Lycosidae) but the size and pattern of eyes can most easily distinguish them. Like wolf spiders, the funnel weavers are very fast runners. Funnel weaver spiders capture prey with a horizontal sheet web, constructed of thick silk. In one corner of the web is a narrow funnel “retreat,” which is often out of sight extending into a protective recessed area. The web is not sticky but usually includes vertical strands that can help impede passing insects. Funnel weavers can be easily found from brown recluses by several features including patterning of the abdomen, banding on the legs, and hairiness of the body and legs, among other characters. Arthropods have a sensory system which mediates environmental interactions and supports essential activities such as foraging and mating (Stevens 2013). Besides the well-developed visual sense, arthropods have many small internal and external sense organs, distributed all over the body and all appendages, which process various sensory stimuli (Foelix 2011 and Barth 2001). While considerable information is available on the development, distribution and physiology of all types of sense organs in insects, the remaining arthropod groups lack behind. Information is available on the development, distribution and physiology of all types of sense organs in insects, the remaining arthropod groups lack behind (Barth et al 2004 and Barth 2004). Similar to the other arthropod groups, spiders exhibit a large variety of sensilla shapes. Here we focus on the six best described sensilla: the mechanosensory setae, trichobothria, slit sensilla, lyriform organs and chemosensory setae.

The chemosensory setae (also called tip-pore sensilla) of spiders exhibit a blunt end with an open pore, are striated and slightly curved and arise at a steep angle from the socket (Pfreundt and Peters 1981). They are the only type of chemosensory setae described so far in spiders and it is therefore assumed that they are used both for gustatory and olfactory reception (Barth 2001; Ganske and Uhl 2018). Mechanosensory setae are touch sensitive, have a tapered tip and can be short, long and slender (hair-like), or sturdy (bristle-like). MS setae show a longitudinal grooved profile with spines, while chemosensory setae appear striated due to shallow spiral indentations and have a pore at the tip. In mechanosensory setae, the sockets open towards distal, while they open vertically in chemosensory setae. The first chemosensory setae appear at the tip of the tarsus, close to the claw and can clearly be distinguished from the mechanosensory setae by the above described morphological features. Trichobothria are present on the tibia and metatarsus and exhibit the typical cup-like socket. Similar to mechanosensory setae, the cuticular outgrowth shows a grooved surface with spines but it arises at a steep angle and is only half as wide as the mechanosensory setae. Trichobothria are the air movement sensors of spiders and unique to arachnids (Barth 2001). Single slit sensilla are scattered over all podomeres and vary in size (8–20 µm). The lyriform organs, which are composed of several slit sensilla, are always located close to the joints. Many exhibit serrated surface but smooth mechanosensory setae have been described as well (Eckweiler et al 1989). Lyriform organs composed of many parallel individual slits (Barth 2012a). Slit sensilla respond to mechanical strain of the cuticle, which can be triggered by muscular activity, haemolymph pressure, and gravity and substrate vibrations (Barth 2001). Aim of these study revealed the distribution of these sensory structures on all parts of the male and female of *Lycosoides coarctata*.

Materials And Methods

The specimens of *Lycosoides coarctata* (Dufour 1831) were collected feed cattle stores and accumulate on the palm trees located in the farm of Assiut Agriculture College, at Assiut governorate, Egypt. They have characteristic webs, consisting of a flat, slightly concave silk sheet with a funnel-shaped retreat at the corner. The webs were close to the soil surface and among the trunks of the olive and palm trees. Specimens were collected seasonally during a year. Specimens were collected by hand-Pick up and Sweep net. Specimens were washed carefully by water and then dissected and saved each part in 70% ethanol for light microscope-investigation and all samples were brushed using a thin painting brush of synthetic fibers, following the direction of the hair. Very dirty samples, especially of hard structures such as the male copulatory bulb were cleaned for a few seconds in an ultrasonic cleaner. Before drying, some hairs had to be removed with fine forceps to expose structures. For preparing samples for (SEM), all samples were critically-point dried after dehydration in ethanol series. Each sample was mounted on a separate aluminum stub, using adhesive carbon tabs or adhesive copper tape. During mounting, some further depilation was made with fine forceps, the loose hairs or dirt then removed with brush and a jet of air blowing through a thin pipette connected to a rubber tube. To allow for better conductivity, once positioned on the adhesive medium, the borders of the pieces were glued to the conductive substrate with colloidal graphite on isopropanol base. Such conductive paint reduces the charging of the sample under the SEM, and further secures the piece. The preparation identifier was engraved on each stub with a needle to make it visible in the SEM monitor with the aid of binocular stereomicroscope and scanning electron microscope. The identification of this specimen was carried out on the light of the available taxonomical knowledge. Many keys, papers and catalogues were used for identification of this recorded species (Petrunkevitch (1939); Levi (1968); Kaston (1978); Tikader (1987); Coddington and Levi (1991); Roth (1993); Sewlal and Cutler (2003); Ubick et al (2005); Jocoquè and Dippenaar_Schoeman (2006) and El-Hennawy (2006 and 2010) and Hussien (2011 and 2015). Here we analyze the distribution and development of the external sense organs on all body parts of *Lycosoides coarctata* with specific focus on the different types of setae which distributed on all appendages.

Results

Members of this species are medium-sized spiders, commonly known as the funnel-web spiders. Their colour is brown, dorsum usually with pattern consisting of a reddish brown folium and a series of pale spots; legs banded. The body consists of prosoma (cephalothorax) and opithosoma. The prosoma takes a pear-shape with brown demarcations. Cephalic region elongated and raised upwards while the thoracic one circular in shape (Fig. 1(A&B). The size is ranging between 8–12 mm (found the male slightly smaller than female and legs more slender). On the ventral side, sternum is wide, heart-shaped (Fig. 1C).

Eyes located on the frontal end of prosoma are eight black eyes arranged into two rows (4:4) and equal in size (Figs. 1D, E&F). **Tactile sensory hairs** are thin, long, blunt tips and bear buds on the surface. They are distributed on the dorsal side of prosoma and between eyes with different length (Fig. 1(E&F)). **Sensilla placodea** are oval to nearly circular disc with numerous pores, where they are surrounded by a multi-porous membranous ring, so they are distinguished as plate organs (Fig. 2A). They are located above, or below the cuticular surface. Tactile hairs are distributed on dorsal side of prosoma between eyes of male and female (Fig. 2B&C).

Thickened trichobothria with different length, blunt tip and large prominent sockets are present on the dorsal side of prosoma. This type of trichobothria may act as mechano-chemosensory receptors and detect air vibration and current. Chelicerae are composed of articulated fang with pointed retromarginal and promarginal teeth (Fig. 2D&E). Tactile hairs are accumulated with thickened trichobothria on dorsal and ventral sides of male and female chelicerae (Fig. 2F&G). The stridulatory sense ridges are present on the ventral side of male and female chelicerae (Fig. 2G, H and 3A, B). On female *Lycosoides coarctata*, there are sensory papillae like sensory warts present around the cheliceral retromarginal and promarginal teeth (Fig. 3B&C). Short tactile curved hairs are distributed on the dorsal side of chelicerae (Fig. 3D&E). Mouthparts of males and females of *Lycosoides coarctata* are composed of two maxilla and labium. Labium take a triangular shape (Fig. 3F&G).

Sensilla trichodea type1 are a hair-like projection which articulated by a membranous prominent socket so that it is free to move. They are slightly elevated above the cuticle, each sensillum had a straight had a straight, blunt tip that narrowed at the distal region. Trichoid sensillum has a smooth surfaced and blunt-tipped shaft. Slightly curved trichoid sensilla with many tiny sensory hairs on each maxilla are present. The wall of the shaft is perforated by numerous minute pores. There are present on the interior side of maxilla beside the sharped teeth with tactile sensory hairs (Fig. 3H, I, J and K). Female pedipalps are composed of tarsus, tibia, patella and femur (Fig. 4A&B).

Large tactile seta is long as corn-shaped and bears small barbs on lines. This seta inserted into a socket present on the ventral and lateral side of the region near the joint between tarsus and tibia in female pedipalps. Large tactile setae are present on lateral side of the female pedipalps with thickened trichobothria (Fig. 4C&D).

The chemosensitive hairs are a bent hair shaft which is smooth at the base but bears spiny extensions more distally and the hair tip is blunt and exhibits a small pore that connects the outside with dendritic nerve fibers inside the hair shaft. They are present between thickened trichobothria and tactile hairs surrounded by three claws on the female pedipalps (Fig. 4E&F).

Urticating hairs are barbed. When threatened, the spider “kicks” them off using a rear leg. These spiders brush their back legs rapidly across the back of the abdomen. This sends clouds of loosely attached barbed hairs into the eyes, nose, or mouth of the predator chasing them. These are present on the dorsal side of tibia of the female pedipalps (Fig. 4G).

Slit sensilla (Lyriform organ) are slit-shaped holes in the cuticular exoskeleton. They present singly in loose groups and in tight groups called lyriform organ. Lyriform organ are present on the ventral side of the joint between femur and patella of the female pedipalps (Fig. 4H&I). Male Pedipalps consisted of coxa, trochanter and femur are normal. Patella is triangular in shape with two long prominent and slender macro-setae. Tibia is short, covered with hairs and provided with pro-lateral apophasis. Palpal organ is large. Cymbium is slightly rounded, blackish, covered with short and long white hairs and bears a paracymbium near its base. Tegulum is intact. Conductor is highly sclerotized and supporting the embolus. The latter is thick and curled in a semi-circular shape, arising above a large oval median apophasis. Median apophasis is broad at its base and ends with a very long stout spur. Terminal apophasis is dark red and its surface bears small tubercles (Fig. 4J, K &L). Large tactile setae and thickened trichobothria are distributed on the dorsal side of the cymbium of the male pedipalps (Fig. 5A).

Filiform trichobothria are short, thin, bear barbs and with sharp apical end. They are present in straight line with tactile hairs, urticating hairs and single group of slit sensilla on the dorsal side of tibia of the right male pedipalps (Fig. 5B&C and D). Short tactile setae are present on the ventral side of tibia of the right male pedipalps (Fig. 5E).

Opisthosoma of male and female is narrowly oval, tapering posteriorly, covers in dense hairs; dorsum with pattern. Epigynum is sclerotized plate slightly bulging from the opisthosoma, forming a broad dark brownish sclerotized swallow. The latter is fused into a short triangular scape, which in turn widens into two black oval expansions that have prominent rims (Fig. 5F&G). These widens comprise the floor of the two genital openings. Vulva are two openings in the genital plate lead to two short spermathecal ducts that are connected with two globular sperm receptacles. There are two book lungs; one pair of tubular tracheae close to spinnerets (Fig. 5G). Spinnerets are brown and covered with black hairs. The anterior spinnerets are widely separated, the posterior spinnerets are long and slender; two segmented, with apical segment towards tip (Fig. 5H&I). Colulus is reduced to small projection with short black setae. Anal tubercle is dark brown and its tip covered with strong black hairs. On the ventral side of opithosoma there are short anterior spinnerets, long posterior spinnerets and triangular epigynum. Numerous numbers of tactile sensory hairs, urticating hairs and thickened trichobothria cover the dorsal and ventral of opithosoma (Fig. 5J). There are Aciniform spigots with long posterior lateral spinnerets (Fig. 5K).

Walking legs are long, slender and armed with numerous setae. Tarsi on the first left leg with three claws. Long tactile setae and urticating hairs are present on the dorsal side of tarsus and on the joint between tarsus and metatarsus on the male first left leg (Fig. 6A&B). Two types of tactile hairs (long and short), large tactile seta and urticating hairs distributed on ventral and dorsal side of metatarsus, femur and tibia of the first left leg (Fig. 6C, D and E).

Scopulate hairs are the dense adhesive hairs that give many ground spiders the ability to walk on vertical and even overhanging smooth surfaces like glass. These hairs are used for locomotory purposes for many spiders. There are relatively numbers of scopulate hairs on the ventral side of claws (Fig. 6F). Large tactile seta are present on dorsal and ventral side of the joint between tarsus and metatarsus of the male first right leg (Fig. 6G). The scopulate hairs are accumulated on the ventral side of tarsal claws (Fig. 6H&I). Thickened trichobothria and large tactile setae are present on numerous numbers on the dorsal and ventral sides of all walking legs (Fig. 6J&K).

Discussion

Spiders have a good mechano and chemo-sensory system. They respond to external stimuli such as touch, hanged which the sensory hairs on the legs help spider to sense the substrate and important in interactions ranging from mating to prey capture. Spider vision was unimportant for spiders that depend on capturing prey within webs. Agelenidae spiders use patterns of vibration on the web to distinguish among prey, predator, or mate. Most spiders have poor eyesight and many of them are active during the dark night hours. Web-building (Aglenidae) spiders have poor vision (Barth 2002). In the present study found eyes of *Lycosides coarctata* located on the frontal end of prosoma are eight black eyes arranged into two rows (4:4) and equal in size. Eyes are considered "simple": they do not have multiple lenses and facets as do the compound eyes found on some insects according to (Jackson 1986). Although some *Lycosides coarctata* can only see the difference between light and shadow according to (Barth 2015). Tactile sensory hairs are widely distributed on the dorsal and ventral sides of prosoma of the males and females of *Lycosides coarctata*. McIver (1985) indicated that despite a large variety in size and shape, the mechanosensitive hair sensilla of arachnids share the following characteristics: (I) A hollow cuticular shaft, suspended movably in a socket via an articulating membrane, and (2) several sensory cells whose dendrites are attached to the base of the hair shaft. A multiple innervation is typical for arachnid mechanoreceptors, whereas tactile hairs in insects are singly innervated according to (Jackson 1986 and Jocqué et al 2013). The tactile sense is a close-range sense par excellence. Tactile hairs all have a so-called tubular body in their dendritic ends indicating their mechanorece types of morphology and arrangement (Seyfarth 2000). These tactile hairs are surprisingly well “designed” to serve their particular sensory purpose. The sense of touch, however, is served by the other group of sensors, the hair sensilla. Bays et al (2006) stated that tactile hairs are particularly numerous in hunting or wandering spiders which do not build webs to catch prey but roam around and much more rely on their tactile sense than do for instance orb weavers. The function of tactile suppression, or movement-related gating of tactile stimuli, is most likely to suppress inputs that can be predicted from the motor command, so as to enhance the detection of other novel stimuli (Coulter 1974 and Chapman et al 1988). These controls act to limit the quantity of afferent feedback that is processed at higher levels of the neuraxis. Sensilla placodea are distributed on dorsal side of prosoma of the males and females of *Lycosides coarctata*. According to (Stevens 2013), they are divided into open placodea surrounded by an outer membranous ring, positioned below the cuticular. (type I); closed placodea covered externally by an oval or elliptical plate surrounded by a narrow outer membranous ring, positioned at the cuticular surface (type II); and closed Placodea covered externally by an oval or elliptical plate surrounded by wider outer membranous ring, positioned above the cuticular surface (type III). Suwannapong et al (2012) suggested that the sensilla placodea serve as odour receptor function which present on large numbers on antenna in Thai single open nest honey bees (Hymenoptera: Apidae). Awad (1999) indicated that these types of sensilla are present between Ommatidea of the compound eyes of male and female of beet armyworms moths and may present in large area under the compound eyes as lashes and suggested that may have a role in detecting general odor. Sensilla trichodea are present on the ventral side of maxilla and tinny tactile hairs are widely distributed on labium and two maxilla of males and females mouthparts of *Lycosides coarctata*. Awad (1999) found twelve trichoid sensilla on the dorsal surface of the labrum of the noctuid, *Spodoptera exigua*. Grimes and Neunzig (1986) indicated that when the mandibles are closed, the sensilla trichodea lean against the mandible's outer surface. They also suggested that the sensilla trichodea serve as mechanoreceptors, responding to the movement of the mandibles.

Urticating hairs are distributed on dorsal side of prosoma of the females of *Lycosides coarctata*. Ganske and Uhl (2018) suggested that the urticating hairs can lead to skin or mucosa irritation even when dead specimens or molts were handled or cages of pet tarantulas cleaned. Urticating hairs are not just thrown at an enemy as a first line defense, but are also used as an indication of territory according to (Peters 1967). They can be found on and around the burrow entrance and in webbing for protection (for example, some subfamily Theraphosinae species include these bristles in cocoon silk). Shultz etal (2009) stated that urticating hairs protect tarantula egg sacs (*Avicularia* spp. and *Theraphosa blondi* respectively). This is thought to discourage fly larvae from consuming their eggs and young. Urticating hairs are found on the dorsal prosoma of males and females and distributed randomly with the different length of tactile sensory hairs. There are distributed when threatened, the spider “kicks” them off using a rear leg.

Lycosides coarctata spiders brush their back legs rapidly across the back of the abdomen. This sends clouds of loosely attached barbed hairs into the eyes, nose, or mouth of the predator chasing them. The spider escapes while its stalker is confused by the highly irritant hairs. Thickened trichobothria are distributed on female and male palpi, opithosoma and all walking legs, these results agree with Foelix and Bruno (2010). (Buchl 1969; Reissland and Görner 1985) reported that trichobothria are sound detectors but they can also detect substrate vibrations. Dahl (1883) reported that trichobothria are sound detectors but they can also detect substrate vibrations (Buchl 1969; Reissland and Görner 1985). The stridulatory ridges observed on dorsal and ventral side of males and females chelicerae. There are two types of tactile sensory hairs, long straight type and short curved type. Foelix (1985) suggested that the stridulatory ridges may have chemoreceptor functions. Through high magnification of the ventral side of left female chelicerae there are sensory papillae like warts surrounded the retromarginal teeth which may act as chemosensitive sensilla. In the contrary, on male chelicera these sensory warts disappear on the ventral side. These sensory papillae like sensory warts which may act as chemosensitive receptors for the pheromone according to Harris and Mill (1973). Vollrath and Selden (2007) stated that the arrangements of the Aciniform spigots of some mygalomorphs in a line along the long axis of the long posterior lateral spinneret is apparently an ancient trait. Large tactile seta is long as corn-shaped and bears small barbs on lines. These results agree with (Ghiradella 2010). Ghiradella (1998) recorded that touching the setae elicits action potentials, as was shown by electrophysiological recordings. Thus, the large tactile setae can be interpreted as typical contact chemoreceptors, responding to both mechanical and chemical stimuli. This may cause more resistance to air currents and since they sit rather firmly in their sockets, they may transmit mechanical load to slit sensilla in the cuticle (Barth et al 2013). Setae on insect wings could serve many different functions: reducing the weight of the insect (Sunada et al 2002), providing an aerodynamic benefit (Davidi and Weihs 2012), enhancing electrostatic charges to help in dispersal, similar to what has been suggested for spiders (Gorham 2013), helping to fold and unfold the wings (Ellington 1980), or acting as mechanosensory structures, similar to those in Drosophila (Valmalette et al 2015). These large tactile setae may act as mechanoreceptors according to (Petrunkevitch 1925).

Declarations

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Authors' contributions

Marwa A. Abdel-Mageed collected all specimens, prepared all figures, and drafting the manuscript. Ahmad H. Obuid-Allah was the main contributor to the idea of this research, put the study design and revised the manuscript. Nasser A. Elshimy and ElAmier H. M. Hussein revised the draft of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated are available in the manuscript and could be asked from the corresponding author any time.

Code availability Not applicable.

Conflict of interest The authors have no conflict of interest to declare.

Ethics approval and consent to participate

All animal experiment methods were carried out in accordance with the Institutional Animal Care laws and were authorized by Assiut University. All animal procedures were carried out in accordance with the Declaration of Helsinki and the NIH protocol for the care and use of experimental animals. We tried to keep animal distress and the number of animals to a minimum.

Consent for publication

Not applicable.

Consent to participate Not applicable.

Competing interests

The authors declare no competing of interests.

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Figures

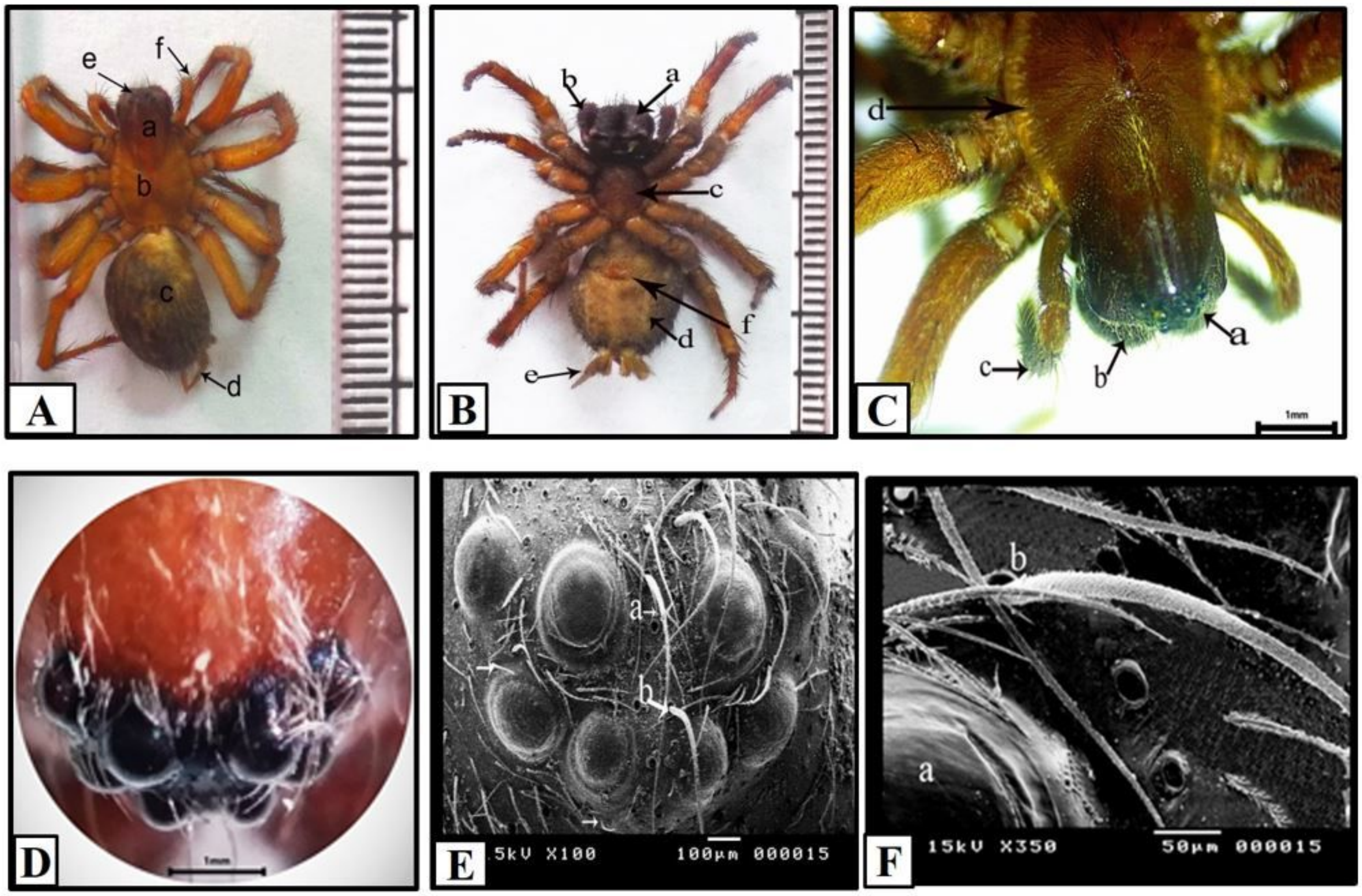

Figure 1

(A) Light photograph of the dorsal side of the adult female of *Lycosoides coarctata* showing: a. Prosoma. b. Cephalic region. c. Opithosoma. d. Spinnerets. e. Chelicerae. f. Female pedipalps. **(B)** Light photograph of the ventral side of adult male of *Lycosoides coarctata* showing: a. Chelicerae. b. Male pedipalp. c. Sternum. d. Opithosoma. e. Spinnerets. f. Epigynum. **(C)** Light photograph of the frontal side of prosoma of the female showing: a. Eyes. b. Chelicera. c. Female pedipalps. d. Prosoma. **(D)** Light photograph of the frontal side of prosoma of the male showing: high magnification of the eyes. **(E)** Scanning electron micrograph of the frontal side of prosoma of the female *Lycosoides coarctata* showing: a. tactile hairs. B. sensilla trichodea type2 (arrow). **(F)** SEM of the dorsal side of prosoma of the female showing: a. Lateral eye. B. tactile hair.

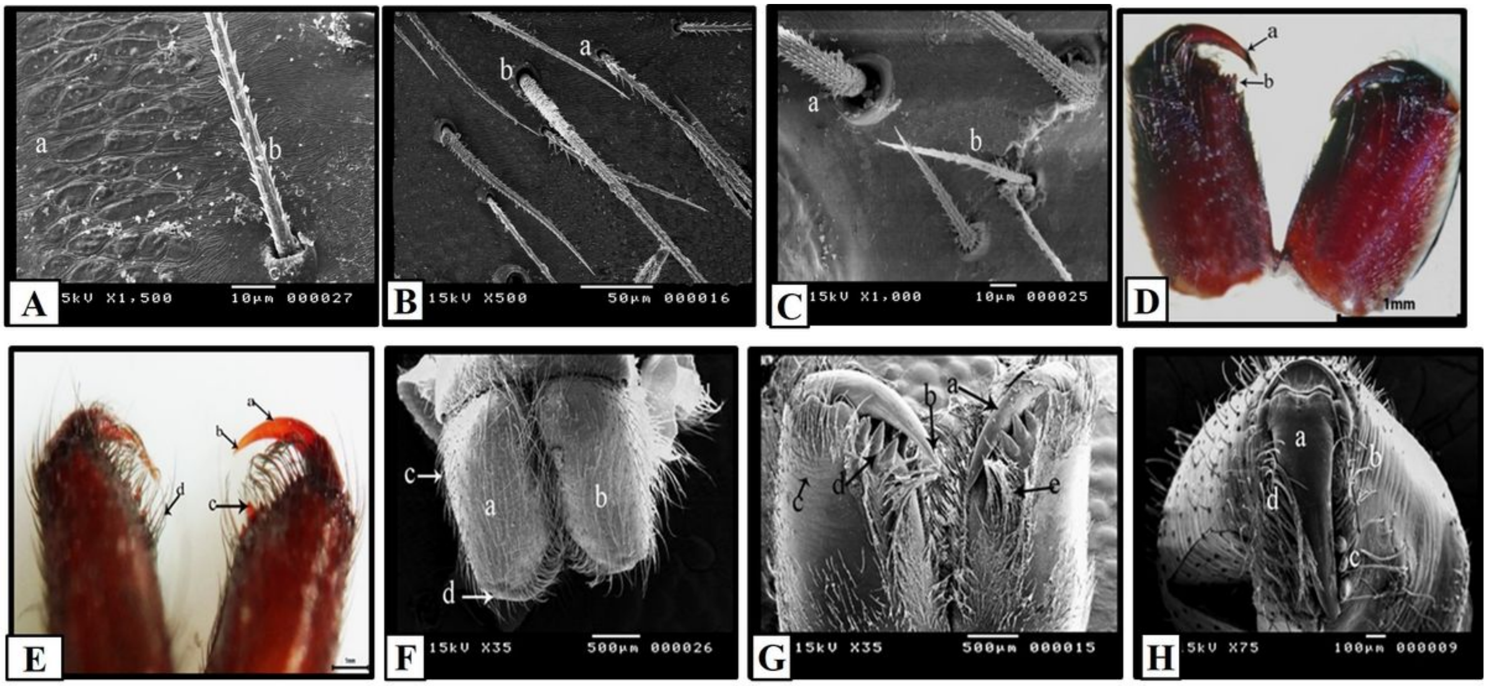

Figure 2

(A) SEM of the dorsal side of prosoma of the male showing: a. Sensilla placodea. b. Thickened trichobothria. **(B)** SEM of the dorsal side of prosoma of the male showing: a. Urticating hair. b. Long tactile hair. **(C)** SEM of the ventral side of the female prosoma showing: a. Long tactile hair. b. Short tactile hair. **(D)** Light photograph of the ventral side of the male chelicera showing: a. Right articulated fang. b. Retromarginal teeth. **(E)** Light photograph of the ventral side of the female chelicerae showing: a. Left articulated fang. b. Opening of venom gland. c. Retromarginal teeth. d. Tactile hairs. **(F)** SEM of the frontal side of the male prosoma showing: a. Right chelicera. b. Left chelicera. c. Tactile hairs. d. Right cheliceral fang. **(G)** SEM of the ventral side of the female right chelicerae showing: a. Left fang. b. The opening of venom gland. c. basal segment of right chelicera. d. Retromarginal teeth. e. Dense tactile hairs. **(H)** SEM of the frontal side of the female right chelicera showing: a. The articulated fang. b. Stridulatory ridges. c. Retromarginal teeth. d. Dense tactile hairs.

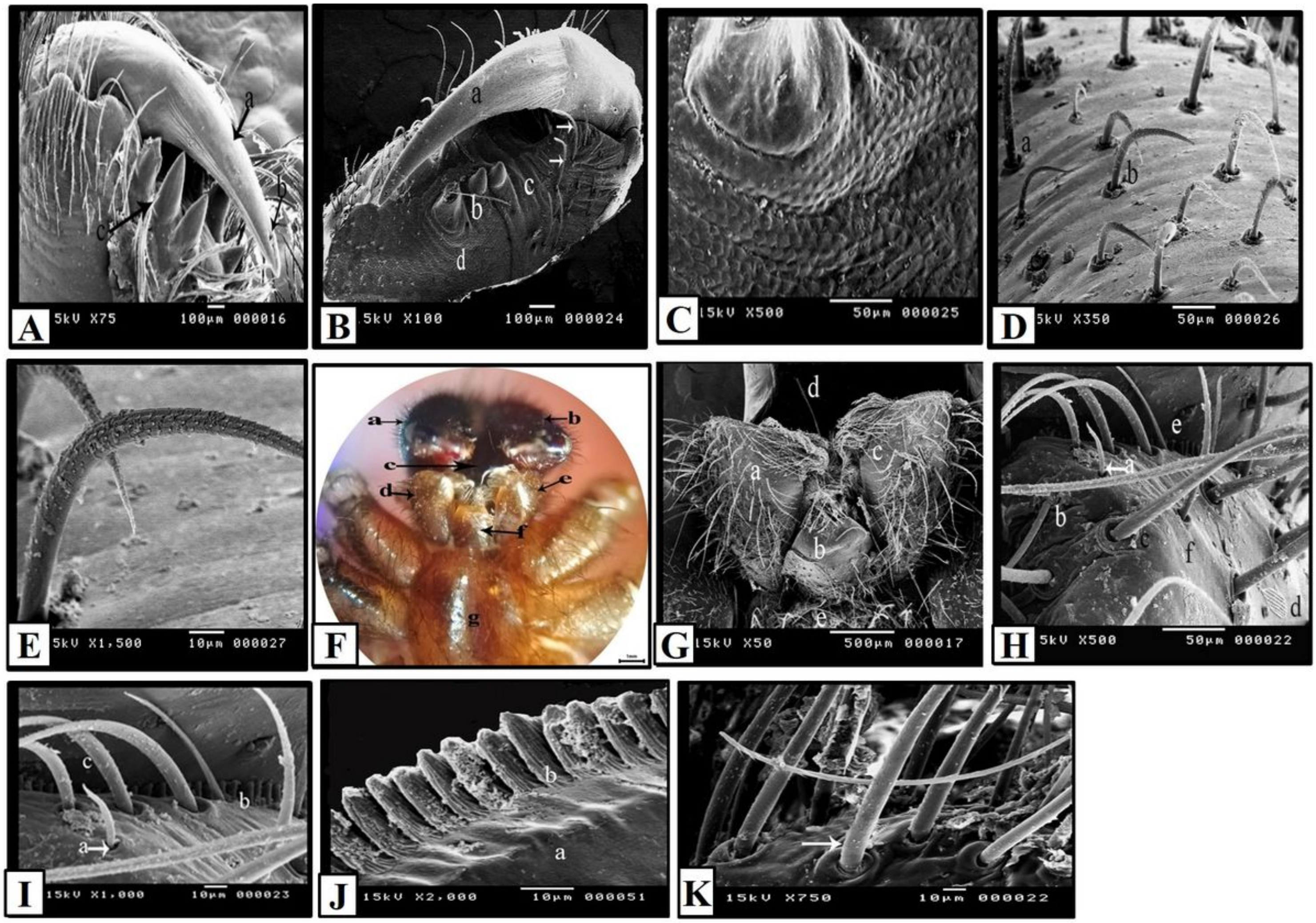

Figure 3

(A) SEM of the female right chelicera showing: a. Cheliceral fang. b. Opening of venom gland. c. Retromarginal teeth. **(B)** SEM of the ventral side of the female left chelicera showing: a.. Articulated fang. b. Retromarginal teeth. c. Stridulatory ridges. d. Sensory warts. **(C)** SEM of the high magnification of the sensory waets surrounded the female left cheliceral teeth. **(D)** SEM of the dorsal side of the basal segment of the right male chelicera showing: a. Long tactile hair. b. Short curved tactile hair. **(E)** SEM of the dorsal side of the male chelicera showing: high magnification of the short curved tactile hairs. **(F)** Light photograph of the ventral side of the female showing: a. Right chelicera. b. Left chelicera. c. mouth opening. d. Right maxilla. e. Left maxilla. f. Labium. g. Sternum. **(G)** SEM of the ventral side of the female prosoma showing: a. Right maxilla. b. Labium. c. Left maxilla. d. Mouth opening. **(H)** SEM of the ventral side of the male prosoma showing: a. Sensilla trichodea type1. b. Sensilla trichodea type2. c. Taxtile hairs. d. Slit sensilla. e. Teeth. **(I)** SEM of the ventral side of the male prosoma showing: a. Sensilla trichodea type1. b. Teeth. c. Tactile hairs. **(J)** SEM of the ventral side of right maxilla of the female showing: a. Right maxilla. b. Teeth. **(K)** SEM of the dorsal side of left male maxilla showing: tactile hairs (arrow).

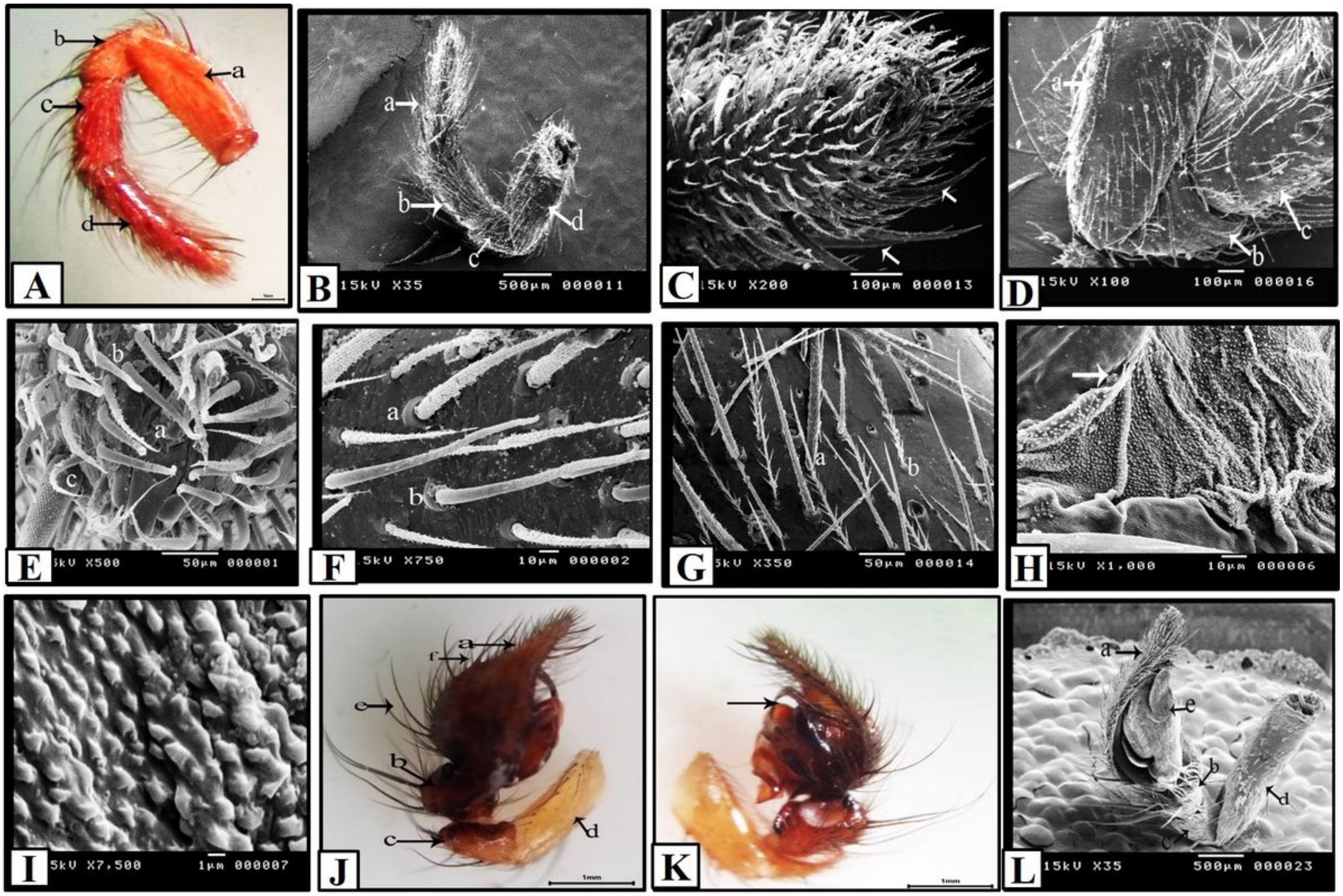

Figure 4

(A) Light photograph of the right female pedipalp showing: a. Femur. b. Patella. c. Tibia. d. Tarsus. **(B)** SEM of the left female pedipalp showing: a. Tarsus. b. Tibia. c. Patella. d. Femur. **(C)** SEM of the lateral side of right female pedipalp showing: large tactile setae (arrow). **(D)** SEM of the lateral side of the right female pedipalp showing: a. Femur. b. Patella. c. Tibia. **(E)** SEM of the distal end of tarsus of the right female pedipalp showing: a. Claw pedipalp. b. Chemosensitive hairs. c. long tactile hair. **(F)** SEM of the dorsal side of the tarsus of the right female pedipalp showing: a. Long tactile hair. b. Chemosensitive hair. **(G)** SEM of the dorsal side of the tibia on the left female pedipalp showing: a. Large tactile hair. b. Urticating hair. **(H)** SEM of the ventral side of the joint between femur andpatella of the left female pedipalp showing: slit sensillae (chemoreceptor functions). **(I)** SEM of the ventral side of the joint between femur and patella of the left female pedipalp showing: slit sensellae (lyriform organ). **(J)** Light photograph of the dorsal side of the left male pedipalp showing: a. Cymbium. b. Tibia. c. Patella. d. Femur. e. Long tactile hairs. f. Short tactile hairs. **(K)** Light photograph of the ventral side of the left male pedipalp showing: embolus (arrow). **(L)** SEM of the ventral side of the right male pedipalp showing: a. Cymbium. b. Tibia. c. Patella. d. Femur. e. Embolus.

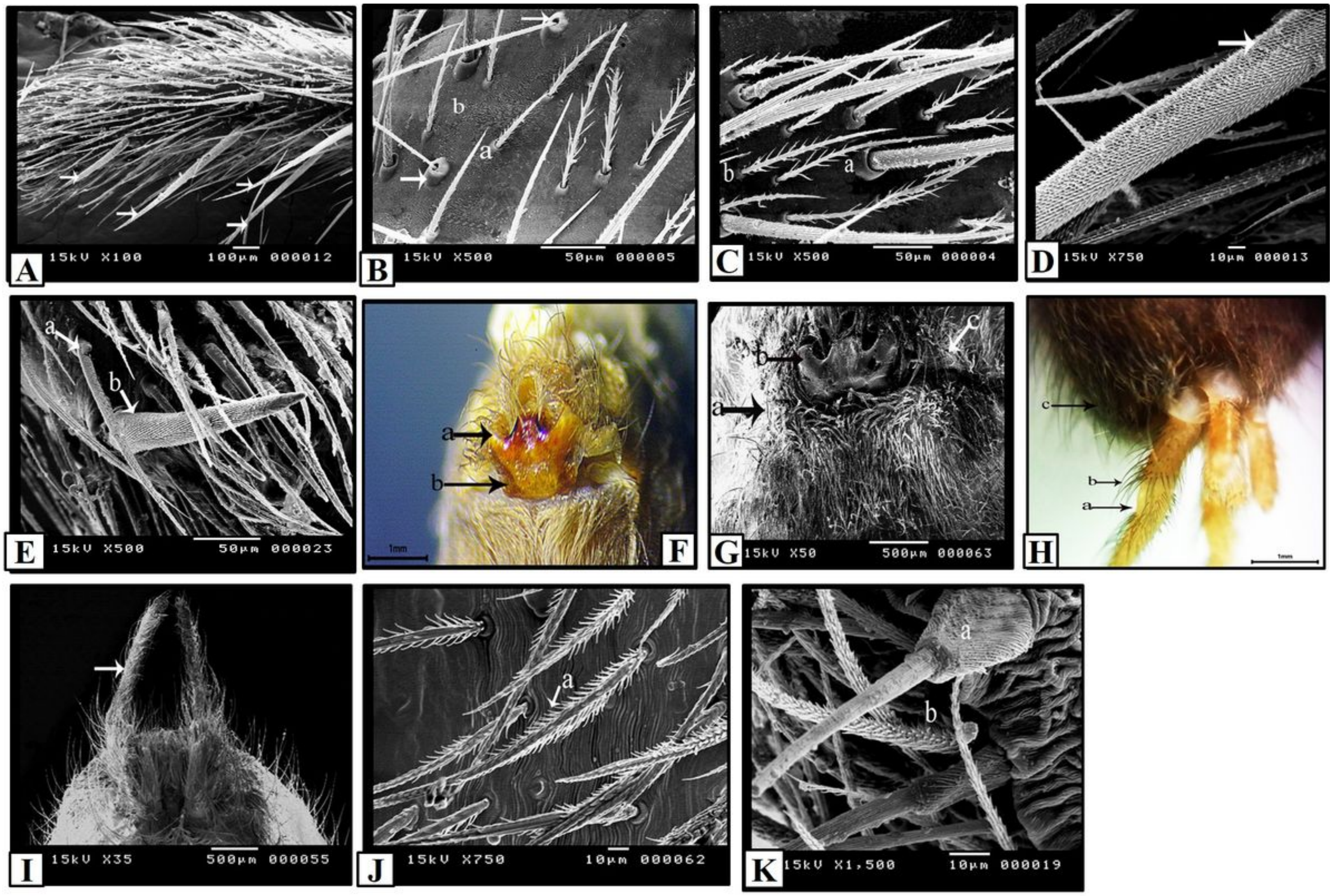

Figure 5

(A) SEM of the dorsal side of the cymbium (tarsus) of the right male pedipalp showing: large tactile setae (arrows). **(B)** SEM of the dorsal side of tibia of the right male pedipalp showing: a. Tactile hairs. b. Slit sensillae. Filiform trichobothria (arrows) distributed on straight line. **(C)** SEM of the dorsal side of cymbium of the left male pedipalp showing: a. Large tactile setae. b. Urticating hair. **(D)** SEM of the high magnification of the large tactile seta. **(E)** SEM of the ventral side of tibia of the right male pedipalp showing: a. Tactile hairs. b. Short tactile seta. **(F)** Light photograph of the ventral side of the female opithosoma showing: a. Epigynum. b. Lung slit. **(G)** SEM of the ventral side of the female opithosoma showing: a. Lung slit. b. Epigynum. **(H)** Light photograph of the distal end of the male opithosoma showing: a. Posterior long segmented slender spinnerets with apical segments. b. Tactile hairs. c. thickened trichobothria. **(I)** SEM of the ventral side of the distal end of the male opithosoma showing: the posterior long segmented spinnerets (arrow). **(J)** SEM of the ventral side of the male opithosoma showing: a. Urticating hairs. **(K)** SEM of the interior side of the female spinnerets showing: a. Aciniform spigots. b. Tactile hairs.

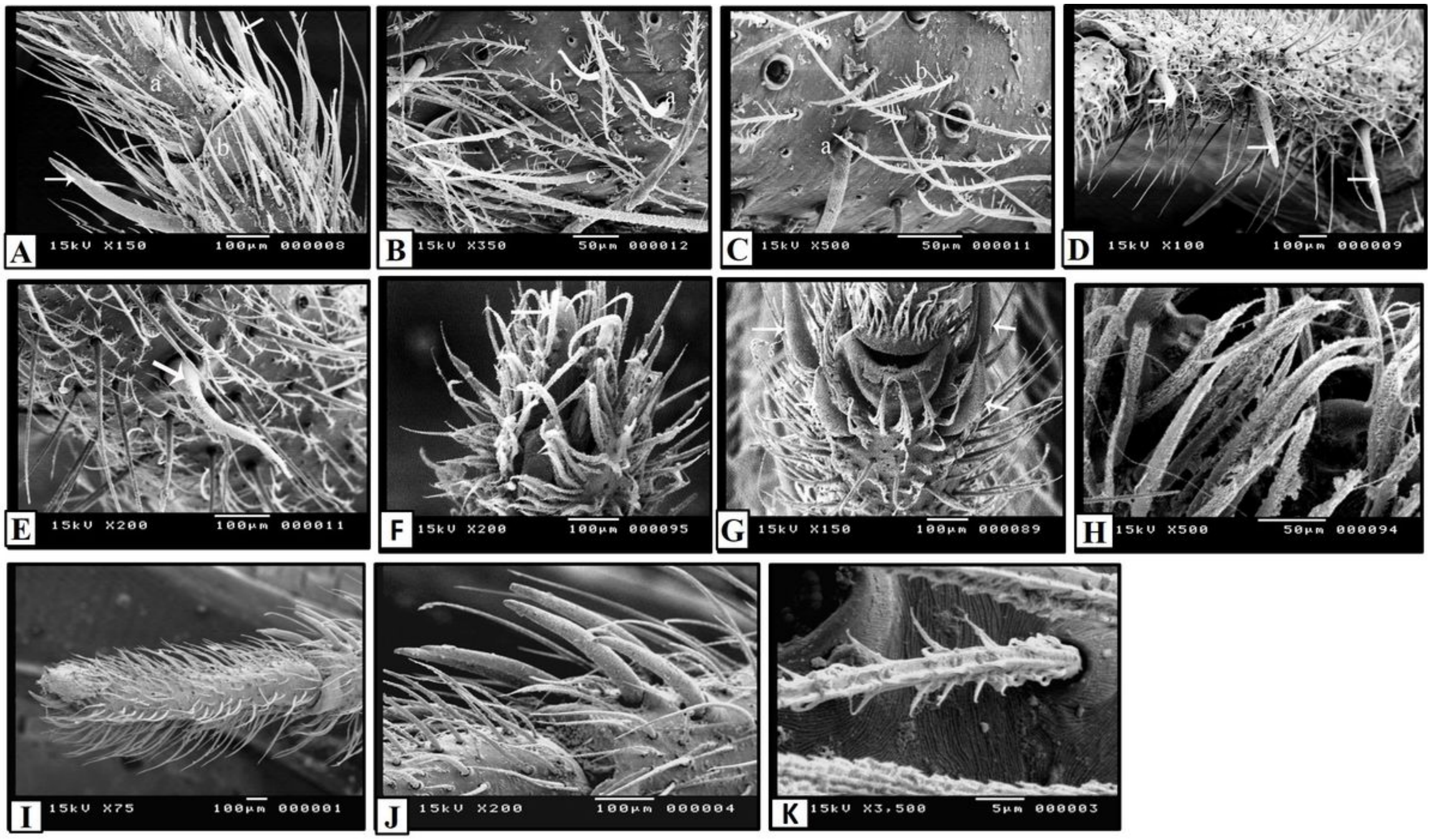

Figure 6

(A) SEM of the dorsal side of the joint between tarsus and metatarsus of the male first left leg showing: a. Tarsus. b. Metatarsus. Large tactile setae (arrow). **(B)** SEM of the ventral side of femur of the male first left leg showing: a. Tactile hairs. b. Urticating hairs. c. Large tactile setae. **(C)** SEM of the ventral side of the metatarsus of the male first left leg showing: a. Large tactile seta. b. Urticating hairs. **(D)** SEM of the ventro-lateral side of the metatarsus of the female first left leg showing: Large tactile seta (arrow). **(E)** SEM of the ventral side of tibia of the female first left leg showing: Large tactile seta (arrow). **(F)** SEM of the ventral side of the distal end of tarsus of the female first right leg showing: three claws (arrow). **(G)** SEM of the ventral side of the female first right leg showing: the joint between tarsus and metatarsus surrounded by large tactile setae (arrows). **(H)** SEM of the lateral side of the distal end of tarsus of the female first right leg showing: the scopulate hairs. **(I)** SEM of the lateral side of tarsus of the female first right leg showing: tarsus claws. **(J)** SEM of the ventral side of the joint between tarsus and metatarsus of the female fourth right leg showing: large tactile seta. **(K)** SEM of the dorsal side of the tarsus of the female fourth left leg showing: thickened trichobothria.