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Research Article

Leg Sensilla of *Ilyocoris cimicoides* (Heteroptera: Naucoridae): A SEM Study with Notes on Mouthpart Morphology

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ABSTRACT: In this study, the types and morphological characteristics of sensilla located on the legs of *Ilyocoris cimicoides* (Linnaeus, 1758) were examined using scanning electron microscopy (SEM). The main objective of the study was to reveal the structural diversity of leg sensilla and their distribution across different segments.
Different sensilla types, including sensilla trichodea (ST), sensilla chaetica (SCh), sensilla coeloconica (SCo), and sensilla placodea multilobata (SPM), were identified. Sensilla trichodea was found to occur in two distinct morphological subtypes. It is suggested that the sensilla are generally mechanoreceptive, while some types may also be involved in the perception of chemical and environmental stimuli.
The findings provide important data on the diversity and distribution of sensilla in *I. cimicoides*, suggesting that these structures may be associated with the sensory adaptations of the species.

KEYWORDS: *Ilyocoris cimicoides*, leg sensilla, aquatic adaptation, mechanoreceptive sensilla, sensilla morphology, scanning electron microscopy (SEM), aquatic Hemiptera, sensory ecology

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INTRODUCTION

Insects represent a highly diverse and widespread group of animals across the globe, owing to their high reproductive potential and remarkable adaptability. One of the key factors contributing to their survival, dispersal, and reproductive success is the structure of the integument and the sensory organs associated with it. The integument functions as a cuticular exoskeleton that forms a boundary between internal systems and the external environment. Sensory organs associated with this structure enable insects to perceive environmental stimuli and facilitate intraspecific communication (Hallberg & Hansson, 1999; Amutkan Mutlu et al., 2021; Polat et al., 2021).

The fundamental sensory unit in insects is referred to as a sensillum, which is also described in the literature as a sensory hair, sensory projection, or sensory receptor. These structures are specialized sensory organs that allow insects to detect physical and chemical stimuli from their surroundings (Schneider, 1964; Ryan, 2002). Sensilla exhibit considerable diversity in terms of shape and size and play a crucial role in the perception of environmental signals.

Sensilla are defined as structures composed of epidermally derived accessory cells and associated bipolar sensory neurons. Each sensillum perceives stimuli through a specialized receptor structure located on the cuticle and transmits this information to the brain via the nervous system (Zacharuk, 1980; Rebora et al., 2019). Although these structures are distributed across various body regions, including antennae, mouthparts, and appendages, they are particularly concentrated on the tarsi (Chapman, 1998).

In insects, sensory organs are not limited to antennae but are also found on mouthparts, legs, genital structures, and wings (Peregrine, 1972; Backus, 1985; Devetak et al., 2004; Guerenstein & Hildebrand, 2008; Nichols & Vogt, 2008; Brożek & Bourgoin, 2013; Brożek, 2013; Brożek & Zettel, 2014; Kanturski et al., 2016; Wang & Dai, 2017). These structures play significant roles in behaviors such as host detection, mate selection, oviposition, and defense (Ahmad et al., 2016).

Nepomorpha constitutes an important group within aquatic Hemiptera and plays a key role in regulating food webs in aquatic ecosystems (Runck & Blinn, 1994; Blaustein, 1998). Although this group is distributed worldwide, the highest species diversity is observed in tropical regions (Schuh & Slater, 1995). Species within Nepomorpha typically inhabit stagnant or slow-flowing waters and predominantly exhibit predatory feeding strategies (Menke, 1979).

The family Naucoridae, belonging to Nepomorpha, represents a group adapted to a variety of aquatic habitats. Species within this family are commonly found in both lotic and lentic environments, with notable habitat differences among subgroups (Chen et al., 2005). In a comprehensive study on the aquatic Heteroptera fauna of Türkiye, a total of 9 families, 14 genera, and 28 species belonging to Gerromorpha and Nepomorpha were recorded (Banbal & Fent, 2020). *Ilyocoris cimicoides cimicoides* (Heteroptera: Naucoridae) was reported as a new record for the fauna of Türkiye and documented for the first time in Edirne Province (Banbal & Fent, 2020). This species is known to prefer habitats with greater water depth and rich vegetation (Hufnagel et al., 1999; Karaouzas & Gritzalis, 2006). Despite these studies, detailed information on the morphology and function of sensory structures, particularly leg sensilla, within Naucoridae remains very limited. While antennal sensilla in Nepomorpha have been relatively better documented (Popov, 1971; Chen et al., 2005; Schuh & Weirauch, 2020), the structure and functional diversity of leg sensilla have largely been neglected.

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Previous studies have mainly focused on antennal and labial sensilla in various Hemiptera groups (Brożek, 2013; Brożek, 2014; Nowińska & Brożek, 2017; Nowińska & Brożek, 2021). In contrast, leg sensilla have been reported only in a limited number of species, and these studies are mostly restricted to chemoreceptive and campaniform sensilla (McIver & Siemicki, 1978; Schmidt & Smith, 1987; Yosano et al., 2020; Dinges et al., 2021). Importantly, comprehensive morphological studies focusing specifically on leg sensilla in Naucoridae are still lacking.

Therefore, there is a clear gap in the literature regarding the detailed morphological characterization and distribution of leg sensilla in Naucoridae species. In this context, the present study aims to investigate the types, distribution, and morphological characteristics of leg sensilla in *Ilyocoris cimicoides* using scanning electron microscopy (SEM). This study is expected to contribute to a better understanding of sensory systems and ecological adaptations in aquatic Hemiptera.

MATERIALS AND METHODS

Adult male and female specimens of *Ilyocoris cimicoides* (Linnaeus, 1758) were collected alive from two localities: Taşköprü, Eber Lake (38°35′N, 31°17′E; 975 m) in Sultandağı, Afyon, and Ulupınar Village (37°06′N, 29°36′E; 955 m) in Gölhisar, Burdur, Türkiye.

A total of 10 adult specimens (5 males and 5 females) were used in the study. After collection, the specimens were transported to the laboratory, where dirt and debris on the body surface were carefully removed.

Following the cleaning process, the specimens were air-dried under room conditions and prepared for scanning electron microscopy (SEM). Subsequently, they were carefully mounted on appropriately sized SEM stubs.

To enhance image quality, the prepared specimens were coated with a thin layer of gold using a Polaron SC502 sputter coater. After gold coating, the specimens were examined using a JEOL JSM 6060 LV scanning electron microscope, and images were obtained at an accelerating voltage of 5–15 kV.

All microscopic examinations and imaging procedures were carried out at the Prof. Dr. Zekiye Suludere Electron Microscops Center, Faculty of Science, Gazi University. In addition, high-resolution supplementary images of the specimens were obtained using a Hitachi SU5000 FE-SEM at the Central Laboratory Application and Research Center (MERLAB) of Ankara Yıldırım Beyazıt University.

RESULTS

In this study, the head morphology, mouthparts, leg structures, and sensilla types of male and female individuals of *Ilyocoris cimicoides* were examined using a stereo-microscope and scanning electron microscopy (SEM).

Comparative dorsal views of the heads of male and female individuals are presented in Figs. 1–2. One of the most prominent differences observed in the head region was related to eye pigmentation. The eyes were dark brown in females and light brown in males, indicating the presence of sex-related morphological differences between individuals.

The forelegs were of the raptorial type and adapted for prey capture. A hook-like structure was observed on the distal segments. The femur, located proximally to this structure, was distinctly enlarged and exhibited a more pronounced swelling,

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particularly in male individuals (Figs. 3–4). Additionally, sensilla coeloconica (SCo) were identified on these specialized leg structures (Fig. 5).

Examination of the dorsal view and mouthparts of the male individual revealed a typical heteropteran piercing–sucking mouthpart structure. The labium was segmented, and the labrum was found to support the feeding system in relation to the oral opening (Fig. 6).

The middle and hind legs of both male and female individuals were first examined under a stereomicroscope (Figs. 7–8), followed by SEM analysis of the middle legs (Figs. 9–11).

In these regions, sensilla trichodea (ST) and sensilla chaetica (SCh) were identified. Sensilla trichodea were classified into two subtypes based on their morphological characteristics. ST1 was slender, elongated, and tapered toward the apex, whereas ST2 was thicker in appearance with a more rounded apical region.

In female individuals, sensilla placodea multilobata (SPM) were also observed. In addition, the presence of sensilla coeloconica (SCo) was confirmed (Figs. 12–13).

In the labrum region, sensilla coeloconica (SCo) (Fig. 14) and sensilla trichodea (ST1) were identified on the mouthpart segment (Fig. 15). The lengths of sensilla trichodea were measured as 92.8 µm, 109 µm, and 45.5 µm, respectively.

Figure 1 . Dorsal view of the head of a female *Ilyocoris cimicoides* (stereomicroscope).

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Figure 2. Dorsal view of the head of a male *Ilyocoris cimicoides* (stereomicroscope).

Figure 3. Raptorial foreleg of a female *Ilyocoris cimicoides* (stereomicroscope).

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Figure 4. Raptorial foreleg of a male *Ilyocoris cimicoides* (stereomicroscope).

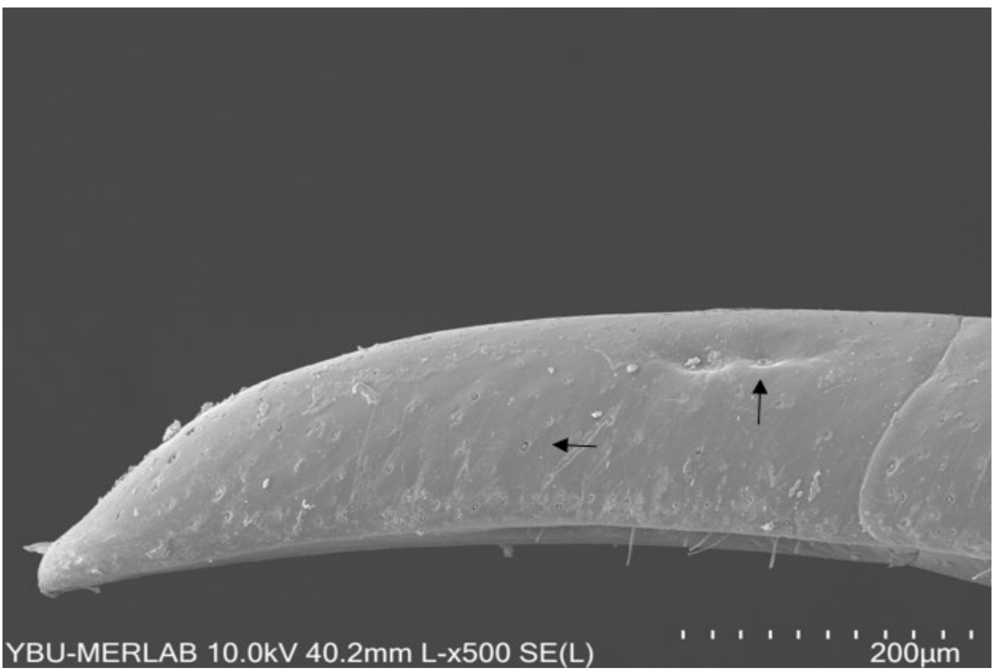

Figure 5. Sensilla coeloconica (SCo) on the raptorial leg of a male *Ilyocoris cimicoides* (SEM; arrow indicates SCo).

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Figure 6. Ventral view of the mouthparts of a male *Ilyocoris cimicoides* (stereomicroscope).

Figure 7. Ventral view and middle and hind leg pairs of a female *Ilyocoris cimicoides* (stereomicroscope).

Figure 8. Ventral view and middle and hind leg pairs of a male *Ilyocoris cimicoides* (SEM).

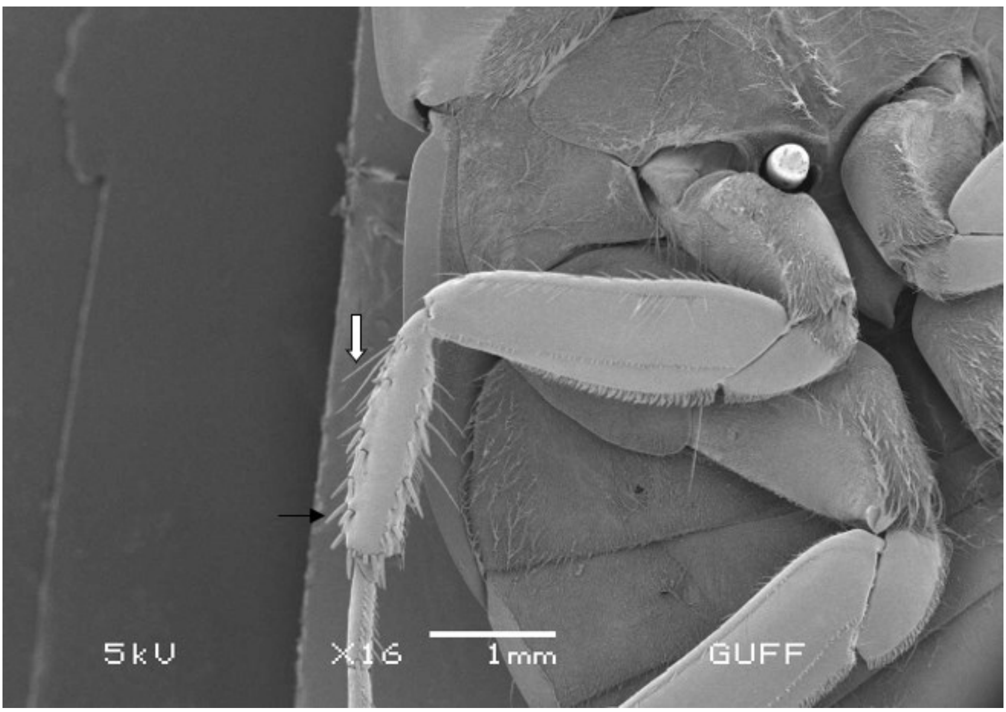

Figure 9. Sensilla trichodea (ST) and sensilla chaetica (SCh) on the tibia of the middle leg of a female *Ilyocoris cimicoides* (SEM; black arrow indicates SCh, white arrow indicates ST).

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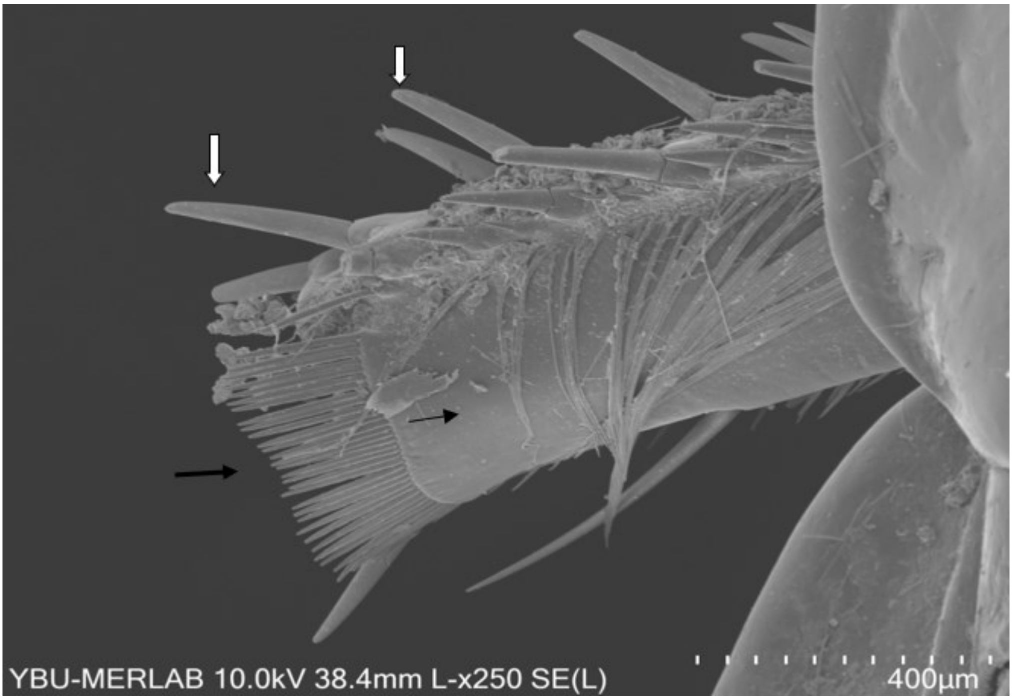

Figure 10. Sensilla trichodea (ST) and sensilla chaetica (SCh) in a male *Ilyocoris cimicoides* (SEM; black arrow indicates ST, white arrow indicates SCh).

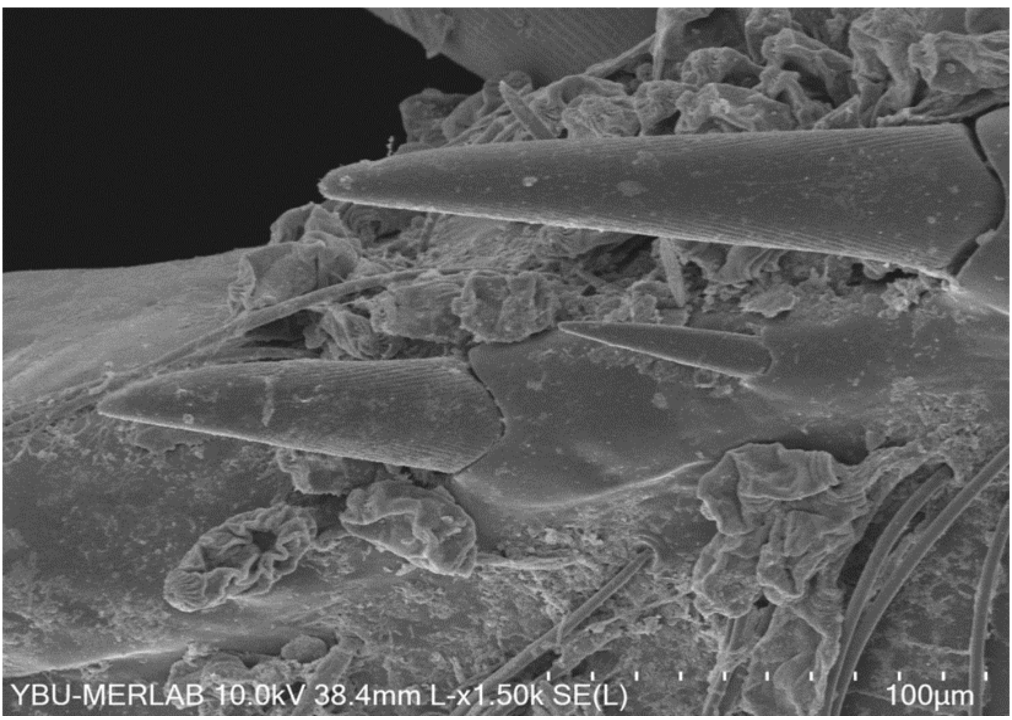

Figure 11. Detailed view of the longitudinally ribbed surface of sensilla chaetica (SCh) in a male *Ilyocoris cimicoides* (SEM).

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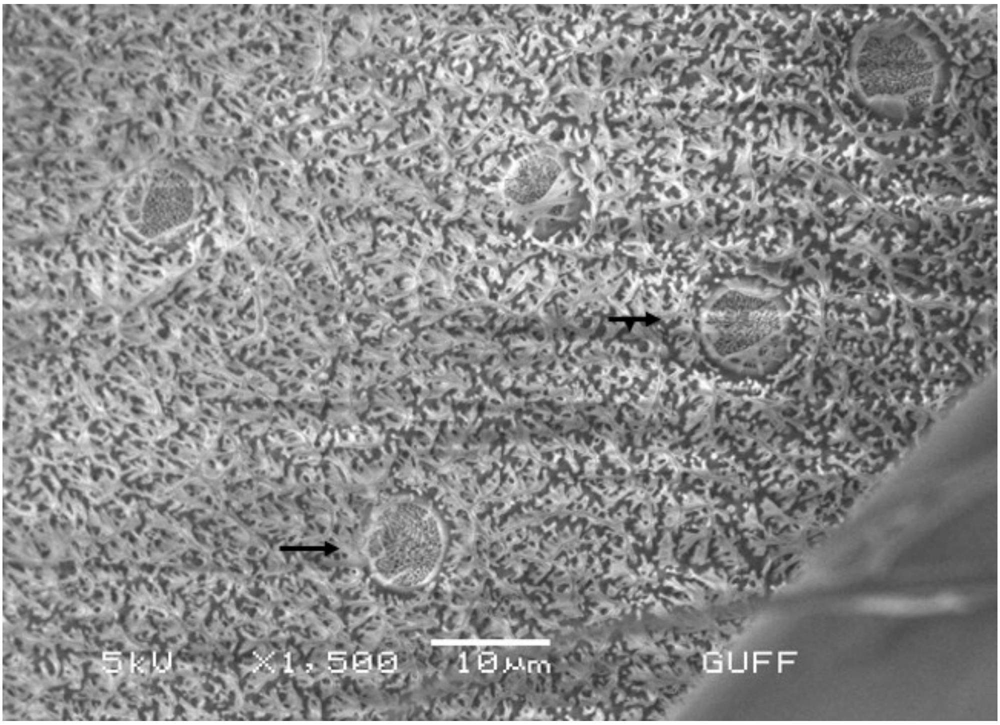

Figure 12. Sensilla placodea multilobata (SPM) in a female *Ilyocoris cimicoides* (SEM; arrow indicates SPM).

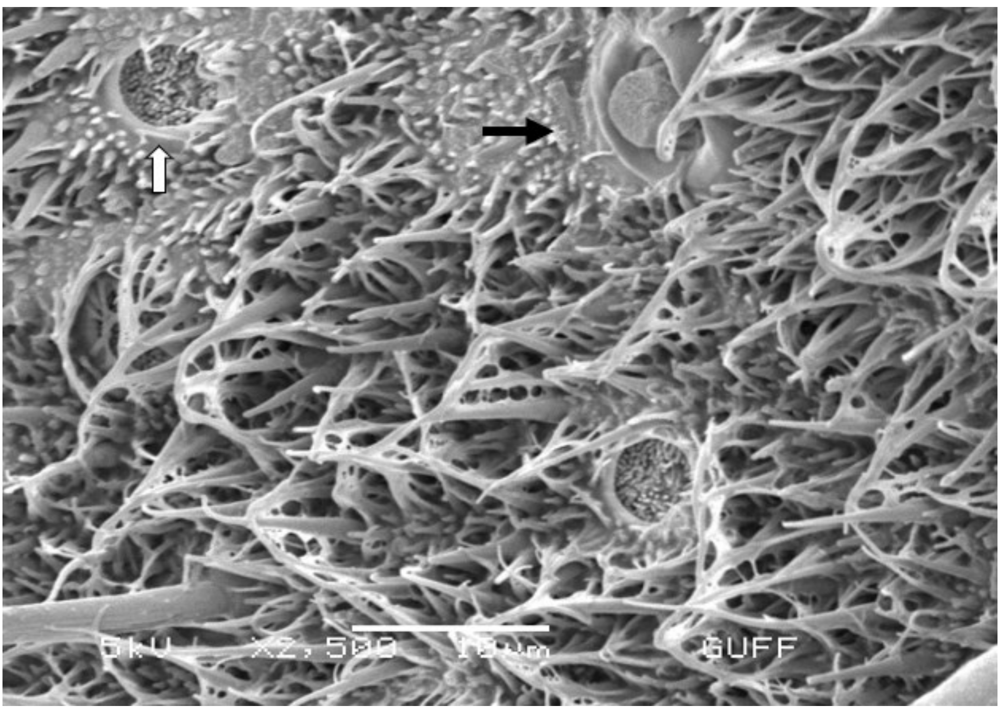

Figure 13. Sensilla coeloconica (SCo) and sensilla placodea multilobata (SPM) in a female *Ilyocoris cimicoides* (SEM; black arrow indicates SCo, white arrow indicates SPM).

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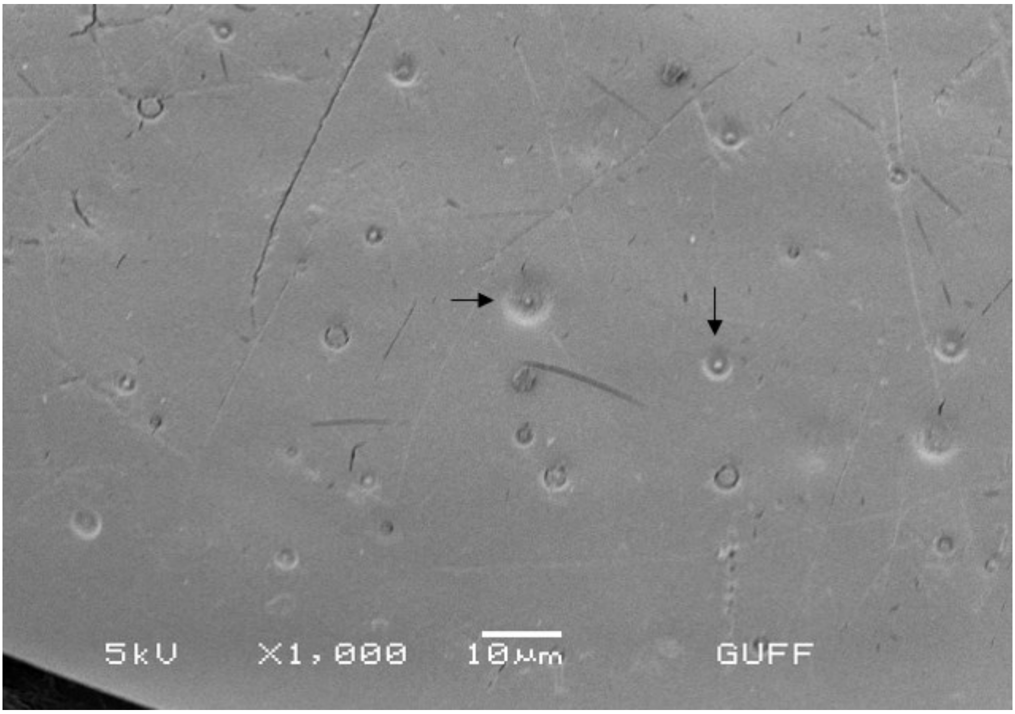

Figure 14. Sensilla coeloconica (SCo) on the labrum of a female *Ilyocoris cimicoides* (SEM; arrow indicates SCo).

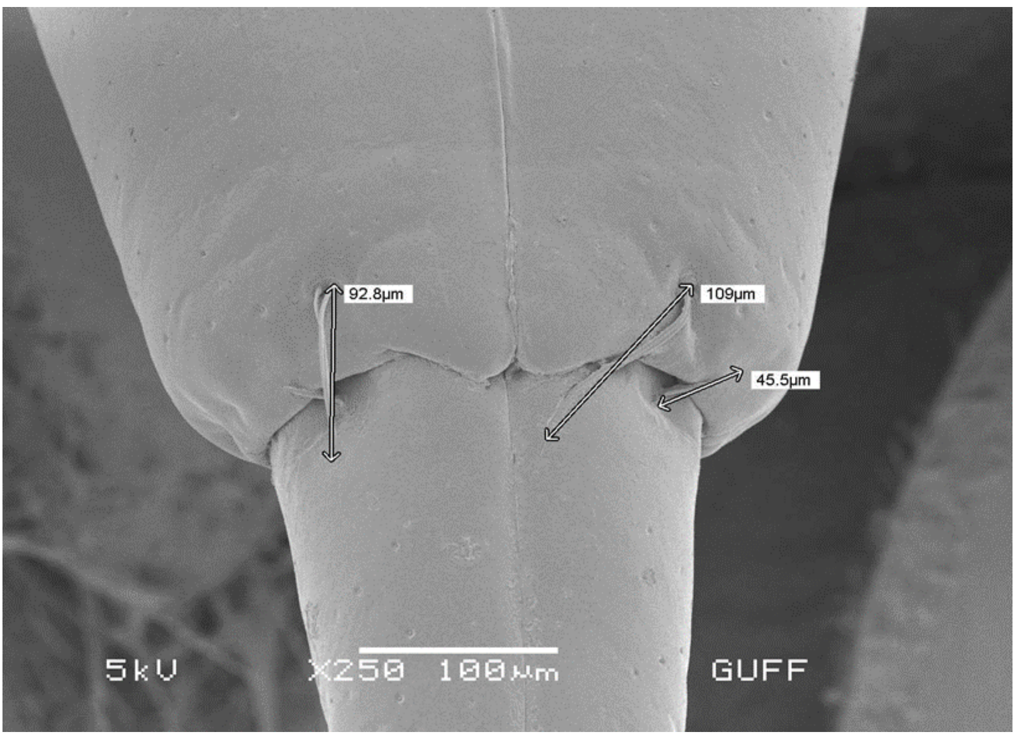

Figure 15. Sensilla trichodea (ST1) on the mouthparts of a female *Ilyocoris cimicoides* (SEM), with measured lengths of 92.8, 109, and 45.5 µm.

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DISCUSSION

The findings obtained in this study demonstrate that *Ilyocoris cimicoides* (Linnaeus, 1758) exhibits distinct morphological differences at the structural level. In particular, the variation in pigmentation observed in the head region is considered to represent sexual dimorphism. The presence of darker eyes in female individuals and lighter brown eyes in males indicates sex-related visual differences associated with ocular morphology within the species. Indeed, it has been reported that eye structure may vary between male and female individuals in some insect taxa (Meyer-Rochow, 2015). Moreover, sexual dimorphism in compound eyes has been documented as a common phenomenon in mayflies (Kluge, 2004).

The raptorial type of the forelegs suggests an adaptation consistent with a predatory lifestyle. The claw-like structure on the distal segments and the markedly enlarged femoral region are interpreted as adaptations for prey capture. In particular, the more developed femoral region in male individuals indicates the presence of sexual dimorphism, which may be associated with behavioral or functional roles.

The heteropteran piercing–sucking mouthparts are consistent with the feeding strategy of the species. The segmented structure of the labium and the position of the labrum relative to the oral opening are considered morphological features that may contribute to mechanical support during feeding and the direction of food intake (Wang et al., 2020; Amutkan Mutlu et al., 2021). In addition, the presence of sensilla on the mouthparts suggests that sensory perception may also play a role during feeding.

Overall, sensilla trichodea (ST) types are generally classified as mechanoreceptors. However, some studies have indicated that sensilla trichodea may exhibit different sensory functions depending on their morphological variation; for instance, in *Plea minutissima*, thick ST sensilla have been reported to exhibit olfactory functions, whereas thin ones show chemoreceptive properties (Nowińska & Brożek, 2021). In this context, the sensilla trichodea and sensilla chaetica structures identified on the midlegs in this study are considered likely to be associated with mechanoreceptive functions. These sensilla types have been reported to play roles in the perception of touch, movement, and environmental vibrations (Wang et al., 2019; Amutkan Mutlu et al., 2021; Nowińska & Brożek, 2017; 2021).

It has been reported that sensilla are not limited to feeding-related functions but also play roles in behavioral processes such as mate finding. These processes may involve the detection of volatile compounds such as pheromones or food-related cues through chemical, mechanical, or thermo-hygroreceptive pathways (Chapman, 1998; Carey & Carlson, 2011; Brożek & Zettel, 2014; Parveen et al., 2015; Nowińska & Brożek, 2021; Rani et al., 2021).

The co-occurrence of sensilla placodea multilobata and sensilla coeloconica suggests the presence of a sensory system potentially involved in chemoreception and environmental perception in this species. Sensilla coeloconica are widely distributed on antennae and legs in Hemiptera and have been reported to be particularly associated with thermo-hygroreceptive functions (Nowińska, 2025; Nowińska & Brożek, 2017). These sensilla types are suggested to contribute to habitat selection by enabling insects to detect environmental temperature and humidity (Nowińska & Brożek, 2019; 2021).

The presence of both sensilla coeloconica and sensilla trichodea in the labrum region suggests that sensory perception may not be limited exclusively to the antennae. The variation in sensilla trichodea length (45.5–109 µm) may indicate potential functional differentiation within the same sensillum type.

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However, it should be noted that interpretations regarding sensilla functions require experimental validation, and variability in classification criteria among studies may complicate comparisons. Future studies are recommended to include transmission electron microscopy for ultrastructural investigations and functional experiments to more precisely determine the roles of sensilla (Fan & Xie, 2025).

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