THE ANTENNAL MORPHOLOGY IN THE GENUS *HYDROTREPHES* (HEMIPTERA: HELOTREPHIDAE)

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Abstract.–Antennal sensilla are documented for the first time in the family Helotrephidae. Sensilla in *Hydrotrephes* sp. include three forms of trichoid sensilla and two forms of leaf-like sensilla. Most of the sensilla are located on the apical two thirds of the distal segment. Morphology of the antenna in Helotrephidae appears to be of taxonomic use to define genera and it may be useful to determine relationships between genera within Helotrephidae and between the families Helotrephidae and Pleidae.

Keywords: sensilla, antenna, Pleoidea, Nepomorpha

The hemipteran superfamily Pleoidea includes the families Helotrephidae and Pleidae and is a sister group to the family Notonectidae, all within the infraorder Nepomorpha (Wang et al. 2021). The Helotrephidae differ from Pleidae primarily in usually having a fusion of the head and prothorax into a cephalothorax, and this single trait has been used to distinguish between the two families (Schuh & Weirauch 2020). However, members of the helotrephid genus *Neotrephes* have a distinct suture between the head and thorax and thus only a partially fused cephalothorax (Nieser & Chen 2002) and share some similarities to the pleid species *Heteroplea ornata* that was recently described by Cook (2020), which lacks any fusion of the head and thorax into a cephalothorax. It is possible that *H. ornata* should actually be moved to *Neotrephes*. Differences between these families also include their number of antennal segments. Helotrephidae has either a 1- or 2-segmented antenna, with Pleidae having a 3-segmented antenna (Esaki & China 1928; Schuh & Weirauch 2020). The recently described *Heteroplea ornata* again brings this generality into question because it clearly has an unfused head and thorax but has only two antennal segments (Garza et al. 2021). The antenna has not been well characterized in most members of these families, leaving more

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possibilities to their being exceptions to the characters currently used to define them.

The antenna of both Pleidae and Helotrephidae is small and difficult to view, making it rarely used in the taxonomy of species in these families. However, a recent study by Garza et al. (2021) suggested that antennal morphology represents a basis for defining species in Pleidae. The same may be true for the closely related Helotrephidae but there is only rudimentary knowledge of the antenna of this family. A better knowledge of the antenna could also contribute to better defining Pleidae and Helotrephidae.

Characterization of the antenna in species of Helotrephidae has either been omitted or treated in a cursory manner. The monograph by Esaki & China (1928) that essentially characterized the family Helotrephidae described the basic shape, location, and number of segments found in the family but only provided greater detail for two species, *Helotrephes bouvieri* and *Helotrephes martini* (both species are now in the genus *Hydrotrephes*). The antennae of *H. bouvieri* and *H. martini* are both two segmented and were described by Esaki & China (1928) as having "a first segment fusiform with a few scattered hairs; second segment longer than first" and the apical segment two thirds covered by "strong curved pointed hairs" that are medially dilated. There are also two "very long filiform hairs that are longer than the second segment". Esaki & China (1928) provided drawings of the antennae of *H. bouvieri* and *H. martini* that show differences in shape of the antennal segments and the general size and shape of what they call hairs. Lundblad (1933) provided a treatment similar to Esaki & China (1928) for the antennae of *Helotrephes corporaali* and *Idiotrephes chinai*. China (1936) illustrated the antenna of *Neotrephes usingeri.* China (1940) illustrated the antennae of *Neotrephes plaumanni* and *Paratrephes hintoni*. Rodrigues et al. (2012) documented the antenna of the macropterous form of *Paratrephes hintoni.* Other descriptions of species of Helotrephidae have generally only reported the number of antennal segments. Papáček et al. (1989) reported the antenna of *Mixotrephes hoberlandti* to be two-segmented,

with the distal segment having four long apical setae. The drawing of *M. hoberlandti* lacks detail but shows many other short hairs on both segments along with the noted long setae. Papáček (1994) described the antenna of *Idiotrephes major* as being two-segmented with a flattened distal segment, and he provided a figure showing four long hairs, several hairs only slightly shorter than the four longest, many short hairs on the distal segment, and a few short hairs on the basal antennal segment. A similar antennal description was given for *Idiotrephes meszarosi* (Papáček 1995). Zettel (1997) provided a photo of the antenna of *Idiotrephes chinai* using light microscopy but did not comment on its morphology. Other descriptions of Helotrephidae are even less detailed.

The antennal structures labeled as hairs of various shapes by Esaki & China (1928) are generally sensory in function, most being more accurately recognized as antennal sensilla. Sensilla in nine species, representing all four genera of Pleidae, were characterized by Garza et al. (2021) but no sensilla have been previously documented on the antenna of Helotrephidae. The study herein documents sensilla and antennal characteristics in a species of *Hydrotrephes* and compares general antennal morphology within this genus.

MATERIALS & METHODS

The five specimens used for this study were from museum collections housed in the Enns Entomology Museum, University of Missouri. All specimens were originally pinned but were removed from the pins prior to mounting for SEM observations. The antenna on imaged specimens was naturally exposed requiring no additional manipulation. All specimens were from the same collection with the following collection data:

> Indonesia: Halmahera Island, Kao District, Kao River Basin, Air Kanan Kampung Tuguis, 1–14 March 1981, A. C. Messer and P. M. Taylor collectors.

The specimens most closely match *Hydrotrephes zetteli*, which is known from Sangir Island, Indonesia. However, the specimens used for this study are most likely an undescribed species because they differ from *H. zetteli* in having a prosternal carina that is not bifid, as is found in *H. zetteli* and having somewhat different shaped male parameres and being larger than *H. zetteli*.

Specimens for SEM imaging were prepared by mounting onto an SEM stub using carbon tape. Mounting of samples on the carbon stub was done under a stereo microscope. The specimen was sputter coated with gold for 90 sec (300A) using a Cressington 108 sputtercoater. The gold sputtered specimen were imaged under high vacuum with acceleration voltage ranging from 1–10kV and a working distance of 5 mm. The images were captured using a Hitachi SU3500 SEM with secondary electron detector. The specimen stage was tilted (max 5 degrees) whenever required. The charging of the specimen was prevented by reducing the kV and spot size, respectively (Murtey & Ramasamay 2015).

Terminology for the sensilla follow that of the sensilla found in Pleidae by Garza et al. (2021).

RESULTS

The antenna of the *Hydrotrephes* species (*Hydrotrephes* sp.) examined in this study is two segmented with sensilla on both segments (Fig. 1). The basal segment is curved and longer (~68 μm) than wide (~42 μm), with a width that is generally uniform throughout. The apical segment is narrow at the base, extending to a bulbous apex and is longer (~98 μm) than wide (~30 μm), with the base being ~53 μm at its greatest width. The segments are joined by a narrow neck (Fig. 1, 3). Both segments are often concealed under a cuticular ledge of the head region of the cephalothorax (Fig. 2).

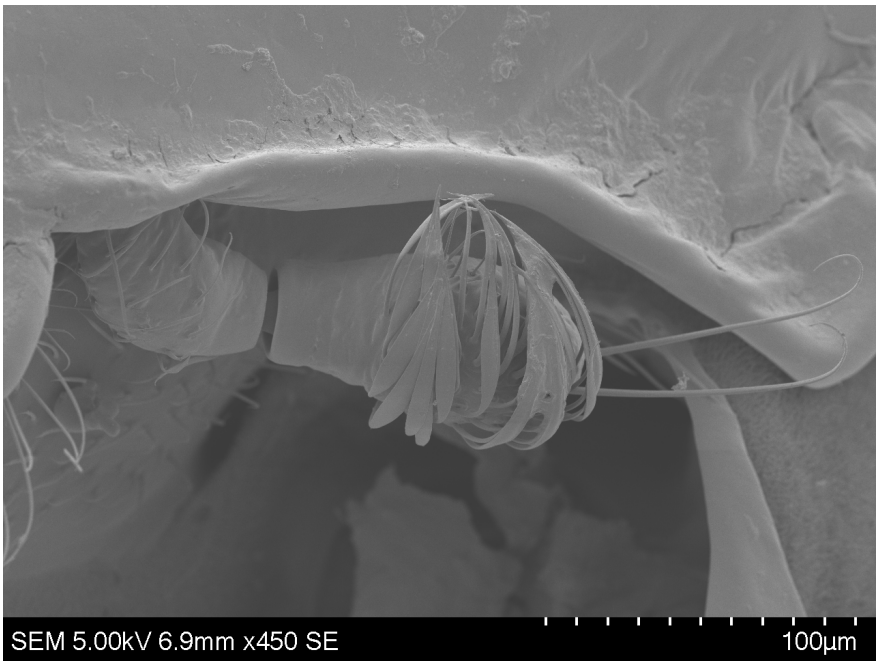

Figure 1. Antenna of *Hydrotrephes* sp. Scale bar at lower right.

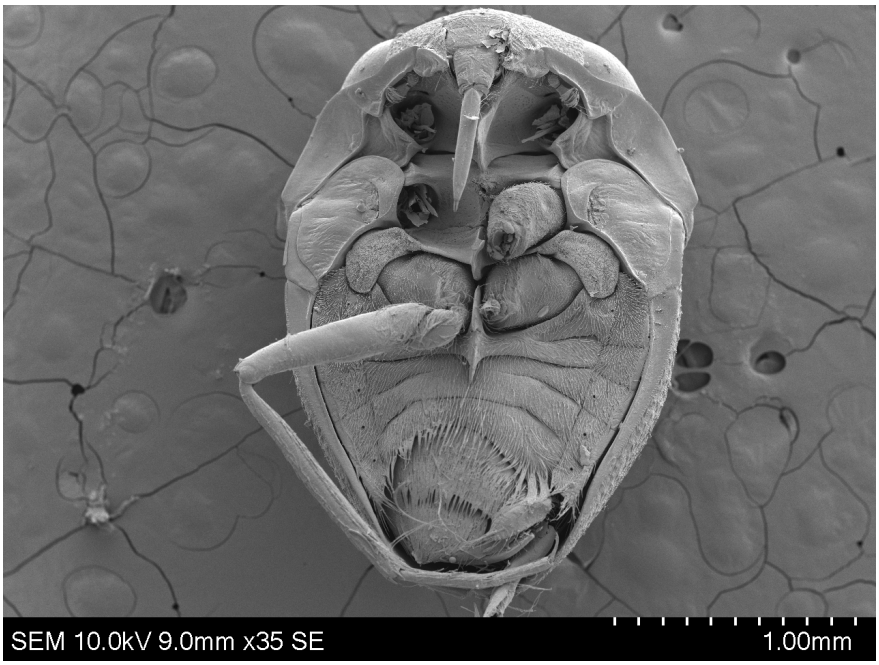

Figure 2. Ventral view of *Hydrotrephes* sp., showing location of antenna indicated by arrows. Scale bar is in the lower right.

The basal segment includes two types of sensilla, both visible on the lateral side (Fig. 3). The long, round sensilla that are most common are sensilla trichoidea (ST1), which is defined as a flexible hair-like sensilla that acts as a mechanoreceptor. At the ventral edge of the basal segment there are one or two sensilla leaf-like (SL1). These are also thought to be mechanoreceptors but their function has not been fully evaluated.

The apical segment has more types of sensilla and numerically more sensilla in general than the basal segment (Fig. 4). The narrow basal third of the apical segment is smooth and has no sensilla. On the apical two thirds. Four different types of sensilla are present. In the center of this region there are several sensilla trichoidea (ST1), similar to those on the basal segment. Originating along the ventral margin of the apical segment there are an accumulation (more than 10 on all antennae examined in this study) of broad leaf-like sensilla (SL2). There is also at least one SL1 type sensilla located near the center of the antenna

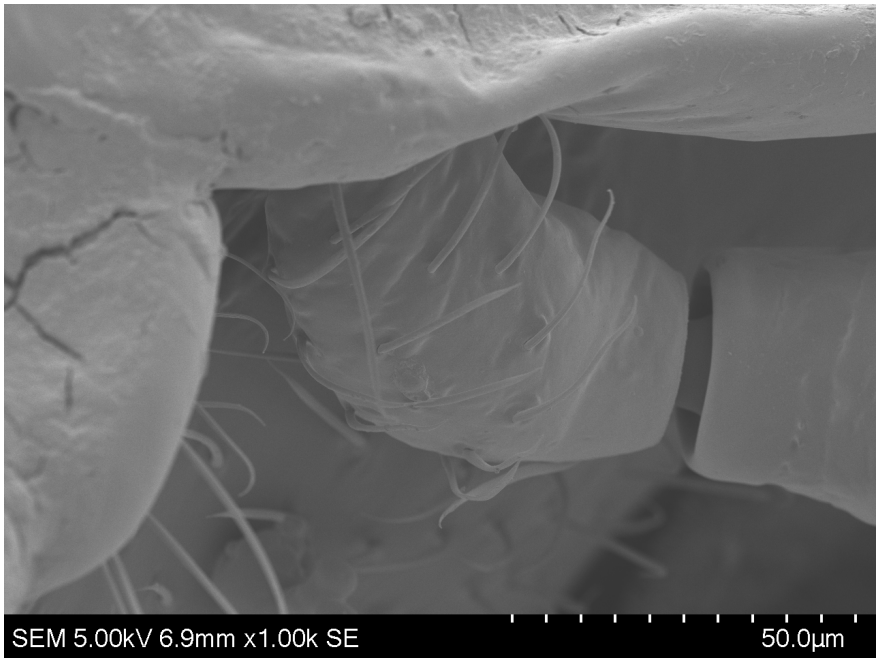

Figure 3. Basal antennal segment of *Hydrotrephes* sp. showing two types of sensilla. ST1 shows type 1 of sensilla trichoidea, SL1 shows the broader sensilla leaf-like type 1. Scale bar is at lower right of figure.

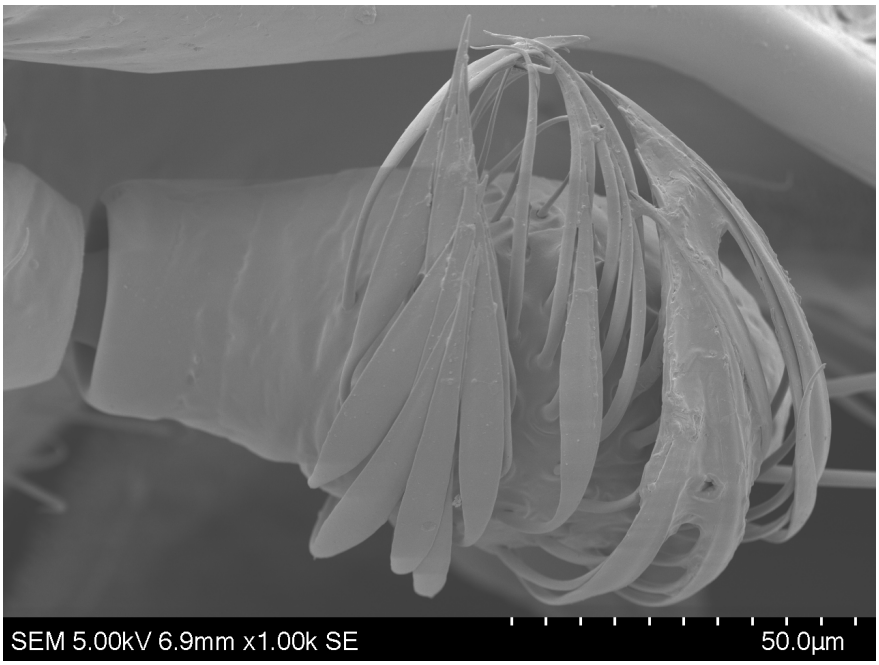

Figure 4. Apical antennal segment of *Hydrotrephes* sp. ST1 shows sensilla trichoidea type 1, ST2 shows sensilla trichoidea type 2, SL1 shows sensilla leaf-like type 1, SL2 shows sensilla leaf-like type 2, and ST3 shows the basal part of sensilla trichoidea type 3. Scale bar is in the lower right corner.

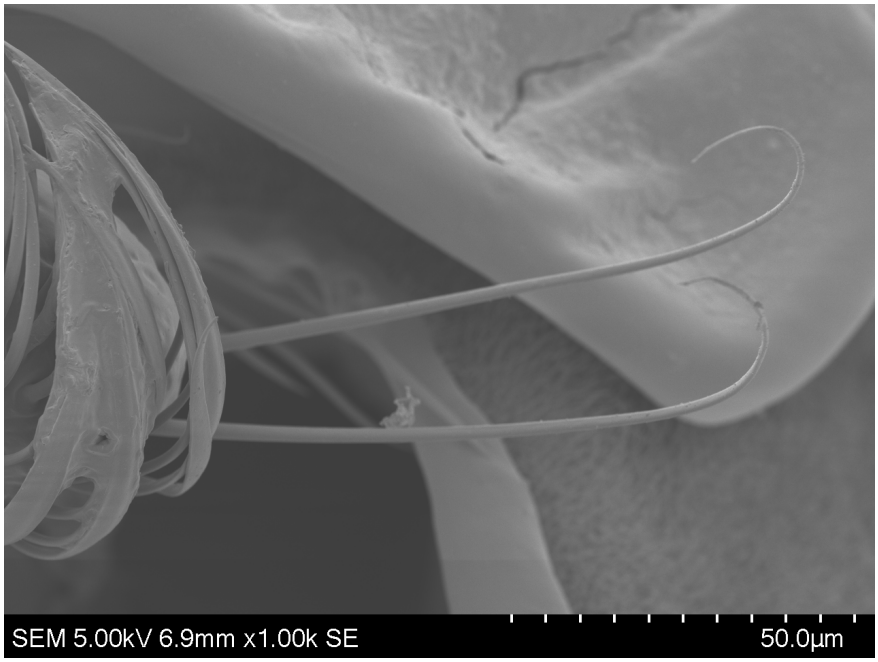

Figure 5. Apex of antenna of *Hydrotrephes* sp. showing the terminal sensilla trichoidea (ST3). Scale bar is in lower right corner.

towards the basal margin of the field of sensilla. Near the dorsal center of the apical segment there are at least two different sensilla trichoidea (ST2) that are less than half that of ST1. At the end of the apical segment, there are two long sensilla trichoidea (ST3) that are over twice the length of ST1 (Fig. 4, 5).

DISCUSSION

Characteristics of the antenna appear to have taxonomic value for the family Helotrephidae. While the antennae of many species of Helotrephidae have not been documented, there appear to be similarities at the genus and family level. Number of segments, general shape of antennal segments and arrangement of sensilla all appear to be useful taxonomic characters.

In the genus *Hydrotrephes*, all known species appear to have a two-segmented antenna, with a shorter narrow basal segment and a wider more bulbous apical segment. Three species of *Hydrotrephes* have been studied to show that the basal segment has widely scattered sensilla trichoidea (the hairs drawn by Esaki & China (1928) are interpreted to be sensilla trichoidea). The number and arrangement of these sensilla may have enough variation that they cannot be used to distinguish taxa, but the shape of this segment does appear to be a good species level character. *Hydrotrephes bouvieri* has a basal segment that is elongated and nearly as long as the apical segment, as well as having a distinct curvature, while *H. martini* has a short, almost square basal segment (Esaki & China 1928). The basal antennal segment of the *Hydrotrephes* species of this study is shaped similar to *H. bouvieri* but is only about half as long as the apical segment. The shape of the basal segment of *Mixotrephes* (see Papáček et al. 1989) and *Idiotrephes* (see Lundblad 1933, Papáček 1994) bends at a right angle and is essentially L-shaped, with the basal portion much narrower than the rest of the segment. Similar differences can be found with the apical segment. For example, *H. bouvieri* has an irregular-shaped apical segment that is nearly square at the apex, while *H. martini* has a nearly round apical segment (Esaki and China 1928). *Idiotrephes chinai* has a short bulbous apical segment that is narrowed distally (Lundblad 1933). *Helotrephes corporaali* has

an apical segment similar to *H. bouvieri* but is not as squared (Lundblad 1933). The apical segment of the *Hydrotrephes* species of this study is more elongate with a narrow base and bulbous apex. All *Hydrotrephes* appear to have two long sensilla trichoidea type 3 at the end of the apical segment. In *Mixotrephes hoberiandti* there are four of these long hairs (Papáček et al. 1989) and an even larger number in *I. major* (Papáček 1994). However, *I. chinai* appears to have no more than four long hairs (see Lundblad 1933). The long hairs shown by these authors are almost certainly sensilla trichoidea type 3.

Until recently, the state of having a fused cephalothorax in Helotrephidae and a separate head and thorax in Pleidae appeared to accurately separate these families of Pleoidea. However, the recent description of the pleid *Heteroplea ornata*, which has an unfused head and thorax but otherwise greatly resembles the helotrephid genus *Neotrephes*, calls into question whether other characters are needed to define these families. The antenna of the pleid *H. ornata* is two-segmented (Garza et al. 2021) as are most Helotrephidae but the head and thorax are completely unfused and there is a callus associated with the head that is typical of other species in *Heteroplea*. Still, as mentioned previously, *H. ornata* may need to be transferred to *Neotrephes*. All other *Heteroplea* have a three segmented antenna but the basal segment is very reduced. The uncertain classification of *Neotrephes* and *Heteroplea* is further demonstrated by the recent study by Wang et al. (2021) who found that *Neotrephes* was more closely related to members of Pleidae than those of its current association in Helotrephidae. Characters of the antennae may become useful to further sort out the taxonomy of these species.

The utility of using types and arrangements of sensilla for taxonomy is currently uncertain for the Helotrephidae. Garza et al. (2021) found that these characters were taxonomically useful in the Pleidae but since only the one species of this study has had its sensilla specifically documented, it is uncertain if the same taxonomic relationship is true for Helotrephidae. It is of interest that the *Hydrotrephes* species of this study had far fewer types of sensilla than were found in the sister family

Pleidae. Further study of species of Helotrephidae are needed to make any definitive statements about the sensilla of this family.

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