COMPARATIVE ANATOMY OF THE ANTENNAL SENSILLA OF
PERLA MARGINATA, DINOCRAS CEPHALOTES AND PERLODES
MICROCEPHALUS (PLECOPTERA) AQUATIC INSECT NYMPHS

Anca-Narcisa NEAGU
“Al. I. Cuza” University Iași, Faculty of Biology, Bd. Carol I 20A, 700505 Iași, Romania, aneagu@uaic.ro

Abstract. A scanning electron microscopy (SEM) examination was made of the larval antennae of three species of stoneflies: Perla marginata (Panzer, 1799), Dinocras cephalotes (Curtis, 1827) and Perlodes microcephalus (Piclet, 1833), collected from the permanent tributaries of the Bicaz Reservoir (Eastern Carpathians, Romania). The three analyzed species are active predators, abundant and widespread especially in the substratum of water courses. The different kinds, morphology, location and relatively great abundance of sensilla show that these complex structures are actively involved in stimuli reception processes in running water, leading to the hypothesis that they function as mechano- and chemoreceptors, contributing in this way to the prey localization, too.

Keywords: aquatic insects, antennae, sensilla, chemoreceptors, mechanoreceptors.

Introduction
Many authors show that the various types of sensillum present on the body parts of water-living insects are involved in the reception of different stimuli from the freshwater environment (temperature variations, water flow characteristics, chemical composition) and these structures function especially as chemo- and mechanoreceptors (Wichard et al., 2002). The fine structure of sensilla in stoneflies and mayflies was described by Kapoor (1983, 1984), Gaino & Rebora (1999a, 1999b, 1999c and 2003), etc.

Perla marginata, Dinocras cephalotes and Perlodes microcephalus are hemimetabolous insects, whose nymphs are carnivorous, strictly aquatic and living under stones in running water.

Fenoglio et al. (2005), shows that Perlodes microcephalus, for example, is a rheophilous mesothermal species with a wide distribution in Europe, feeding mostly at night and as all Perlodidae, this species is known to be active predators, being the most active of Dinocras cephalotes, Perla bipunctata and Isoperla grammatica, with a mean prey consumption about three times higher than each of the others and the highest attack rate. We suppose that these stonefly species are tactile predators, using their antennae to detect the swimming patterns and to locate the prey. Stoneflies hunt their prey nocturnally under rocks and, in these conditions, antennal sensilla and the use of vision are the main attributes for ambushing, detecting and hunting their prey. Kapoor (1985) cited by Gaino
Anca-Narcisa Neagu

& Rebora (1999) linked the different kinds of sensilla on the antenna of the nymph to its behaviour in the stream.

Kapoor (1985, 1987) cited by Gaino & Rebora (1999a) studied the fine structure of antennal larval sensilla of Paragnetina media (Walker) (Plecoptera: Perlidae), a predatory american stonefly, commonly feed on hydropsychid larvae, nymphs of mayfly and chironomid larvae. For the different parts of the antennae (scape, pedicel and flagellum) different types of sensilla were identified: trichodea, basiconica, coniform complexes, sensilla coeloconica and campaniformia.

Material and Methods

Nymphs of Perla marginata, Dinocras cephalotes (Perlidae) and Perlodes microcephalus (Perlodidae) were collected in the benthos of the permanent tributaries of Bicaz Reservoir (Bistriţa and Izvoru Alb rivers) with a Surber sampler device. For scanning electron microscopy (SEM), antennae were dissected from ether anesthetized (Perla marginata and Dinocras cephalotes) and ethanol fixed specimens (Perlodes microcephalus). The specimens were cleaned using a 1:1 solution of ammonium hydroxide and water, thoroughly washed in distilled water and transferred to 70%, then to 99% ethanol. To prevent collapsing, the specimens were transferred from 99% ethanol to hexamethyldisilazane (HMDS) in a vial for about 30 minutes, then to a glass dish with HMDS for another 30 minutes and then the HMDS is allowed to evaporate. After being mounted on specimen stubs with double-sided sticky tape, the material was coated with silver and examined and photographed with VEGA TESCAN scanning electron microscope.

Results and Discussion

Using the scanning electron microscopy (SEM), we identified the different kinds of antennal sensilla of Perla marginata, Dinocras cephalotes and Perlodes microcephalus nymphs.

The antenna is made by a scape, a pedicel and a flagellum, formed by numerous segments, whose dimensions decrease from the base to the distal part of antenna. We observed on the distal part of each segment of the flagellum a higher number of different types of sensilla of Perlodes microcephalus, about 50, from the base to the tip of flagellum (Figs. 1a and 1b) and a smaller number of sensilla of Perla marginata (Fig. 1c) and Dinocras cephalotes (Fig. 1d), with 20-25 sensilla per segment.

On the distal margin of flagellar segments of Perlodes microcephalus (Fig. 1a and 1b) and Perla marginata (Fig. 1c) there are three interspersed types of sensilla: trichodea, basiconica and coniform complexes. Dinocras cephalotes (Fig. 1d) has only two kinds of sensilla: trichodea and coniform complexes.

The sensilla trichodea of Perlodes microcephalus and Perla marginata (Fig. 2f) are represented by long and slender hairs, 45-50 µm in length. At Dinocras cephalotes the hairs are thicker and straight, 45-55 µm in length, forming a single row as a bridge between the successive segments of the flagellum.

Thin-walled sensilla basiconica, missing at Dinocras cephalotes, are present at the other two species, more numerous at Perlodes microcephalus (10-12/segment) than at Perla marginata (6-8/segment), having, at both species, a tapered-blunt tip (Fig. 2e).

The coniform complexes are of a higher density at Perlodes microcephalus, 8-10 for each segment and they are less dense at the two other species, 4-5 coniform complexes per segment. In all three cases, each coniform complex is made by 3-11 cuticular spines ranged after a linear or circular pattern in the pits, about 13-17 µm in length. These spines are situated in a pit and they converge in a conical tuft perpendicularly to the surface of
the flagellum (Figs 2a, 2b and 2c). At the base of each spine there is a socket and at the tip there is a depression (Fig. 2d).

Thick-walled club-shaped sensilla basiconica are present on the scape (Fig. 3c) and the pedicel (Fig. 3b) of Dinocras cephalotes antennae (Fig. 3a), showing longitudinal grooves on their surface and a crown disposition, encircling the distal margin of the pedicel or forming clusters on the scape. The length of these structures is 60-70 µm and the width is 10-12 µm. Similar structures were observed at Perla marginata (Fig. 3d), having 36-40 µm in length and 10 µm maximal width.

On the entire surface of each segment, there are dispersed sensilla coeloconica and campaniformia (Figs 1 a, b, c and d). The number of sensilla coeloconica increases to the tip of the antenna. At Dinocras cephalotes we have identified the uniporous sensilla coeloconica (Fig. 3f), showing some convergent ridges along most of their length. The nonporous coeloconic pegs are present at Perla marginata (Fig. 3e), having a rounded pit centered by a conical structure with 2 µm in length.

**Conclusions**

By this comparative analysis of the antennal larval sensilla of the three carnivorous stoneflies species, two of them belonging to Perlidae family and the other one to Perlodidae family, we observed that there are differences between them concerning the distribution and the number of these sense organs on the different flagellum segments. We suppose that, according to the higher predatory activity and to the behaviour of Perlodes microcephalus, the number of different types of sensilla on the margin of each antennal segment is consequently higher. There are not particularly types of sensillum, specific for a genus, but at Dinocras cephalotes we identified a type of hair whose morphology differs from that identified at Perla marginata and Perlodes microcephalus. Our observations lead to the conclusion that these sensilla could be involved in the complex phenomenon of prey detection.

**Acknowledgments**

I am grateful to Dr. Maria-Magdalena Dascălu and Physicist Dumitru Răileanu for the aid in preparing the biological material and in assuring the quality of images. This work was supported by CNCSIS 1453/2006-2008 and PN II 93/2007-2009 projects.

**References**


Figure 1. Kinds and distribution of antennal larval sensilla. a. Distal antennal segments of *Perlodes microcephalus*; b. Basal antennal segments of *Perlodes microcephalus*; c. Distal antennal segments of *Perla marginata*; d. Distal antennal segments of *Dinocras cephalotes*. Arrows show the different types of sensilla and their distribution on the distal margins and on the surface of the flagellum segments.
Figure 2. Types of sensilla I. a. Coniform complexes of *Perla marginata* larvae showing the cuticular convergent spines; b. Coniform complexes of *Perlodes microcephalus*; c. Coniform complexes of *Dinocras cephalotes*; d. The morphology of the spine types of *Perla marginata*; e. Thin-walled sensilla basiconica of *Perlodes microcephalus*; f. Sensilla trichodea of *Perla marginata*. 
Figure 3. Types of sensilla II. a. Distribution of sensilla on the scape and the pedicel of Dinocras cephalotes; b. thick-walled sensilla basiconica of Dinocras cephalotes, on the distal margin of the pedicel; c. Longitudinal grooves on the thick-walled sensilla basiconica on the scape of Dinocras cephalotes; d. Longitudinal grooves on the thick-walled sensilla basiconica of Perla marginata; e. Nonporous sensilla coeloconica of Perla marginata; f. Uniporous sensilla coeloconica of Dinocras cephalotes.