GALEAL TIP SENSILLA OF A CARNIVOROUS STONEFLY NYMPH, *PERLA MARGINATA* (PLECOPTERA: PERLIDAE)

Anca-Narcisa NEAGU
“Al. I. Cuza” University, Faculty of Biology, 22A Carol I Bvd., 700506 Iași, Romania,
aneagu@uaic.ro

Abstract. The distal part of the galea belonging to the nymphs of carnivorous stonefly species – *Perla marginata* (Pictet, 1833) - was studied by means of a scanning electron microscope (SEM). This species develops water-living, active and tactile predator nymphs, which use their mouthparts sensilla “to touch”, “to taste” or “to smell” the food and the substrate. The maxillary and labial palps, galea, glossa and paraglossa end with sensory complexes involved in the detection of the chemical qualities of the substrate and of the pray. This paper presents the external morphology of the tip of the galea, and describes the main types and the distribution of its sensilla. The tip of galea is a distinct region, having an oval-plate form, oblique, limited by a semicircular cuticular ridge. There is a relative similarity between the position, external morphology and the general structure of the apical sensillar complexes of the galeea and the glossa/paraglossa tips. The apical sensillar complex of galea contains a group of sensilla styloconica, rare short and many long sensila chaetica and rare sensilla trichodea. These apical structures developed the chemosensory and mechanosensory functions.

Keywords: stoneflies, galea, sensilla, chemo-mechanosensory complex.

Rezumat. Sensile galeale apicale la nimfa carnivoră de *Perla marginata* (Plecoptera: Perlidae). Partea distală a galeei la nimfele carnivore ale speciei *Perla marginata* (Pictet, 1833) a fost studiată utilizând microscopia electronică de baleiaj (SEM). Această specie are nimfe acvatice prădătoare tactile, active, folosindu-și sensilele pieselor bucale pentru „a pipăi”, “a gusta” și “a mirosi” hrana și substratul. Palpii maxilari și labiali, galea, glossa și paraglossa prezintă complexe senzoriale apicale implicate în decelarea calităților fizico-chimice ale substratului și prăzii. Această lucrare prezintă o descriere a morfologiei externe a vârfului galeei și evidențiază principalele tipuri și distribuția sensilelor la acest nivel. Vârful galeei este o regiune distinctă, cu aspect de platformă ovală, oblică, limitată de o creastă cuticulară semicirculară. Există o relativă similaritate între poziția, morfologia externă și structura generală a complexelor senzoriale apicale ale galeei și glossei/paraglossei. Complexul apical senzorial al galeei conține un grup de sensile styloconice, rare sensilla chaetica scurte și numeroase lungi, alături de rare sensile trichoide. Aceste complexe senzoriale apicale dezvoltă funcții chemo- și mecanosenzitive asemănătoare.

Cuvinte cheie: plecoptere, galea, sensile, complex chemo-mechanosenzorial.

Introduction

Angelini & Kaufman (2005) show that the primitive mandibulate insect mouthparts consist of a mandible, a pair of maxillae, each one bearing a segmented paraxial palp and two medial endites – lacinia and galea, and a medially labium with lateral articulated palps and two pairs of medial endites - glossa and paraglossa. The insect mouthparts have been extensively modified in different patterns as insects have exploited particular food resources. Chapman (1998) shows that biting and chewing insects cut off a fragment of food which is pushed back towards the mouth by the mandibles, often aided by the maxillae.

Monakov (2003) classified the stonefly nymphs in a few categories, taking account their type of food: phyto-detritophages, detritophages, phyto-zoophages, zoo-phytophages and zoophages. The predominantly zoophages nymphs (some Perlidae, Perlodidae and Chloroperlidae) have an external morphology of their mouthparts adapted for a carnivorous feeding type.

Gaino & Rebora (2003) show that the food selection and gestation are very important to sustain the growth and development of carnivorous immature stages.

According to Zacharuk & Shields (1991), taste and tactile cues for food selection and gestation are of primary importance during the immature stage of insects. The sensilla of immature insects can function as mecanosensilla, thermo-hygrosensilla, gustatory and olfactory chemosensilla or these may be composite sensilla.

Green & Hartenstein (1997) described three types of sensilla on the larval insect body: hairs or bristles (sensilla trichodea and sensilla chaetica), pegs (sensilla basiconica, sensilla coeloconica) and pits or papillae (papilla sensilla, sensilla campaniformia). Usually, the hairs range in size from a few to hundred micrometers, being aporous and representing mechanoreceptors. Peg sensilla may function as hygroreceptors.

Kapoor (1989), analyzing the distribution and innervation of sensilla on the mouthparts of the North-American carnivorous stonefly nymph, *Paragnetina media* (Perlidae), shows that the "nonsocket uniporous pegs crown the tip of galeae and are also scattered over the surface of the glossae and paraglossae".

Mouthpart sensilla are primarily contact chemoreceptors used to taste food and determine the chemical characteristics of the substrate (Bland *et al.*, 1998). Shields (1996) shows that the styloconic sensilla on the maxillary galea of larval *Mamestra configurata* are the only sensilla type permeable to an aqueous solution of cobalt chloride, only minimally permeable to mercury ions and not permeable to lead ions. These galeal styloconic sensilla have the greatest contribution in host plant discrimination. The same author shows that during feeding, the styloconic sensilla of maxillary galea are in continuous contact with the substances liberated from the plant leafs, with a probably gustatory function.

Material and Methods

Nymphs of *Perla marginata* were collected from the benthos of the permanent rivers, tributaries of the Bicaz Reservoir (Eastern Carpathians, Romania), using a Surber sampler device. For a scanning electron microscopy (SEM) examination, nymphs were fixed in 70% ethanol and were cleaned using an ammonium hydroxide solution, and were washed in distilled water. The maxillae were dissected under a stereomicroscope and dehydrated by using ethanol gradients and acetone. As alternative to critical point drying, the nymphal maxillae were transferred from 99% ethanol to hexamethyldisilazane (HMDS), air dried, and mounted on aluminum stubs, sputter-coated with silver, examined and photographed with a VEGA TESCAN scanning electron microscope at 30 kV, in the Electron Microscopy Laboratory of the Faculty of Biology, of the "Alexandru Ioan Cuza" University of Iași.

Results and Discussion

The distal parts of the mouthparts of carnivorous stonefly larvae show two different morphological patterns: the mandible and lacinia end in sharp-elongated teeth, while the galea, maxillary and labial palps, glossa and paraglossa end with apical sensory complexes (Fig. 1).

The galeae are relatively long, their length exceeding half the length of the maxillary palps. The galea is a curved, bi-segmented appendix, bearing a large apical sensory complex at its tip (Fig. 1). The base of this apical sensory complex is a platform, oval in shape and obliquely disposed, showing a rise margin oriented to the maxillary five-segmented palp and a low margin disposed to the longer tooth of the lacinia.

This apical plate contains a cluster of 20 sensilla styloconica, disposed on the both the anterior (Fig. 2a) and posterior (Fig. 2b) sides of the rised part of the apical plate.

According to Zacharuk & Shields (1991), sensilla styloconica “are mostly uniporous, gustatory chemosensilla but are sometimes aporous-mechanosensory pegs set on elongated style”. These sensilla styloconica may be similar with to the nonsocked uniporous pegs described for the tip of the galeae of the North-American nymph of *Paragnetina media* (Plecoptera: Perlidae) (Kapoor, 1989).

The apical sensilla styloconica have above 6-16 μm in length and 5.7-7.6 μm in diameter at the base, consisting of an elongated stylus/style and a small apical peg/cone, centered by a median porous and depressed at the apex (Fig. 3b). The sensilla styloconica set in 5 semi-concentrical rows, surrounding the lower part of the platform, occupied by long and strong sensilla chaetica. Faucheux (2008), analyzing the mouthparts and the associated sensilla of *Synempora andesae* (Lepidoptera: Neupseustidae), shows that the sensilla styloconica are present in the distal half of the galea and are only truly characteristic at the apex of the galea.

The tip of the apex is represented, only on the posterior side, by a group of long sensilla chaetica, one of them being longer, above 58 μm in length and 6 μm in diameter at its base. According to Zacharuk & Shields (1991), “sensilla chaetica are heavy, thick-walled bristles or spines that are aporous (tactile) or uniporous (chemomechanosensilla)”. The apical sensory complex of the galea has 9 bristles, 5 lower and the other 4 higher placed. The longer hair is included among the higher placed groups of bristles, prolonging the galea. Shields (1996) reported the same dorsposteriorly position of trichoid sensilla on the maxillary galea of larval *Mamestra configurata* (Walker) (Lepidoptera: Noctuidae) and of five other species.

On the posterior side of the apical sensory complex there is only one sensilla trichodea – “hair that may be aporous (mechanosensory, thermo-hygrosensory, or rarely, olfactory chemosensilla” (Zacharuk & Shields, 1991).

On the anterior side of the apical sensory complex there are one sensilla trichodea and one small sensilla chaetica, placed side by side in the most apical row of sensilla styloconica.

Conclusions

By this analysis of the galeal nymphal sensilla of the carnivorous stoneflies species, we observed that the tip of galea is a distinct sensory region, having an oval-plate form, oblique, limited by a semicircular cuticular ridge. There is a relative similarity between the position, external morphology and the general structure of the apical sensillar complexes of the galeea and the glossa/paraglossa tips.

The apical sensillar complex of galea contains a group of 20 sensilla styloconica, present at this level on the other groups of insects, too, but in a different number and distribution, rare short and many long sensilla chaetica and rare sensilla trichodea.

These apical structures developed chemosensory and mechanosensory functions. By the presence of the apical pore, the sensilla styloconica prove their chemosensory function, while the sensilla chaetica and trichodea have a mechanosensory role. By their emplacement on the tip of the quite long galea, this apical sensory complex may be equally involved in detection of the pray and in “taste” both of the chemical qualities of the pray and of the substratum.

Acknowledgments

I am grateful to Professor Ionel Miron for skippering during field work and for constructive comments. I thank Dr. Maria-Magdalena Dascălu and Physicist Dumitru Răileanu for the technical assistance. I acknowledge the founding provided by ANCS PN II Capacities 93/2007-2009 and UEFISCSU Ideas 434/2007-2010 projects.

References

Angelini, D. R., Kaufman, T. C., 2005. Insect appendages and comparative ontogenetics. *Developmental Biology*, **286**: 57-77.

Bland, R. G., Slaney, D. P., Weinstein, P., 1998. Mouthpart sensilla of cave species of Australian *Paratemnopteryx cockroaches* (Blattaria: Blattellidae). *Int. J. Insect Morphol. & Embryol*., **27 (4)**: 291-300.

Chapman, R. F., 1998. *The insects: Structure and function*. Cambridge University Press.

Faucheux, M. J., 2008. Mouthparts and associated sensilla of a South American moth, *Synempora andesae* (Lepidoptera: Neopseustidae). *Rev. Soc. Entomol. Argent*., **67 (1-2)**: 21-33.

Gaino, E., Rebora, M., 2003. The sensilla on the labial and maxillary palps of the nymph of *Baetis rhodani* (Ephemeroptera: Baetidae). *Research Update on Ephemeroptera & Plecoptera*, University of Perugia: 445-451.

Green, P., Hartenstein, V., 1997. Structure and Spatial Pattern of the Sensilla of the Body Segments of Insect Larvae. *Microscopy Research and Technique*, **39**: 470-478.

Kapoor, N. N., 1989. Distribution and innervation of sensilla of the mouthparts of the carnivorous stonefly nymph, *Paragnetina media* (Walker) (Plecoptera: Perlidae). *Can. J. Zool*., **67 (4)**: 831-838.

Monakov, A. V., 2003. Feeding of freshwater invertebrates. *Kenobi Productions*, Belgium: 267-278.

Shields, V. D. C., 1996. Comparative external ultrastructure and diffusion pathways in styloconic sensilla on the maxillary galea of larval *Mamestra configurata* (Walker) (Lepidoptera: Noctuidae) and five other species. *Journal of Morphology*, **228**: 89-105.

Zacharuk, R. Y., Shields, V. D., 1991. Sensilla of immature insects, *Annu. Rev. Entomol*., **36**: 331-354.

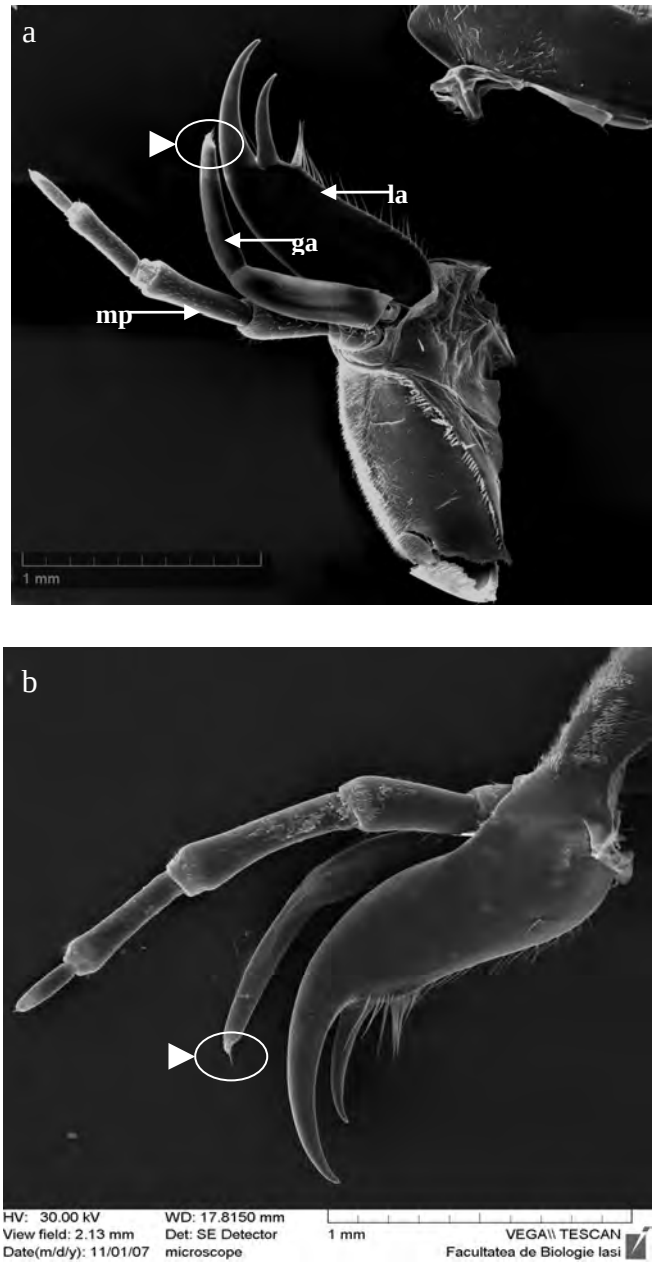

Figure 1. Distal anatomy of the galea of *Perla marginata* nymphs (SEM): a. posterior side, b. anterior side. Arrow-heads indicate the position of the apical sensillar complex of galea, la – lacinia, ga – galea, mp – maxillary palp.

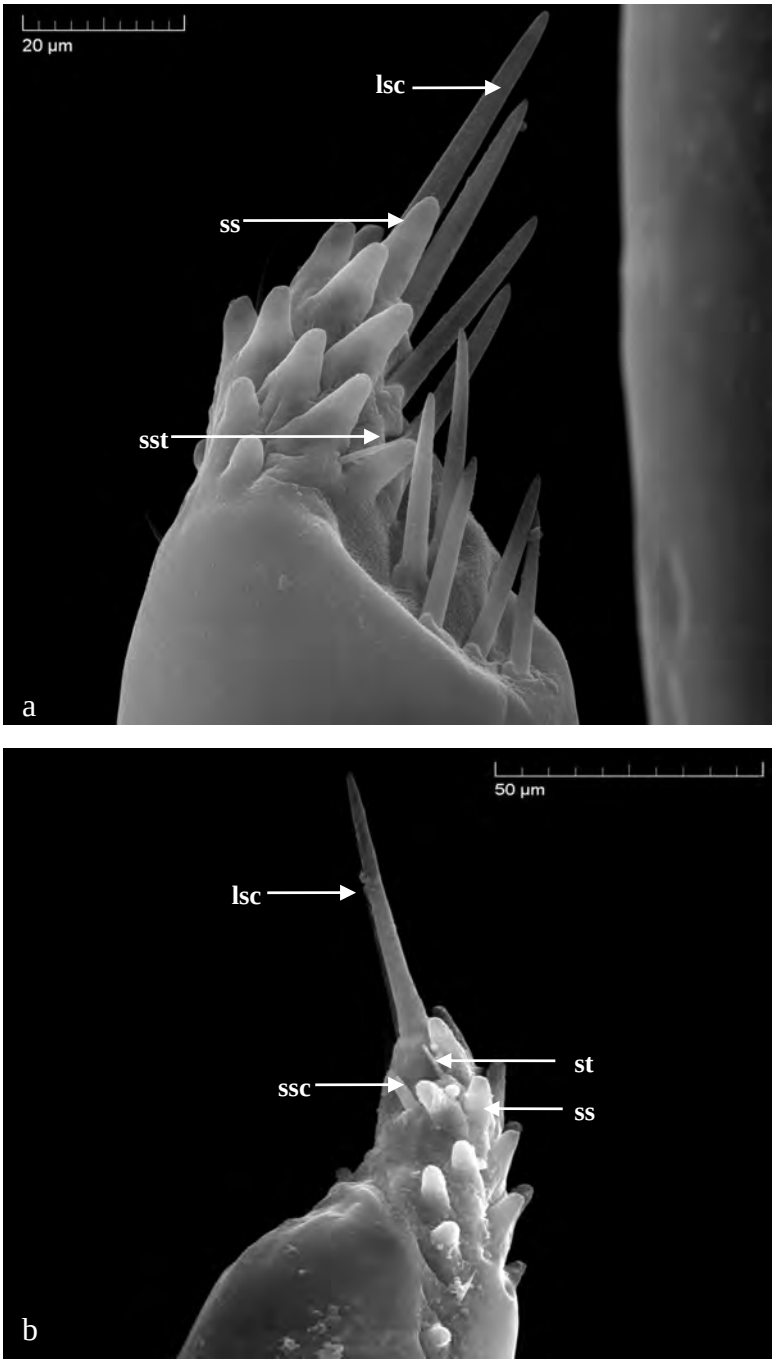

Figure 2. Sensillar complex of the tip op galea of *Perla marginata* nymphs (SEM): a. poserior side, b. anterior side. lsc – long sensilla chaetica, ssc – short sensilla chaetica, ss – sensilla styloconica, st – sensilla trichodea.

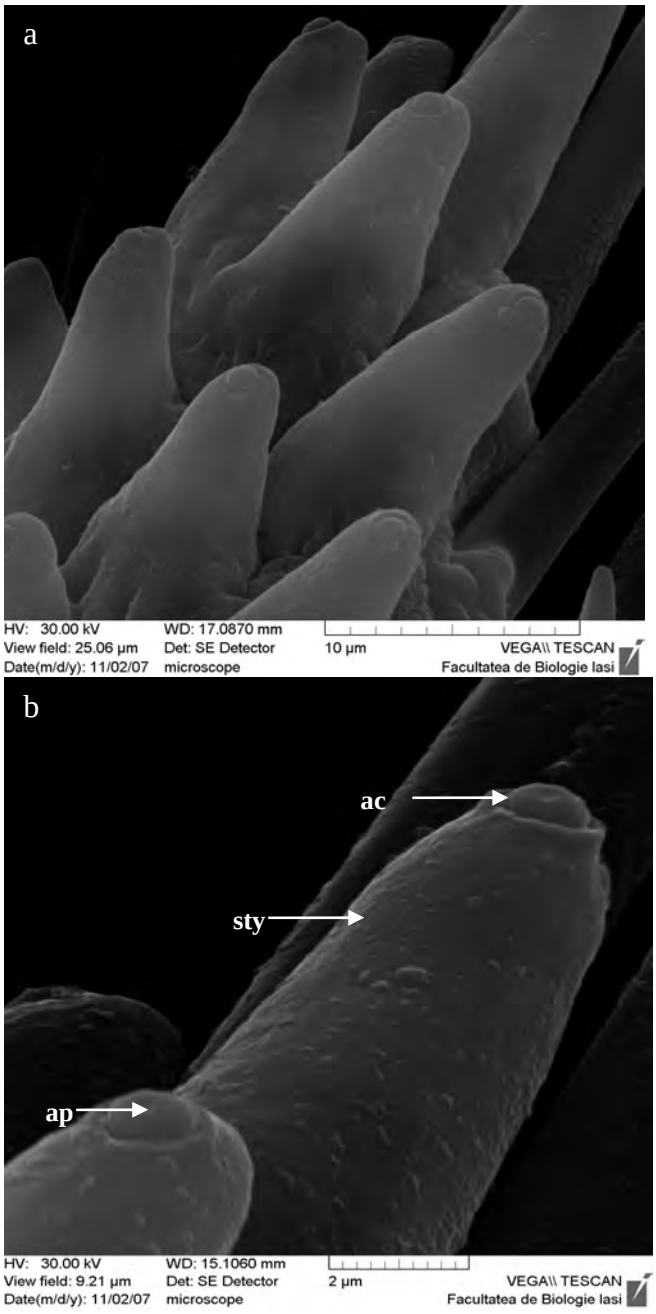

Figure 3. Sensilla styloconica of the tip op galea of *Perla marginata* nymphs (SEM): a. distribution of sensilla in concentric rows, b. detail, ac – apical cone, ap - apical pore, sty - stylus.