



Ultrastructure of mediodorsal setae in biting midge larvae of the genus *Atrichopogon* Kieffer with notes on their biological significance (Diptera: Ceratopogonidae)



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ABSTRACT

The ultrastructure of the strong mediodorsal setae in terrestrial stage IV larvae of *Atrichopogon* (*Meloehalea*) *oedemerarum* and *A. (M.) meloesugans* was examined using light, scanning and transmission electron microscopy. Serrated setae placed on prominent processes are distributed in pairs on all thoracic and abdominal segments. Setae are innervated by a single dendrite and their surface has no pores. The trichogen cell is not retracted from the setal lumen on completion of the hair-forming process but fills the mediodorsal seta also when the larval cuticle is fully sclerotised. Such a phenomenon was previously reported in terrestrial larvae of the genus *Forcipomyia*. We suggest that the mediodorsal setae described in *Atrichopogon* are plesiotypic mechanoreceptors for the subfamily Forcipomyiinae. They are preserved in the truly terrestrial larvae of *Atrichopogon*, but modified to secretory setae in the genus *Forcipomyia*. Both genera bearing distinct mediodorsal setae have developed functional tracheal gills, unknown in other biting midges.

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1. Introduction

Biting midges of the family Ceratopogonidae are a group of small nematoceros flies which develop in a wide range of habitats, from fully aquatic to truly terrestrial, and the ecological preferences of their larvae range from fresh to salt water and from swamps to moist soil. Since they are apneustic, respiratory gases are exchanged through the cuticle.

The ceratopogonids are a well-studied group of insects because some of them (especially the genus *Culicoides*) are blood-sucking vectors of dangerous pathogens like arboviruses, trypanosomes and filarial nematodes (Mellor et al., 2000; Seblova et al., 2012). Research into the sensory organs of biting midges has focused mainly on the antennal or palpal chemoreceptors of haematophagous females. The antennal sensilla of adult *Culicoides* midges is the most common subject of interest in anatomical and functional studies (Blackwell et al., 1992; Blackwell, 2004; Isberg et al., 2013;

Urbanek et al., 2014). Their larvae generally live in aquatic habitats and, like all aquatic larvae of biting midges, bear only delicate and indistinct setae, probably mechanoreceptors.

The preimaginal stages of the genera *Atrichopogon* Kieffer and *Forcipomyia* Meigen (subfamily Forcipomyiinae) live in moist, terrestrial habitats of decaying organic matter like dung or rotting wood, but they can also develop in aquatic and semiaquatic habitats (hygropetric), on partially submerged stones, rotting wood, algae or mosses along the margins of streams, ponds or lakes (Szadziewski et al., 1997). Their larvae can be distinguished by a double row of mediodorsal setae (usually spine-like) running across all the thoracic and abdominal segments (Szadziewski et al., 1995; Urbanek et al., 2011). In fully terrestrial larvae the mediodorsal setae are much more robust and distinct. In true aquatic species these setiform spines are shorter (*Atrichopogon*, subgenus *Psammpogon*) or even inconspicuous (*Forcipomyia*, subgenus *Trichohelea*) (Saunders, 1925; Szadziewski et al., 1995).

The mediodorsal setae of the genera *Forcipomyia* and *Atrichopogon* are evidently homologous (Saunders, 1925; Nielsen, 1951). In the genus *Forcipomyia* they are mechanoreceptors (sensilla trichodea) that additionally secrete a viscous, hygroscopic substance discharged through the pore/pores on the cuticle surface (Urbanek

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