Fine structure of sensilla during moulting in *Neomysis integer* (Leach) (Crustacea, Mysidacea)

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Summary. During the moulting cycle the sensory cells and the newly formed hair shaft remain connected to the old cuticular receptive apparatus of the sensillum by the elongated outer segments of the dendrites, which run through the exuvial space. A surface coat covering the outer dendritic segments protects them against the chemical influences of the exuvial fluid. The findings suggest that the receptors remain functional until ecdysis. This moulting type is considered to be a transitional form between the moulting types so far known.

In arthropods the cuticular receptive apparatus of the sensilla is newly formed under the old cuticle during the moulting processes. Requirements for maintaining the sensitivity of the receptors until ecdysis are that (a) the connection between the sensory cells and the old cuticular receptive apparatus is maintained and (b) the dendrites are protected aginst the chemical influences of the exuvial fluid, which expands between the old and new cuticle.

Investigations of the moulting processes of sensilla in *Neomysis integer* (Leach) revealed a moulting type which differs not only from the moulting cycles described in Crustacea so far[1-3], but is also not known in the more intensively investigated Insecta[4] and Arachnida[5,6]. The present paper deals with the peculiarity of this moulting process.

The sensilla resemble those sensory hairs the morphology and function of which were recently reported[7,8]. Therefore only a few structural details useful for the understanding of the sensillar organization are indicated here.

Methods. The objects were prepared for electron microscopy as described in a previous paper[8].

Results. The sensilla occur on the inner flagellum of the antennulae in *Neomysis.* The hair shaft (length approximately 50 µm) bears irregularly dispersed setules and is inserted on a cuticular bulb (figure 1). 2 sensory cells belong to a hair. The inner segments of the dendrites contain a long, thick rootlet (figures 1 and 2, a). Each inner segment gives rise to an outer segment which runs into the hair shaft. A supporting structure partially surrounds the receptor lymph cavity (figures 1 and 2, b).

Moulting. The electron micrographs of figure 2 show the stage D_2 of the moulting cycle. The epidermis is withdrawn from the old cuticle and an exuvial space extends between the old and new cuticle. All the cell membranes bordering the exuvial space are covered with a uniform epicuticle (figure 2, b–d). Thus the dimensions of the new hair shaft are fixed. The newly forming shaft is invaginated in a cylindrical depression of the epidermal tissue. The future distal part of the new hair shaft lies inside the cylinder, the wall of which is formed by the cuticle of the future proximal hair shaft (figures 1 and 2, b–d). The setules are formed by projections of the outer enveloping cells. The outer dendritic segments run up through the newly forming hair shaft and then stretch through the exuvial space into the old cuticular apparatus (figures 1 and 2, b–f). In the old hair base, the outer dendritic segments are enclosed by a dendritic sheath composed of electron dense substances (figures 1 and 2, f). The lumen of the old hair shaft communicates with the exuvial space. Microtubules are visible in the outer dendritic segments (figure 2, e). No structural damage of the dendrites has taken place due to the enzymes of the exuvial fluid. The outer dendritic segments are covered with a surface coat, which appears as granular, fibrous material after fixation (figure 2, e).

Discussion. 3 different moulting types are known in the cuticular receptors of arthropods. In moulting type I (term, Altner and Thies[9]) the sensilla remain functional until ecdysis, as the sensory cells stay connected with the old

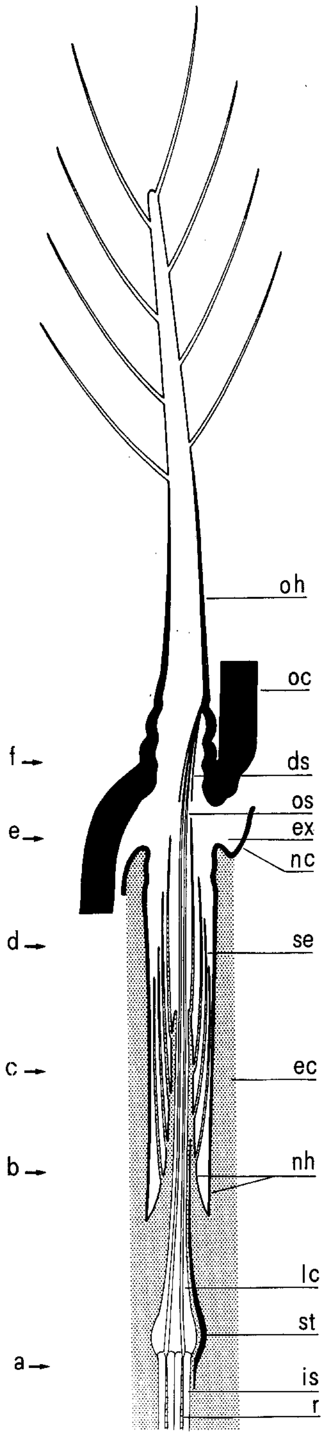

Fig. 1. Diagrammatic longitudinal section through the old (oh) and newly forming hair shaft (nh) of a sensillum. Arrows (a–f) indicate the level of the transverse sections (figures 2, a–f); ds, dendritic sheath; ec, enveloping cells; ex, exuvial space; is, inner dendritic segment; lc, receptor lymph cavity; nc, newly forming cuticle; oc, old cuticle; os, outer dendritic segment; r, rootlet; se, setule of the future hair shaft; st, supporting structure.

cuticular apparatus by the elongated outer segments of the dendrites. The outer segments encased within a dendritic sheath run through the exuvial space. The dendritic sheath protects the dendrites from the chemical influences of the exuvial fluid[1,3-5,9-14].

The sensitivity of the receptors gets lost in moulting types II and III, because the dendritic connection between the old hair shaft and the sensory cells ruptures during apolysis. In type II, the dendrites lacking a protective dendritic sheath withdraw from the old cuticular receptive apparatus[9]. In

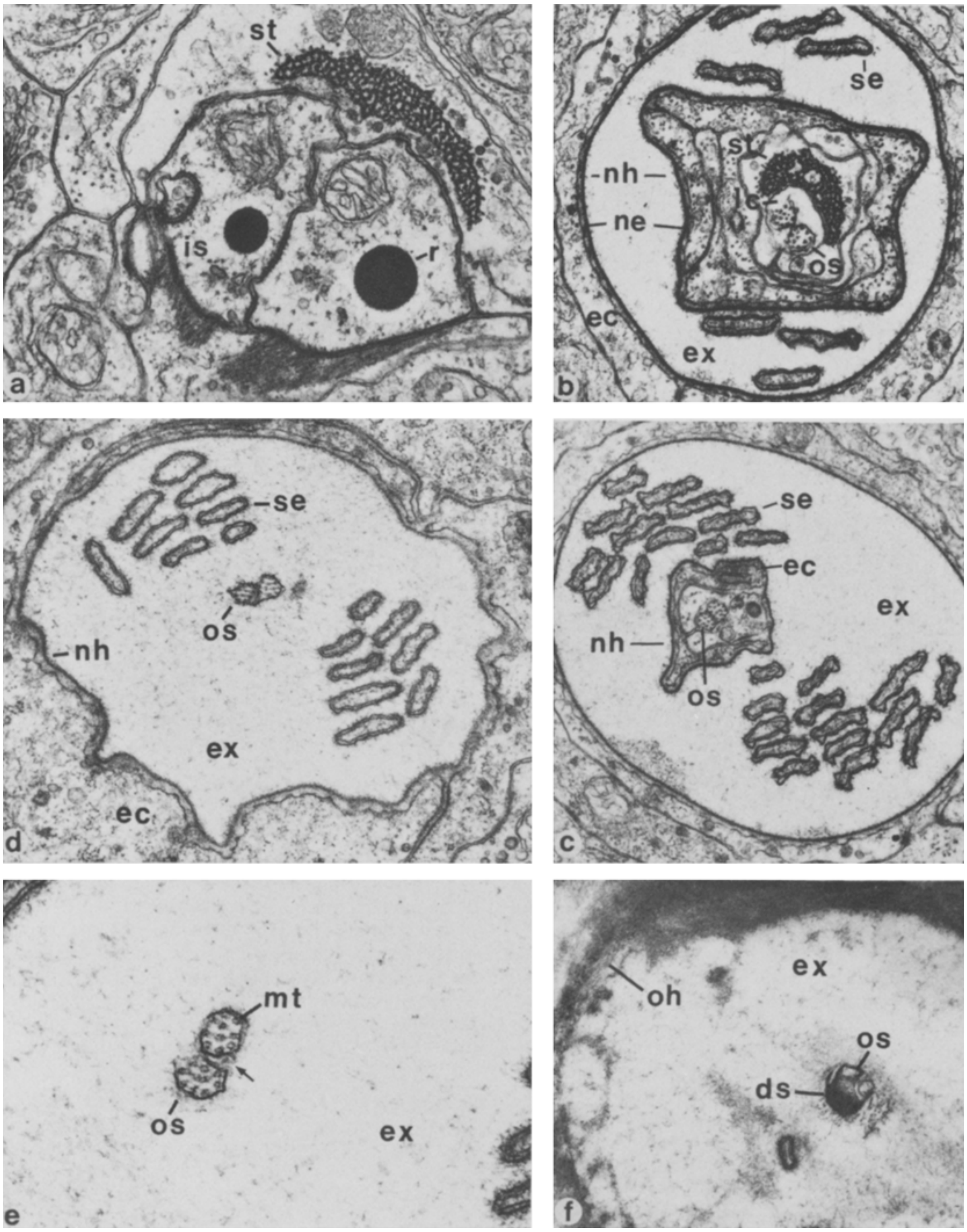

Fig. 2. Transverse sections through a newly forming, invaginated hair shaft (b–d) and the base of the old shaft (f). *a* Transverse section below the setal invagination; the inner dendritic segments (is) of the 2 sensory cells contain a long, thick rootlet (r); st, supporting structure. ×26,800. *b* The newly-forming hair shaft (nh) invaginated; the supporting structure (st) partially surrounds the receptor lymph cavity (lc), in which the outer dendritic segments (os) extend; ec, enveloping cell; ex, exuvial space; ne, new epicuticle; se, setule. ×21,000. *c* The outer dendritic segments (os) run up through the newly forming hair shaft (nh, distal part) closely encased by enveloping cells (ec); ex, exuvial space; se, setule. ×21,000. *d* The outer dendritic segments (os) have left the future distal hair shaft and lie freely inside the setal invagination; ex, exuvial space; nh, newly forming hair shaft (proximal part); se, setule. ×25,800. *e* The outer dendritic segments (os) run through the exuvial space (ex) into the old hair shaft; note the microtubules (mt) in the outer dendritic segments; arrow points to the fibrous, granular material of the surface coat; ex, exuvial space. ×57,000. *f* In the base of the old hair shaft (oh), the outer dendritic segments (os) are enclosed by the electron dense substance of the dendritic sheath (ds); ex, exuvial space. ×29,250.

moulting type III, the outer dendritic segments break off below the old hair base, although the dendrites possess a dendritic sheath[15].

Altner and Thies[9] require transitional types between the moulting cycles I and II. For Larink[15] moulting type III mediates between the forms I and II. The sensilla described here may be considered as another transitional type. The elongated outer segments of the dendrites cross the exuvial space freely (that means, without a dendritic sheath) into the old hair shaft. From the electron micrographs it appears that the dendrites are in a functional state. These findings indicate that the sensitivity of the old receptor is maintained during the moulting cycle. Then a protective mechanism against the enzymes of the exuvial fluid must exist. Such a protection can be provided by the surface coat which covers the outer dendritic segments. Thus both requirements for maintaining the sensitivity of the old sensillum are complied with.

On ecdysis, when the old cuticle is shed, the newly formed hair shaft of the sensillum is everted like the invaginated finger of a glove. The outer dendritic segments break off on or in the new shaft. The formation of the short dendritic sheath, which serves here to anchor the outer dendritic segments to wall of the hair shaft, takes place after ecdysis.

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Influence of chemical signals on the topographic orientation of the cave fish *Caecobarbus geertsi* Boulenger (Pisces, Cyprinidae)[1]

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Summary. Adult individuals of the cave cyprinid *Caecobarbus geertsi* Boulenger, when placed in a choice-apparatus, show a significant tendency to orient towards the zone in which water from a tank occupied by known conspecifics is introduced. The phenomenon is briefly discussed in relation to the physical features of the subterranean biotopes.

Due to the permanent darkness of subterranean biotopes and the phyletic degeneration of the eye, blind cave animals can only rely on 2 types of sensory cues, viz. mechanical and chemical ones. However, as previous studies indicate, chemical cues seem to play a more important role in the behaviour of cave vertebrates than mechanical ones do. Thus, comparative studies on the cave fishes *Astyanax (=Anoptichthys) jordani* Hubbs & Innes and *Caecobarbus geertsi* Boulenger showed that in both forms chemical stimulation is determinant in eliciting the feeding behaviour pattern characterized by a sudden diving response towards the bottom of the aquarium, followed by a continuous active exploration of the substrate[2]. Mechanical stimulation, on the contrary, seems to play only a secondary role: juvenile individuals of *Astyanax jordani* are unable to seize moving prey *(Cyclops)* except when they happen to collide with it while swimming[3]. Moreover, the topographical orientation of the cave urodele *Proteus anguinus* Laurenti is determined by chemical markings on the substrate[4]. More recently, it has been shown that chemical information from conspecifics is effective in orienting the locomotor responses of the blind cave cyprinid *Phreatichthys andruzzii* Vinciguerra. If pure water or water from tanks containing 13–14 known or unknown individuals of this species is introduced randomly into either of the end chambers of a choice apparatus, the water volume introduced being 500 ml in all cases, the test individuals orient significantly towards the treated chamber[5]. The aim of the present study was to investigate whether similar responses to conspecific odour could be shown in the blind cave cyprinid *Caecobarbus geertsi.*

Material and method. 9 adult individuals of *Caecobarbus geertsi* were collected in the lower Congo cave system in July 1976. During the 60 days prior to the experiments and during the experiments themselves (March 1979), they were placed together in a tank as a single group. Using the same method as in the previous experiments on *Phreatichthys,* the presence of the test-fishes in one of the 3 chambers of a choice-apparatus trough: 180×20×8 cm; water level: 8 cm was noted individually every 30 sec for 45 min. Each test-fish was transferred from the group-tank and placed in the

Statistical analysis of results obtained in choice-experiments on *Caecobarbus geertsi* (35 experiments)

Intervals of analysis (min)	Experiments Positive	Neutral	Negative	χ^2	Significance
0′–45	27	0	8	10.31	$0.001 < p < 0.01$
0′–15′	28	2	5	16.03	$p < 0.001$
15′–30′	24	1	10	5.76	$0.01 < p < 0.02$
30′–45′	23	1	11	4.23	$0.02 < p < 0.05$
0′– 3′	20	5	10	3.33	$0.05 < p$ (n.s.)
3′– 6′	18	11	6	6.00	$0.01 < p < 0.02$
6′– 9′	20	7	8	5.14	$0.02 < p < 0.05$
9′–12′	20	6	9	4.17	$0.02 < p < 0.05$
12′–15′	21	4	10	3.90	$0.02 < p < 0.05$