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Axillary glands in the armoured catfish *Corydoras aeneus* (Callichthyidae, Siluriformes)

Axillardrüsen beim Panzerwels *Corydoras aeneus* (Callichthyidae, Siluriformes)

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Summary: In the armoured catfish *Corydoras aeneus* paired axillary glands are described employing conventional histology and ultrathin sections. The tubular gland opens near the first pectoral ray. A strong longitudinal muscle is attached to the connective tissue covering the inner side of each gland. Gland cells are almost completely filled with a rather homogeneous secretory product of varying electron density. The cytoplasm is limited to an area around the nucleus and a small rim close to the lateral plasmalem. These parts are crowded with a considerable amount of dictyosomes and profiles of the rough endoplasmic reticulum. Smaller, electron-lucent cells situated basally between the gland cells are largely undifferentiated; some of them show giant mitochondria with only few cristae.

Key words: Callichthyidae, axillary glands, proteinaceous secretion

Zusammenfassung: Anhand von histologischen Schnitten und Ultradünnschnitten werden beim Panzerwels *Corydoras aenus* paarige Axillardrüsen beschrieben, die neben dem ersten Brustflossenstachel ausmünden. Die Drüsen sind tubulär; ihre Zellen sind nahezu vollständig mit einem relativ homogenen Sekretprodukt unterschiedlicher Elektronendichte gefüllt. Das Cytoplasma an der Peripherie der Zellen und um den Kern herum enthält zahlreiche Dictyosomen und Zisternen des rauen endoplasmatischen Reticulums. Kleinere, meist basal zwischen den Drüsenzellen gelegene Zellen sind undifferenziert; manche besitzen extrem große Mitochondrien mit nur wenigen Cristae.

Schlüsselwörter: Callichthyidae, Axillardrüsen, proteinhaltige Sekrete

1. Introduction

Toxic skin secretions are wide spread among catfishes (Siluriformes). Currently, species at least of nine of the 21 siluriform families are known to have such secretions that are discharged by epidermal cells (crinotoxins) and/or by venom apparatuses (acanthotoxins) (for review see Perriére and Goudey-Perriére 2003). The latter consist of spines of the dorsal and/or pectoral fins, which may be distally flanked by aggregations of single gland cells that rupture during spinous puncture, and/or "axillary" glands that open with a large pore near the base of the pectoral fin, but their secretion does not seem to coat the pectoral spine. The discharged substances are diverse; they may have neurotoxic and hemotoxic properties and symptoms include pain, tissue

necrosis etc. (see Perriére and Goudey-Perriére 2003). In this review the Callichthyidae, namely *Corydoras* spp., are not listed among toxic catfishes. This is surprising, all the more as painful stings by the pectoral spine and fatalities during stress, e.g., during the transport, when some species discharge a whitish or colourless secretion of unknown origin, have been reported by aquarists and fish importers from several species (e.g. Evers 2003).

Here we document the presence of large axillary glands in the armoured catfish *Corydoras aeneus* by light- and electron microscopy. Presence of such glands was shown also in dissected *Corridors sterbai* (Kiehl et al. 2006).

2. Material and methods

Adult and semiadult *Corydoras aeneus* were purchased from a commercial dealer. Two specimens were anaesthetised with MS 222, fixed for several weeks in Bouin's fluid, decalcified and cut serially at 7 µm. Sections were stained with Azan-Heidenhain and AB-PAS (Romeis 1968).

For electron microscopy, the glands were excised, fixed for 2 h in 2.5 % glutaraldehyde in 0.1 mol/l cacodylate puffer, pH 7.2, postfixed in 2% osmiumtetroxide in the same buffer and embedded in Spurr's medium (Spurr 1969). Ultrathin sections were cut with glass knifes, stained with lead citrate (Venable and Coggeshall 1965) and viewed in a Philips electron microscope 300.

3. Results

Each axillary gland opens immediately below the vertical, posthumeral protuberance of the cleithrum near the origin of the strong pectoral spine (the first ossified ray, whose segments are fused). The gland is tubular, non-lobated (fig. 1 a) and covered by a thin capsule of connective tissue. A strong longitudinal muscle is attached to the inner face of each gland. The volume of the gland cells that is relatively small near the entrance increases markedly towards the interior.

Gland cells are completely filled with secretory products, that stain orange after Azan (fig. 1 a), but do not stain after AB-PAS; nuclei are rarely seen in histological sections. Small strands of connective tissue extend between the gland cells (see fig. 1b). Vascularization of the gland is poor.

At the ultrastructural level most cells are filled with large masses of a rather homogeneous secretion of varying electron density. This variation may indicate different maturity (figs. 1b, 2a, c). Cytoplasm and cell organelles such as the nucleus, mitochondria, dictyosomes and abundant profiles of the rough endoplasmatic reticulum are perinuclear or restricted to a small rim at the lateral plasmalemma. Near

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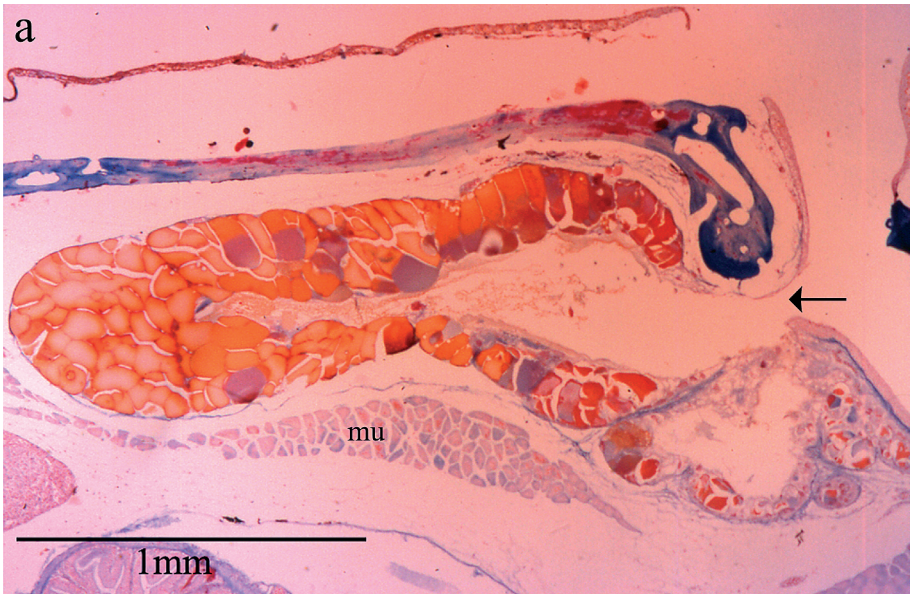
Figs. 1a, b: Histology and ultrastructure of the axillary glands in *Corydoras aeneus*. **a** Note the muscle (mu) at the inner surface, the tubular aspect of the gland, its entrance (arrow), and the large secretory cells (Paraplast, Azan-Heidenhain). **b** Adjacent gland cells separated by a small strand of connective tissue; fibrocytes (1, 2); dictyosomes (di), rough endoplasmic reticulum (rer); various confluent vesicles (arrowheads) and masses of secretion (asterisks) of different electron density; nucleus (nu).

Abb. 1 a, b Histologie und Ultrastruktur der Axillardrüsen von *Corydoras aeneus*. **a** Man beachte den Muskel (mu) an der Innenseite der Drüse, die tubuläre Drüse, die Drüsenöffnung (Pfeil), und die großen Sekretzellen (Paraplast, Azan-Heidenhain). **b** Benachbarte Zellen durch einen schmalen Streifen Bindegewebes voneinander getrennt; Fibrocyten (1,2); Dictyosomen (di), raues endoplasmatisches Reticulum (rer); verschiedene miteinander verschmelzende Vesikel (Pfeilköpfe) und große Ansammlungen von Sekret unterschiedlicher Elektronendichte (Sternchen); Zellkern (nu).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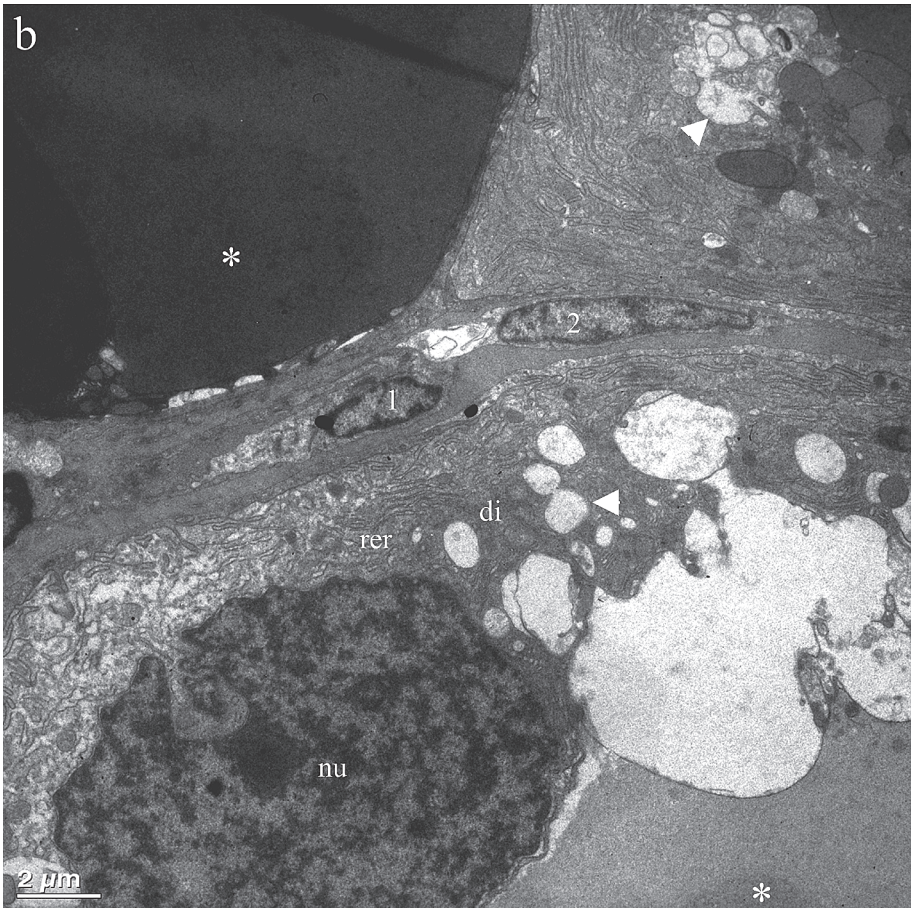
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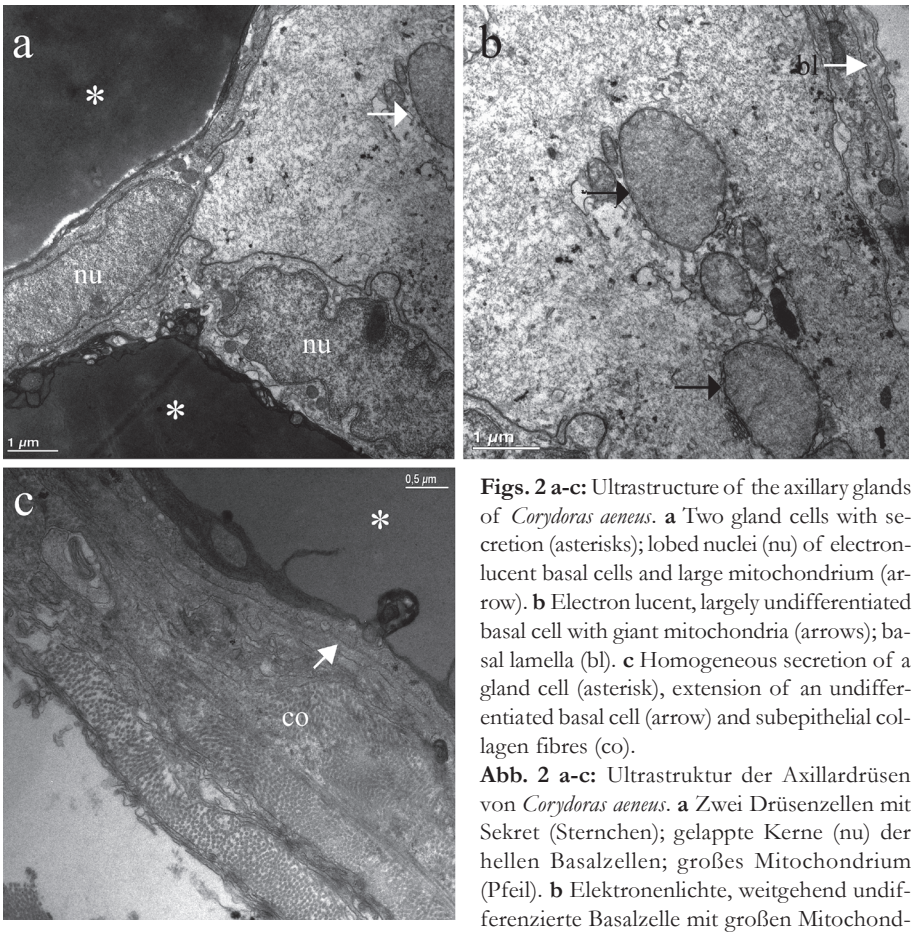

Figs. 2 a-c: Ultrastructure of the axillary glands of *Corydoras aeneus*. **a** Two gland cells with secretion (asterisks); lobed nuclei (nu) of electron-lucent basal cells and large mitochondrium (arrow). **b** Electron lucent, largely undifferentiated basal cell with giant mitochondria (arrows); basal lamella (bl). **c** Homogeneous secretion of a gland cell (asterisk), extension of an undifferentiated basal cell (arrow) and subepithelial collagen fibres (co).

Abb. 2 a-c: Ultrastruktur der Axillardrüsen von *Corydoras aeneus*. **a** Zwei Drüsenzellen mit Sekret (Sternchen); gelappte Kerne (nu) der hellen Basalzellen; großes Mitochondrium (Pfeil). **b** Elektronenlichte, weitgehend undifferenzierte Basalzelle mit großen Mitochondrien (Pfeile; Basallamelle (bl). **c** Homogenes Sekret einer Drüsenzelle (Stern), Fortsatz einer undifferenzierten Basalzelle (Pfeil) und subepitheliale Kollagenfasern (co).

the dictysomes, vesicles coalesce with one another or with the large masses of secretion (fig. 1b). Gland cells are always separated from the basal lamella by undifferentiated cells or their extensions (fig. 2 c). Undifferentiated cells are characterized by their light cytoplasm free of any secretory vesicles and contain occasionally giant mitochondria (fig. 2 d). The first pectoral fin ray covered by connective tissue and the epidermis does not show any aggregations of glandular cells within the dermis. However, number of granular cells, typical for the epidermis, appears larger (not pictured).

4. Discussion

Axillary glands are widespread in catfishes. To our knowledge, however, their presence in members of the Callichthyidae has not been described hitherto. Examination of various *Corydoras* spp. shows that these glands are common among the Callichthyidae (unpublished; see also Kiel et al. 2006). Their position corresponds to that of other Siluriformes (e.g. *Ictalurus nebulosus*, Whitear et al. 1991b). This obviously does not hold for their ultrastructure that appears to be different in the various Siluriformes (insuffi-

ciently investigated as yet) and between *Corydoras* spp. (unpublished).

Axillary glands are invaginations of the integument and their secretory cells are derivatives of the epidermis. Obviously they are replaced by undifferentiated basal cells during turnover; the mode of secretion is probably holocrine (see the discussion in Whitear et al. 1991b). Whether gland cells are modified club cells or new epidermal derivatives is a matter of debate (e.g. Cameron and Endean 1973, Al-Hassan et al. 1987, Whitear and Mittal 1983, Whitear et al. 1991a, b) and is currently under investigation. The weak or even negative AB - PAS reaction as well as the presence of a considerable number of profiles of the rough endoplasmic reticulum suggests a large proteinaceous portion of secretions (see also Kiehl et al. 2006).

Traditionally, catfish toxins are regarded to act in the fish's own defence. Properties of the secretion of the axillary glands, which seem to be less toxic than epidermal secretions in some species (Al-Hassan et al. 1987), are largely unknown. When stressed, most, if not all, Callichthyidae discharge toxins in their environment that perhaps are primarily secretions (crinotoxins) of the epidermal gland cells as in other catfishes. However, water, in which *C. sterbai* was transported, contained also secretions of the axillary glands and was bactericidal (Kiehl et al. 2006). Currently, we do not exactly know to which extent axillary gland secretions contribute to this antimicrobial activity and, strictly speaking, also to which extent they are responsible for the pain and other effects people will suffer when stung by the pectoral fin ray.

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Literature

Al-Hassan, J.M., Thomson, M., Ali, M., Criddle, R.C. 1987. Toxic and pharmacologically active secretions from the Arabian Gulf catfish (*Arius thalassinus*, Ruppell). J. Toxicol. Toxin Rev. 6, 1-43

Cameron, A.M., Endean, R. 1973. Epidermal secretions and the evolution of venom glands in fishes. Toxicon 11, 401-410.

Evers, H.-G. 2002. Der lange Weg der Panzerwelse. Aquaristik Fachmagazin 34 (5): 10-13.

Kiehl, E., Rieger, C., Greven, H. 2006. Axillary gland secretions contribute to the stress-induced discharge of a bactericidal substance in *Corydoras sterbai* (Callichthyidae, Siluriformes). Verh. Ges. Ichthyol. 6, 111-115.

Perrière, C., Goudey-Perrière, F. 2003. Poisonous catfishes: Venom apparatus, acanthotoxins and other skin secretions, pp. 291-314. In: Catfishes, Vol. 1 (Arratia, G., Kapoor, B.G., Chardon, M., Diogo, R., eds). Science Publishers, Inc. Enfield.

Romeis, B. 1968. Mikroskopische Technik. Oldenbourg Verlag, München.

Spurr, A.R. 1969. A low viscosity epoxy resin embedding medium for electron microscopy. J. Ultrastruct. Res. 26, 31-43.

Venable, J.H., Coggeshall, R. 1965. A simplified lead staining for electron microscopy. J. Cell Biol. 25, 407-408.

Whitear, M., Mittal, A.K. 1983. Fine structure of the club cells in the skin of ostariophysan fish. Z. mikrosk. Anat. Forsch. 97, 141-157.

Whitear, M., Zaccone, G., Ricca, M.B., Lo Cascia, P. 1991a. Fine structure and histochemistry of the venom gland in the Indian stinging catfish (*Heteropneustes fossilis*). J. Zool., London 224, 479-489.

Whitear, M., Zaccone, G., Fasulo, S., Licata, A.1991b. Fine structure of the axillary gland in the brown bullhead (*Ictalurus nebulosus*). J. Zool., London 224, 669-676.