Japanese Journal of Ichthyology
Vol. 35, No. 1 1988

魚類学雑誌
35巻1号 1988年

Fine Structure of Supporting Elements of the Small Pit Organ in the Far Eastern Catfish, *Silurus asotus*

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(Received May 20, 1987)

Abstract The small pit organ of the catfish, *Silurus asotus*, was examined by electron microscopy. On the basis of their fine structures and positions in the organ, five types of cells were distinguished: 1) receptor cell (RC), 2) granular (supporting) cell (GC), 3) non-granular (supporting) cell (NGC), 4) mantle cell (MC), and 5) channel cell (CC). Both GCs and NGCs were located between the RCs in the sensory epithelium and had similar fine structures except for striking differences in their apical cytoplasm. The GC contained numerous secretory granules and scattered tonofilaments. By contrast, the NGC was characterized by abundant tonofilaments in their apical cytoplasm where only a small number of secretory granules were counted. The NGC always occurred in direct contact with RCs, whereas the GC never did so. The MCs, forming the outermost part of the organ, were characterized by numerous tonofilaments in the cytoplasm and resembled the ordinary epidermal cells in their fine structure. The CCs lined the duct of the organ, and contained electron dense cytoplasm and rather degenerative organelles. Presumably the GCs contribute to secretion of the mucous substance to the ampullary lumen, whereas the NGCs deal with nutrition and insulation for the RCs.

Within the lateral-line system of the fish, the ordinary and the specialized lateral line organs can be distinguished (Szabo, 1974). The former is established as a mechanoreceptor and the latter as an electroreceptor (Dijkgraaf, 1963; Szabo, 1974). Since the specialized lateral line organs comprise a large variety of sense organs, they are classified morphologically into the ampullary and the tuburous organs. The small pit organ of the siluroids is considered to be a member of the ampullary organs (Szabo, 1974). On the basis of the morphological, behavioral and electrophysiological studies, the *Amiurus* small pit organ has also been accepted as an electroreceptor (Mullinger, 1964; Dijkgraaf, 1968; Roth, 1972; Peters et al., 1974; Bretschneider at al., 1980).

In the Far Eastern catfish, *Silurus asotus*, the organs are distributed all over the body surface, particularly on the cranial regions. Although it is difficult to find them with the naked eye, their openings can be identified on the skin with a dissecting microscope (Sato, 1956). The sensory eptithelium of the organ is located at the lower portion of a pit (ampulla) which opens onto the skin surface through a narrow duct. We previously reported that the RC in the *Silurus* small pit organ showed a similar fine structure to that of *Amiurus*, and suggested that the former might be electroreceptive, though it had not been investigated electrophysiologically (Sato and Katagiri, 1969). In many preceding papers, various features of the supporting elements have been left unnoticed, whereas the RCs have been investigated in detail (Mullinger, 1964; Wachtel and Szamier, 1969; Gelinek, 1978; Szabo, 1974).

The *Silurus* small pit organ seems to deserve attention because of the GCs which contain abundant secretory granules in their apical cytoplasm. The present study aims to describe the fine structure of the supporting elements, which have several different functions, with special reference to corresponding cells found in other species. The RCs will be mentioned briefly, only for the convenience of the description, because they have already been described in a preceding paper (Sato and Katagiri, 1969).

This research was carried out at the Department of Biology, Faculty of Science, University of Hirosaki.

Materials and methods

Far Eastern catfish, *Silurus asotus* Linnaeus, (11–14 cm body length) were obtained from the local "Mawarizeki" irrigation pond in the suburb of Hirosaki, Aomori Prefecture. Under anestheti-

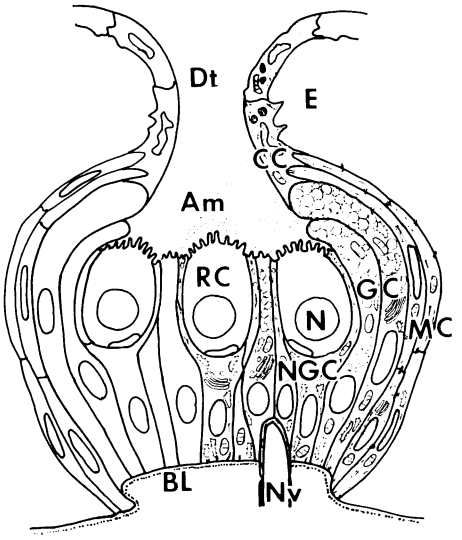


Fig. 1. Schema of the small pit organ of *Silurus asotus*, showing all the cell types in a set. Am, ampulla; BL, basal lamina; CC, channel cell; Dt, duct; E, epidermis; GC, granular supporting cell; MC, mantle cell; N, nucleus; NGC, non-granular supporting cell; Nv, nerve; RC, receptor cell.

zation with MS 222, tiny pieces of the skin containing the small pit organs were taken from the head. The specimens were fixed in 1% osmium tetroxide in Sörensen's phosphate buffer at pH 7.3 for 2 h, or prefixed in 2.5% glutaraldehyde in Veronal-acetate buffer at pH 7.3 for 30 min and post-fixed with 1% osmium tetroxide in Sörensen's phosphate buffer at pH 7.3 for 2 h. Bichromate osmium fixative (Dalton, 1955) was also used. All specimens were dehydrated with a graded ethanol series and embedded in Epon 812. Ultrathin sections were stained with saturated uranyl acetate and Millonig's lead solutions, and examined with the HS-7D electron microscope. For light microscopic observation, semi-thin sections were stained with 0.5% tolutidine blue in the phosphate buffer at pH 7.3. Some sections were subjected to the periodic acid-Schiff (PAS) reaction.

Results

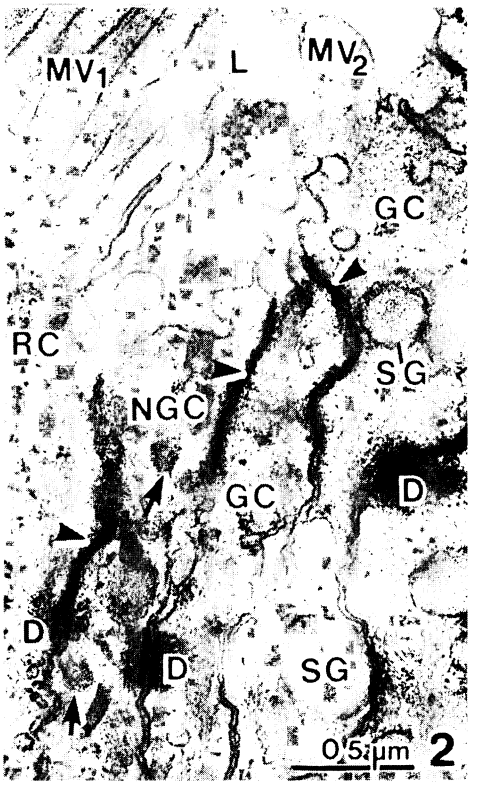
The entire small pit organ of the catfish occurred generally in singles in the epidermis. It consisted of an ampulla and a duct. The duct extended about 1/2 to 1/3 of the epidermal thickness to open at the epidermal surface. The sensory epithelium was located in the base of the ampulla (Fig. 1). On the basis of their fine structures and positions in the organ, five types of the cells could be classified: 1) receptor cell (RC), 2) granular (supporting) cell (GC), 3) non-granular (supporting) cell (NGC), 4) mantle cell (MC), and 5) channel cell (CC). The sensory epithelium was composed of several RCs and a number of GCs and NGCs. Several layers of MCs encapsulated the sensory epithelium entirely, demarcating the organ from the ordinary epidermal cells. A single layer of CCs lined the wall of the duct.

(1) Receptor cell: The RCs were oval in shape and the largest in size (ca. 20 μm in height and ca. 15 μm in diameter). They were located in the upper half of the sensory epithelium, apparently failing to reach the basal lamina (Fig. 1). Their apical projections to the ampullary lumen were characterized by microvilli, irregular in shape as well as in length (Fig. 2). Their somata were surrounded by the cytoplasmic processes of the

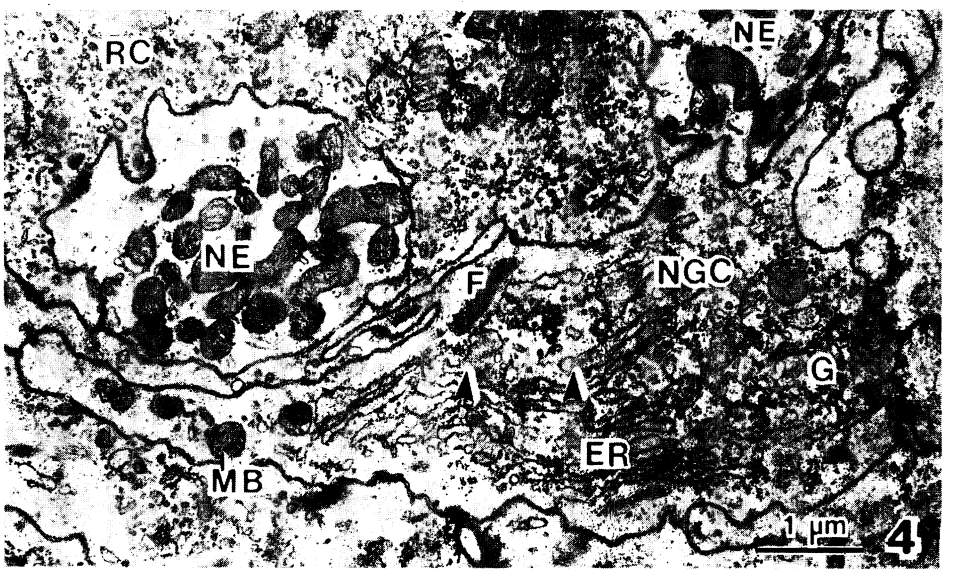
Fig. 2. Electron micrograph of the apical portions of the receptor (RC), non-granular (NGC) and granular supporting cells (GC). Note the microvilli of RC (MV1) are relatively long, while those of GC (MV2) are stubby. Secretory granules (SG) of GC are generally larger than those (arrows) of NGC. Tight junctions (arrowheads) and desmosomes (D) are found between apposed membranes of NGC and GC, and RC and NGC. L, lumen of ampulla. ×31,200.

Fig. 3. Electron micrograph of the basal portions of the receptor cell (RC) and non-granular supporting cells (NGC). Two RCs are separated from each other by lamellated cytoplasmic processes of the NGCs. Rough endoplasmic reticulum (arrowheads) is developed in the perinuclear cytoplasm of the NGC. F, tonofilament; G, Golgi apparatus; N, nucleus; NE, nerve ending. ×8,400.

Fig. 4. Electron micrograph of the basal portion of the receptor cell (RC) in contact with the nerve endings (NE). RC contains numerous vesicular and tubular structures in the cytoplasm. The middle portion of the non-granular supporting cell (NGC) has a stack of rough endoplasmic lamella (ER) and distended cisternae (arrowheads) near the Golgi apparatus (G). F, tonofilaments; MB, multivesicular body. ×13,600.


MV1
L
MV2
GC
RC
SG
NGC
GC
D
D
D
SG
0.5 μm
2


RC
RC
NE
E
F
NGC
G
N
1 μm
3


RC
NE
NE
F
NGC
G
ER
MB
1 μm
4

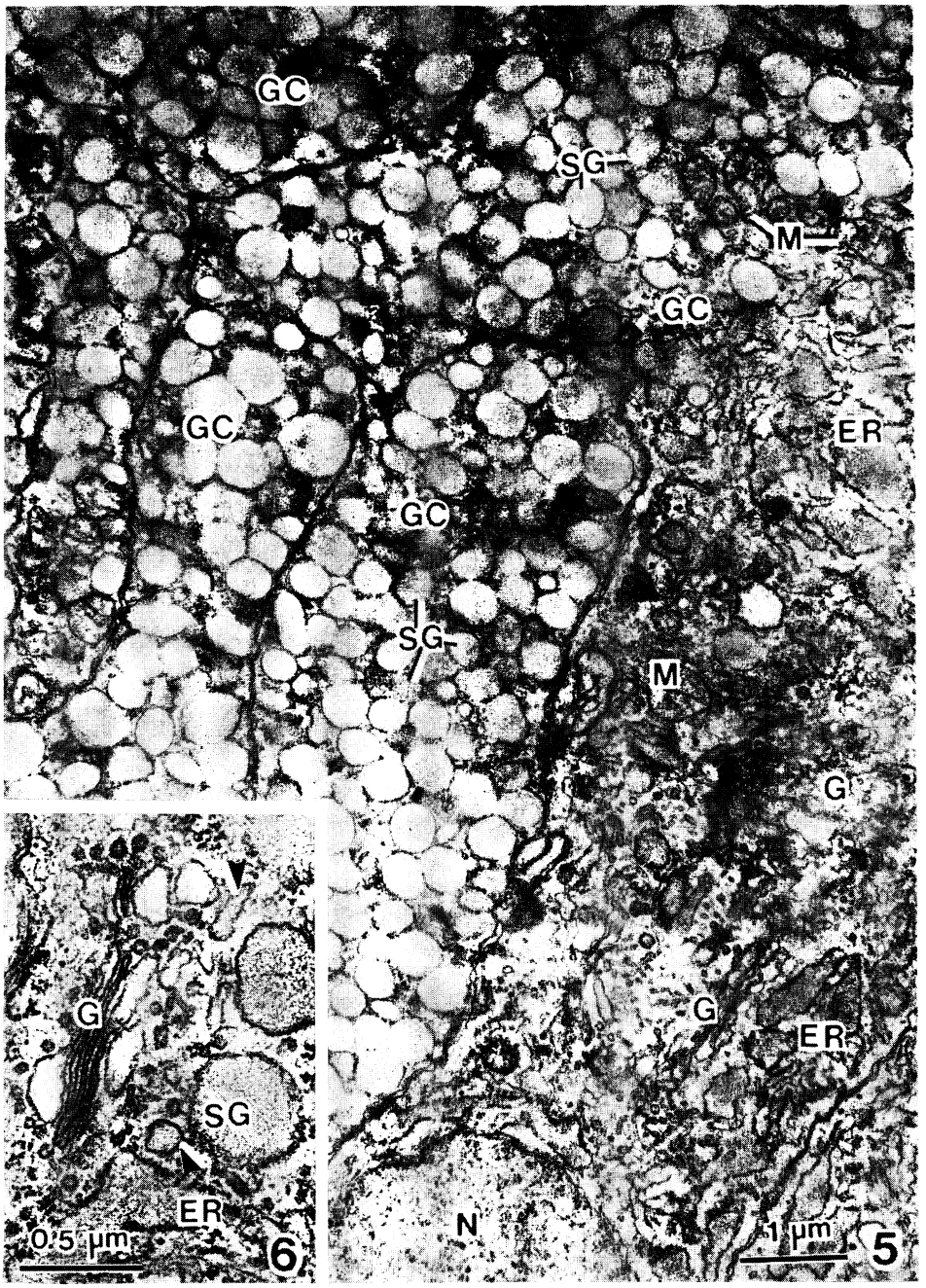


Fig. 5. Electron micrograph of the apical portion of the granular supporting cells (GC) which are occupied by numerous secretory granules (SG). Rough endoplasmic reticulum (ER) and well-developed Golgi apparatus (G) are seen in the supranuclear region. M, mitochondrion; N, nucleus. ×14,500.

Fig. 6. Higher magnification of electron micrograph of the supranuclear region of the granular supporting cell. Secretory granules (SG) and immature secretory granules (arrowheads) are seen near the Golgi apparatus (G). ER, rough endoplasmic reticulum. ×34,000.