shift of a certain amount of water from the intracellular to the extracellular space.

However the results obtained do not indicate whether the increase of inulin uptake due to contractile activity can be attributed to an actual change of volume of the extracellular space rather than to a modification in the diffusion kinetics of inulin: in this latter case we must assume that non equilibrium conditions are present[11]. During contractions, inulin might be taken up more easily by compartments (perhaps other than the extracellular space) where, in resting conditions, it enters at a very low rate: it seems difficult to explain why the phenomenon should be less pronounced or absent following isotonic contractions.

In order to clarify the results obtained, a further investigation will be devoted to the diffusion kinetics of inulin and HTO in resting and active muscles. Anyhow the results obtained suggest that the determination of cellular electrolytes in isolated muscle preparations should be accompanied by an accurate measurement of the extracellular space and its possible changes due to the experimental conditions.

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## A new neurosecretory system in fish, located in the gill region

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*Summary.* A peculiar neurosecretory system is reported in 6 teleost species; *Clarias batrachus, Heteropneustes fossilis, Mystus seenghala, Ompak pabda, Glassogobius giuris* and *Notopterus notopterus.* It is located in the gill region close to the pseudobranch or to the carotid labyrinth. The neurosecretory cells have been identified using stains specific for neurosecretion. The results are discussed in the light of the association of the neurosecretory system with the pseudobranch or the carotid labyrinth, and the airbreathing habit of these fishes.

In fishes, only 2 neurosecretory systems are known; the hypophysial system of the head and the caudal neurosecretory system of the tail. A peculiar 3rd system of neurosecretion has been found by us to exist in certain fishes, and in the present report an account of this is presented. The neurosecretory cells have been identified histologically, using neurosecretory stains like aldehyde fuchsin[2], acid-violet[3] and iron-haematoxylin[4]. So far, this system has been found in 6 teleostean species; namely *Clarias batrachus, Heteropneustes fossilis, Mystus seenghala, Ompak pabda, Glassogobius giuris* and *Notopterus notopterus,* which belong to 3 different orders, but not in the carps *Labeo rohita* and *Cirrhinus mrigala.*

*Results.* In the 6 species mentioned above, neurosecretory cells are found to occur clumped into groups forming a large ganglionic mass, which is located in the gill region in

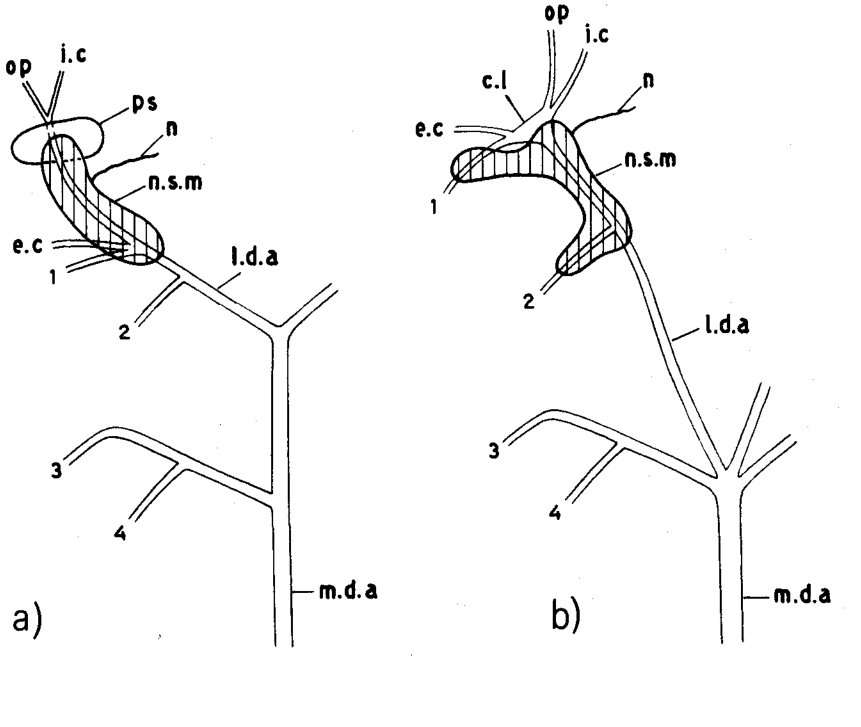
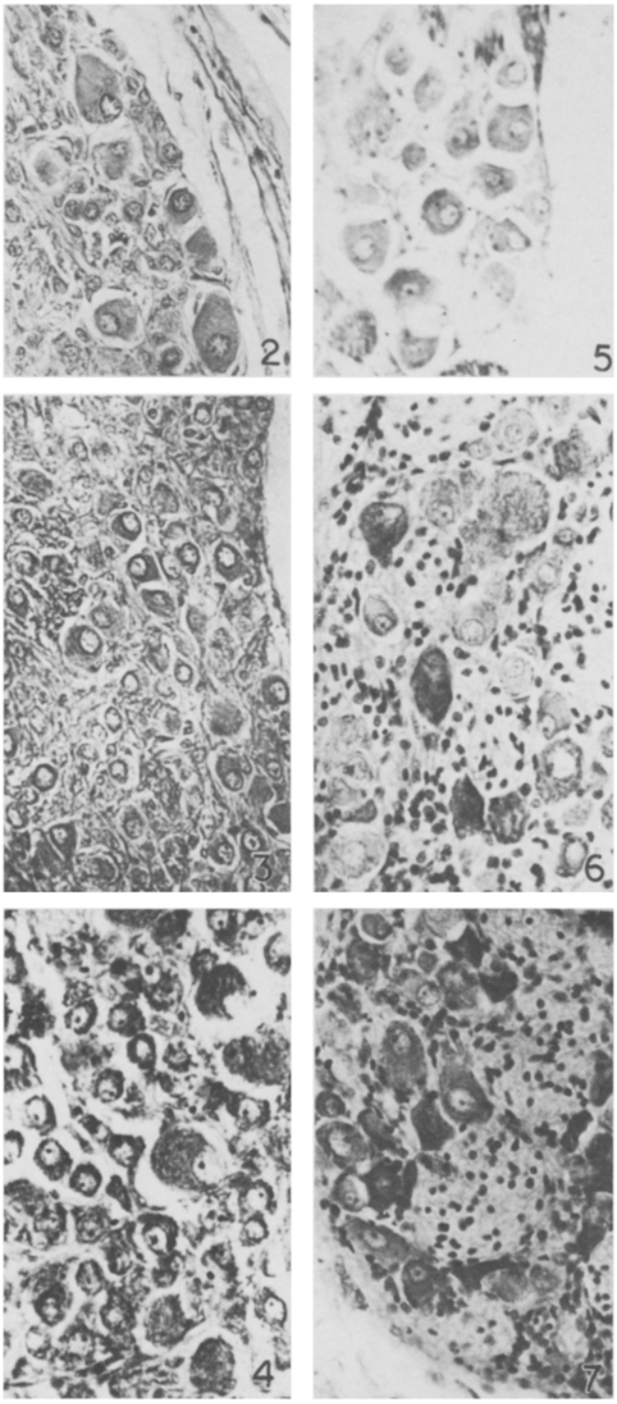



Figure 1. Schematic drawings (ventral view) showing the location of the pseudobranchial neurosecretory mass in *Glossogobius giuris* (a) and in *Clarias batrachus* (b).

Abbreviations used: 1, 1st efferent branchial artery; 2, 2nd efferent branchial artery; 3, 3rd efferent branchial artery; 4, 4th efferent branchial artery; c. l, carotid labyrinth; e.c, external carotid artery; i.c, internal carotid artery; l.d.a, lateral dorsal aorta; m.d.a, median dorsal aorta; n, branch of glossopharyngeal nerve; n.s.m, neurosecretory mass; op, ophthalmic artery; ps, pseudobranch.

close association with the anterior aortic arches and the pseudobranchial vascular architecture (fig. 1). These cells and their processes form, together with blood capillaries, extensive and conspicuous bodies which presumably serve as storage-release organs. The blood capillaries associated with these bodies are connected with either the lateral



Figures 2–7. Photomicrograph of neurosecretory cells of the pseudobranchial neurosecretory system (400:1). Figure 2. *Glossogobius giuris*, acid-violet stain. Figure 3. *Ompak pabda*, acid-violet stain. Figure 4. *Clarias batrachus*, iron haematoxylin stain. Figure 5. *Mystus seenghala*, acid-violet stain. Figure 6. *Notopterus notopterus*, eosin-haematoxylin stain. Figure 7. *Heteropneustes fossilis*, iron-haematoxylin stain.

dorsal aorta close to the carotid labyrinth[5] in catfishes or the vessels supplying the pseudobranch in *Glassogobius giuris*. The neurosecretory cells (figs 2–7) appear large, and possess a prominent nucleus with a distinct nucleolus. The cytoplasm surrounding the nucleus contains conspicuous material which is clearly demonstrable histologically. This enables us to presume that this unusually large quantity of intracellular material is the product of neurosecretory activity of neurons. The neurosecretory cells occur in abundance, cells varying in size in the range of 4–40 µm. The large cells show a greater amount of stainable neurosecretory material which appears in various forms, ranging from very fine particles dispersed in the cytoplasm to large granules and flakes. The density of the granules is also found to vary from cell to cell. A branch of the glossopharyngeal nerve innervates the neurosecretory cell group.

In *Glassogobius giuris* (figs 1a, 2) the groups of neurosecretory cells are situated close to the afferent blood vessel supplying the pseudobranch. In *Notopterus notopterus* (fig. 6) and in all the catfish species examined (figs 1b, 3, 4, 5, 7), neurosecretory cell groups develop into very large bodies which are closely associated with that part of the lateral aorta which receives the 1st and 2nd efferent branchial arteries, as well as with the carotid labyrinth[5] in the case of *Clarias batrachus, Heteropneustes fossilis* and *Mystus seenghala*. (A pseudobranch is unknown in catfishes[6]).

*Discussion.* This neurosecretory system turns out to be new for fish. The neurosecretory cells identified seem to display the principal morphological attributes for a neurosecretory role, viz the presence of neurosecretory material, demonstrable with specific neurosecretory stains, and its close proximity to the capillaries of the blood vascular system. The occurrence of this system in 6 species from 3 orders suggests that this system might be of general significance in teleostean fishes. The role played by this neurosecretory system in the life of the fishes remains to be determined. However, the above mentioned system has been tentatively called the pseudobranchial neurosecretory system because, at least in *Glassogobius giuris*, it may be thought to function together with the pseudobranch – a structure of suspected endocrine function[7].

All the species in which this system is found to occur are either accessory air-breathing fishes or are fishes that are known to tolerate a low oxygen concentration in the water. This fact points to the possibility of this system having evolved alongside the air-breathing habit of teleost fishes.

It is remarkable that the pseudobranchial neurosecretory system is a peripheral one; such systems are not known to occur in other vertebrates though well represented in invertebrates. The location of these cells is such that though they are in contact with the glossopharyngeal system, they do not seem to belong to it. It is possible that these cells are paraneurons similar to those in the carotid body of mammals[8]. Further investigation is necessary to ascertain this.

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