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Morphology of corpuscles of Stannius in the fresh water fish, Notopterus notopterus

Zoology

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ABSTRACT

The morphology of corpuscles of Stannius (CS) in the fresh water fish, Notopterus notopterus found embedded in the anterior portion of the posterior kidney. Only one pair of corpuscles was observed. The CS is formed from evaginations of mesonephric ducts and this origin makes the CS unique among endocrine gland of vertebrates. The location of corpuscles of Stannius in the teleostean kidney presents several variations and this variation in location suggested to be related to the taxonomic position of the fish species.The corpuscles of Stannius of N. notopterus are spherical in shape; the cells of the gland are usually arranged in strands, separated by septa of connective tissue continuous with outer fibrous capsule. The septa contain all the vascular and nervous elements. The vascularization of CS is rich, which results in a better access of the gland cells to the blood circulation. The cyto-architecture of the CS in N. notopterus shows four types of arrangement of connective septa and cells. The first type cells are arranged in the form of cords along the thin septa exhibiting circular appearance. In the second type, thin penetrating connective tissue septa divide the corpuscles into several incompletely delimited lobes. The third type septa are better developed and more prominent then the previous type. The union of ramifying connective tissue causes same groups of cells to become separated from the rest, forming smaller delimated lobes. In the fourth type composed of aggregates of small lobes, each of which consist of a number of complete and incomplete lobes. The penetration of connective tissue septa into single corpuscles makes the corpuscles bilobed, trilobed or even multilobed condition. Two principle types of cells are observed type-I and type-2. Type-1 cells are round with clear vesicular nucleus and stainable material in the cytoplasm ,type-II cells are slender, irregular cell bodies that may contain cytoplasmic processes extending between the type-I cells, A third type-III cells was also noticed.

INTRODUCTION

The corpuscles of Stannius (CS) are small, ovoid endocrine glands unique to teleostean and holostean fishes. Embryonically, the CS may arise from the pronephric, mesonephric or opisthonephric ducts (Garrett, 1942; Ford, 1959; Belsare, 1973; Krishnarnurthy, 1967). A number of important generalizations may be made with regard to the anatomical distribution of the CS. In the more primitive holosteins, such as the bowfin and garpike, the CS tend to be small, numerous and widely distributed throughout the kidney mass (Garrett, 1942; Bauchot, 1953; De Smet 1962; Youson and Butler, 1976). In teleosts, such as the eel, the CS tends to be larger and occurring as a single pair embedded in the ventral surface of the posterior mesonephric kidney (Bauchot, 1953).

The corpuscles of Stannius (CS) are enigmatic glands which vary in number and are usually embedded in the kidneys of holosteans (Bhattacharya et al., 1982; De Smat, 1962; Marra et al., 1992, 1994; Youson and Butler, 1976) and teleostean (Hirano, 1989) fishes. The location of corpuscles of Stannius in the teleostean kidney presents several variations and this variation in location suggested to be related to the taxonomic position of the fish species.

In the present study the location and morphology of corpuscles of Stannius is studied in the freshwater fish, *Notopterus notopterus* and possible taxonomic position of the fish is assessed. In spite of number of reports on the CS with regard to different cell types present in the CS, the identification of different cells needs further study to be confirmed. Hence, in the present investigation the detailed cytology of corpuscles of Stannius through histology, has been studied in the freshwater fish, *Notopterus notopterus*

Material and methods

Freshwater teleost fish, *Notopterus notopterus* is selected for the present study. This fish is available in large numbers in and around Gulbarga. The local fishermen call it as "Chambari". The color of the fish is on the dorsal side either coppery brown or grayish and silvery on the ventral side. The weight of the mature fish ranges from 80 to 120 gms and length range between 23 to 26 cms. Body is highly compressed laterally; head is small with large mouth. Dorsal fin is small and so also pectoral and pelvic fins. Anal fin is much elongated with number of vertical bands and is confluent with caudal fin which is small or aborted (*Gephyrocercal*). It is a commercially important fish. However its flesh is well flavored and rich in protein.

About 180 *Notopterus notopterus* fish were collected with the help of fisherman. The live fish were brought to the laboratory and were kept in large plastic pool tanks having size of 90 cms diameter and 60 cms height. Each tank accommodated 10-15 fishes. About 8-10 days were needed for the fishes to acclimatize. During acclimatization antibiotic tablets (*Chlromphenol* 80 mg in one gallon of water) has been given to prevent from infections. Fishes of both sexes were fed with live earthworms; boiled eggs and small fishes (*Gambusia*). Sex of the fish cannot be identified based on the morphological characteristics. However, they were differentiated after observing their gonads as females and males.

The fish were killed by decapitation, the body cavity was opened and the posterior kidney removed, from the fish fixed in a fixative, Bouin's fluid containing picric acid, formalin and glacial acetic acid. About an hour later the kidney containing the corpuscles of Stannius, were dissected out and returned to fresh fluid. This procedure insured rapid fixation of the rather labile granules of the glandular tissue, followed by dehydration in graded alcohols and embedded in paraffin blocks using standard techniques.

Observation

The general organization of the corpuscles of Stannius in *Notopterus notopterus* shows that, it has a spherical structure and are found lying on or embedded in the anterior portion of posterior part of the kidney (Fig.1.1). Only one pair of the corpuscles was observed. The gland is highly vascularised with rich innervation. The diameter of the corpuscles ranges from 0.5-2.0 mm which varies during different phases of the reproductive cycle. The corpuscles of Stannius of *N. notopterus* are whitish and have a fibrous capsule and are composed of short columnar cells.

Histology of corpuscles of Stannius:

The corpuscles of *N. notopterus* spherical in shape, the cells of the gland are usually arranged in strands, separated by septa of connective tissue continuous with outer fibrous capsule, (Fig.

1.4). The septa contain all the vascular and nervous elements. The Stannius corpuscle is rich in vascularization which results in a better access of the gland cells to the blood circulation. The capillaries are associated with renal arteries and cardinal veins. The Stannius corpuscles probably also have a rich nervous supply. The nerves are found in close association to the corpuscles. This indicates rich innervations.

The cyto architecture of the CS in *Notopterus notopterus* shows that four types of arrangement of connective tissue septa. The first type which is common in which cells are arranged in the form of cords lined by single layer of cells, along thin septa exhibiting circular appearance (Fig. 1.1). In the second type, thin penetrating connective tissue septa divide the corpuscles into several incompletely delimited lobes. The third type septa are better developed and more prominent than the previous type. The union of ramifying connective tissue causes same groups of cells to become separated from the rest, forming smaller delimited lobes (Fig. 1.1). In the fourth type corpuscle is composed of aggregates of small lobes, each of which consist of a number of complete and incomplete lobes. The penetration of connective tissue septa into single corpuscles makes the corpuscles bilobed, trilobed or even multilobed condition. Two principle types of secretory cells are observed as type-l and type-2 . The type-1 cells are round with clear vesicular nucleus and stainable material in the cytoplasm ,type-II cells are slender and irregular cells that may contain cytoplasmic processes extending between the type-I cells, A third type-III cells was also noticed.

Discussion

The corpuscles of Stannius present in the holosteans and teleosteans are specific endocrine structures. Their functional significance remains unsettled for a long time. These glands arise embryologicaly as evaginations of the wall of the pronephric ducts. They are not homologous with adreno-cortical tissues which are formed from the coelomic mesoderm (Matty, 1985). In teleost fishes, the corpuscles of Stannius can be found either as a single pair of symmetrical structure at the dorso-posterior end of the kidney and they occur in variable number in different species of fishes. However, in most cases the number is limited 2-6. In number of telostean fishes posses a single pair of corpuscles (Bauchot, 1953; Krishnamurthy and Benn, 1969). In the fish *Oncorhynchus gorbuseha* a pair of corpuscles of Stannius has been reported (Ford, 1959). Yet in another two species of *Oncorhynchus; Oncostymchus Tshawytstha* and *Onclorhymchus Kisutch* (Nadkarni and Gorbman 1966), have observed 5-6 corpuscles. Compared to holosteans the number of corpuscles in teleosts is usually lower, although up to fourteen have been reported for salmonids (Krishnamurthy, 1976). In gold fish or stickle back (*Gasterosteus aculatus*) only a single pair can be found at the dorso-posterior end of the kidney. The number of peripheral corpuscles has been shown to vary from 4-6 in *Salmo gairdnerii* 4-5 in *Oncorhynchus kisutch,* 2, 3, 4, in *Atherinopsis californiensis,* three in *Sepastobes aurinsbica* (Krishnamurthy and Bern, 1969). The number of CS may vary from 4-10 in *Salnio solar* (Heyl, 1970) and 6-8 in *Salmo trutta* (Bauchot, 1953). It has been also reported in many cases (examples catfishes). The organs become reduced in the adult to single corpuscles (Garrett, 1942). In the earlier reports published by (Belsara, 1973), only one corpuscles of Stannius is present in the fish *Notopterus notopterus*. In our study on the same species a pair a corpuscles of Stannius are present and located in the anterior region of the posterior kidney. In other Indian fishes such as *Heteropreustes fossilis* as many as 4 corpuscles are frequently observed, although one may be present in the same species (Belsara 1973), has also pointed out in catfish viz. *Heteropneustes fossillis*, *Clarias batrachus* and *Mystus vittatus*, the number of corpuscles of Stannius is more than one. After a comparative study of corpuscles of 47 species (Bauchot 1953), concluded that a phylogenetic significance can be attributed to the number and location of the CS. In more primitive fishes the number to be high and glands are often located in the middle of the mesonephric kidneys. However, many exceptions to these rules have been reported in a rather primitive species like *Notopterus notopterus* (order; *Clupiformec*s) only one corpuscle of Stannius is present located in the posterior position (Belsara, 1973). Where as in the more advanced representatives of cypriniformes large number may occur, often in more anterior position, upto 10 may be present in *Clarias batrachus*, upto 8 in *Heteropheustes fossilis* and between 2 and 4 in *Mystus vittatus* (Belsare, 1973; Krishnamurthy, 1976; Subhedar and Rao, 1976; Ahmed and Swarup, 1979).

Moreover, within one species individual differences may occur that are related to age or sex. In *Esox lucius* and *Colisa lalia* the corpuscles of Stannius may be reduced in number from 5-2 during growth of the fish (Krishnamurthy, 1976). Where as, in the *Chilean ching* fish *Sicyasis sanguineus*, the males have two corpuscles while females usually have three corpuscles (Galli Gallardo, 1977). In the present study, the fish *Notopterus notopterus*, a single pair of corpuscles of Stannius were found in both sexes embedded in the anterior portion of the posterior kidney. The variation in the number of corpuscles of Stannius in the same species reported by earlier worker seems to be an embryological speciality rather than a matter of evolutionary or taxonomic significance as suggested by (Belsare 1973). There are also some reports that in the same species such as *Heteropneustes fossilis* as many as four corpuscles are frequently observed although one may be present in some.

The CS were long considered to be the homolog of the adrenal cortex of higher vertebrates because of their location and their superficial resemblance to the *Elasmobranch interrenal*. However, it was later shown that the embryological origin of corpuscles of Stannius was completely different from that of the interrenals. In teleosts it was reported that CS are derived from the pronephric and mesonephric ducts. In several salmonids and in more advanced species like *P. mattatus* (Garret, 1942; Ford, 1959), in catfish (Belsare,1973) and *Lolisa lalia* (Krishnamurthy, 1967). The corpuscles of Stannius are formed from evaginations of mesonephric ducts and this embryological origin makes the CS unique among endocrine gland of vertebrates. The location of corpuscles of Stannius in the teleostean kidney presents several variations and this variation in location suggested to be related to the taxonomic position of the fish species (Bauchot, 1953). In *Notopterus notopterus* in the present study the CS occur at the anterior end on either side of the posterior position of the kidney but in majority of the fishes they are located at the posterior third of the meso nephron (Subhedar and Rao, 1976). In holostean the CS occupy the area near the anterior end of the pronephric duct, in isospondyles they are situated in the mid region, while all the majority of the fishes they have moved back to the posterior third of the mesonephros (Bauchot, 1953; Garret 1942), has pointed out that corpuscles of Stannius move progressively backwards during the evolution as a result of actual shortening of body cavity rather than a migration of corpuscles of (Stannius. Similar observation has been also made in *Heteropneustes fossilis* by Subhedar and Rao 1976), and suggested that it appears that this species (*H. fossilis*) occupies a higher evolutionary status than that of isospondyles. However, in the *Notopterus notepterus* the CS are located at the anterior end of posterior kidney; it is possible that this fish may at the lower status than that of cat fishes.

In *Notopterus notopterus* in the present study, the corpuscles of Stannius are oval in structure, the cells of the glands are usually arranged in strands, lobes or lobules that are separated by septa of connective tissue continuous with the outer fibrous capsule .The septa contains all vascular and nervous elements. After the survey of the organisation of the corpuscles of Stannius in 29 species (Krishnamurthy and Bern, 1969) divided the CS in four categories on the basis the arrangement of the gland cells (varying from major lobes to small aggregate of gland cells) and the extensiveness of the connective tissue septa. Later observations have shown that in some species the arrangement of the gland cell may differ between the CS of individual fish (Ahmed and Swarup, 1979) and more importantly that in many fish the arrangement of the gland cells and the extensiveness of the septa depend on the state of activity of the glands (Heyl, 1970; Ahmed and Swarup, 1979). The cytoarchitecture of the CS of the catfish *Heteropneustes fossilis* has been investigated by (Subhedar and Rao, 1976) based on the arrangement of septa and cells and

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reported that at least 4 principle architectural patterns can be distinguished. In the first type, the cells appear either as cords or as follicles due to complete formation of thin septa in the second category also. The penetrating septa are thin but divide the CS into incompletely delimited lobes. In the third type, the septa are thick and their branches united, some times resulting in the formation of complete lobes. In the fourth type, each CS is formed of aggregates of lobes each of which consists of a number of complete or incomplete lobules. Such similar observation has been made in other fishes (Krishnamurthy and Bern, 1969; Johnson, 1972). On critical observation in the light of evaluation made by others all the four types of CS has been noticed in the CS of *Notopterus notopterus* in the present study. The CS of teleostean fishes contains 2 distinct secretary cell types, the type-I cells and type-II cells (Wendelaar-Bonga, Greven 1975; Wendelaar-Bonga *et al.,* 1977). An additional neurosecretory cell type has been identified in the CS of the white sucker, *Catastomus commersoni* (Marra *et al.,* 1998). The structure of type-I cells resemble that of other cells active in the synthesis and secretion of polypeptides, such as cells of the exocrine pancreas. The type-1 cell is ovoid, contain large nucleus with a pronounced nucleolus, extensive granular endoplasmic reticulum, large Golgi bodies and characteristic large, round, densely-staining secretory granules. In al1 species examined, the majority of CS cells are of the type-1 cytology (Oguri, *et al.,* 1970; Fujita and Honma 1967; Carpenter and Heyl, 1974; Cohen *et al.,* 1975). In the bowfin, toadfish and a number of other species are observed (Youson and Butler, 1978; Wendelaar Bonga and Greven, 1975; Bhattacharya and Butler 1978), the CS is composed almost exclusively four types of cells. The other cell type-II tend to be narrower with smaller irregularly shaped granules sparsely distributed endoplasmic reticulum and fewer Golgi bodies (Wendelaar Bonga and Greven, 1975; Wendelaar Bonga *et al.,* 1977). There is evidence that the two cell types come from a single lineage where by their histological differences may reflect different stages of development or different states of activity (Kaneko *et al.,* 1992; Bhattacharya and Butler 1978; Youson and Butler, 1976; Bhattacharya *et al.,* 1978). It has even been suggested that type-2 cells may represent type-1 cells that are undergoing programmed cell death or apoptosis (Wyllie *et al.,* 1980).In the present study, the fish, *N.notopterus* has three types of cells in the corpuscles of Stannius, however type-I cells are prominent compared to other two type of cells.

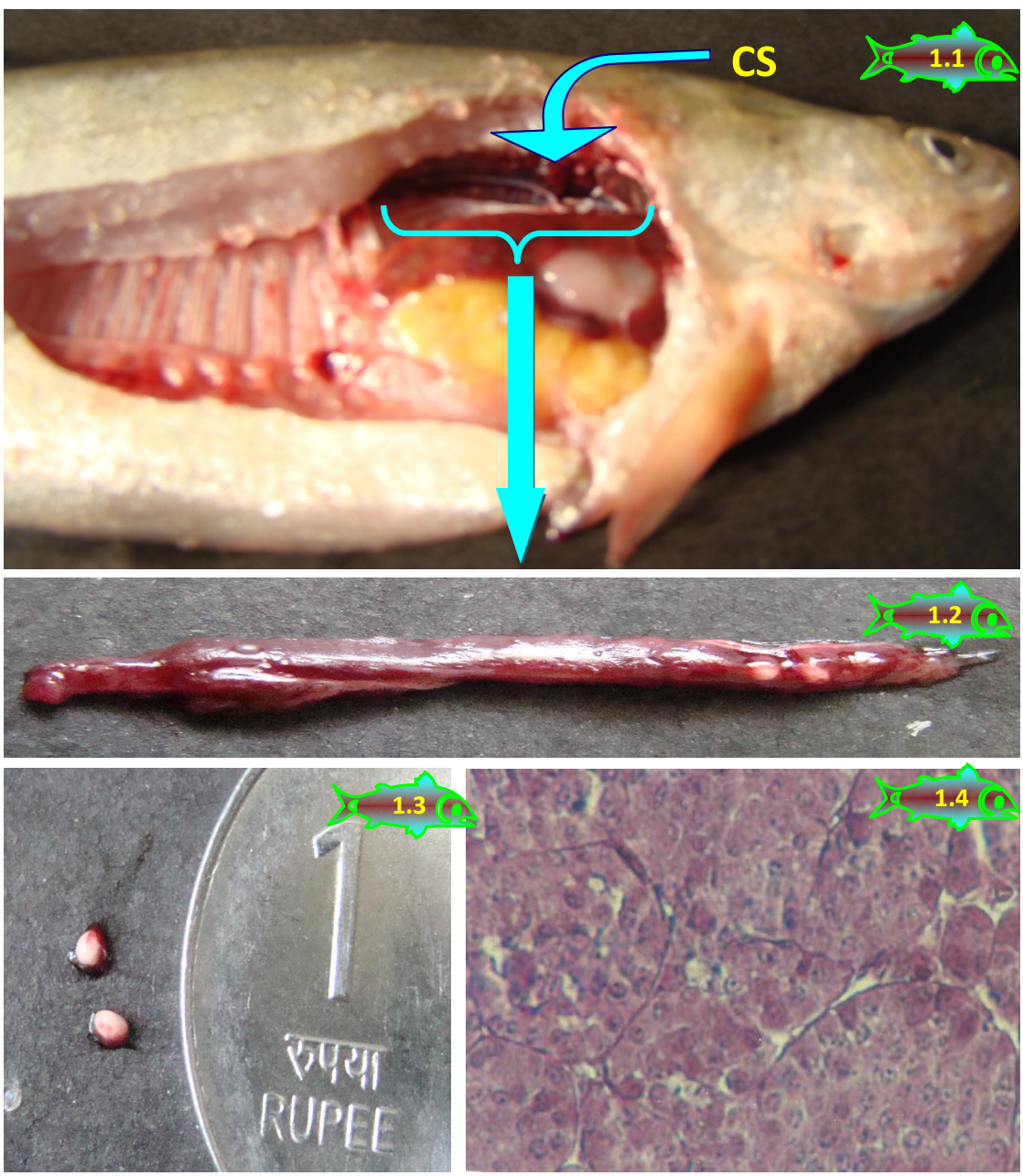

Fig. 1.1: Showing photograph of fish dissected for exposing corpuscles of Stannius embedded in the kidney.
Fig. 1.2: Photograph showing corpuscles of Stannius embedded in the kidney.
Fig. 1.3: Photograph showing a pair of corpuscles of Stannius.
Fig. 1.4: Section of corpuscles of Stannius showing the presence of proteins by Mercury-bromophenol Blue method × 1200.

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