A COMPARATIVE STUDY OF THE PITUITARY OF SOME FRESH-WATER TELEOSTS

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(With 3 Plates)

CONTENTS

I—INTRODUCTION

The pituitary of Teleosts has been studied by various workers (Herring, 1908, 1913 ; Stendell, 1914 ; Tilney, 1911 ; de Beer, 1926 ; Florentine and Weiss, 1931 ; Bell, 1938 ; Levenstein, 1939 ; Woodman, 1939 ; Kerr, 1942 ; Miller, 1944 ; Atz, 1953 ; and Stolk, 1950-57). Seasonal histological changes in the pituitary of Teleosts is described by Bock (1928), Matthews (1936), Lee (1942), and others. The work of Bretschneider and de Wit (1947), Scruggs (1951), Olivereau (1954) and Pickford and Atz (1957) are exhaustive. It is generally observed that the " Übergangsteil " is the component which exhibits marked seasonal changes. Several authors have homologised the components of the teleostean pituitary to that of the higher vertebrates and the terminology involved is very extensive. Charipper (1937) observed variations in the placement of the various components of the teleostean pituitary Scruggs (1939) did not record a *pars anterior* in *Esox niger.* Butcher (1936) reported the absence of well-defined lobes in the pituitary of *Fundulus.* Stolk (1955) recorded abnormal distribution of the lobes in *Xiphophors helleri.* In the salmon, Woodman (1939) described the " Übergangsteil " to be of transitional nature, as described by Stendell (1914). Kerr (1942) has classified the teleostean pituitary into two types : *Type A* : Comprises of forms having no distinct pituitary stalk - *Type B :* Includes those having a definite stalk. The terms platybasic and leptobasic of Bretschneider and de Wit (1947) denote types A and B of Kerr (1942).

Studies on the pituitary of Indian species are meagre and confined to limited aspects, and to a few species such as *Chanos chanos* (Tampi 1951, 1953), *Barbus stigma, Ophicephalus punctatus, Chela bacaila, Cirrhina reba, Mystus seenghala* (Sathyanesan 1957-60), *Hilsa ilisha, Engraulis telara* and *Gadusia chapra* (Misra and Sathyanesan, 1958).

It has been observed by the workers that in the teleosts the arrangement and organisation of the component parts of the pituitary gland widely varies in different species (Stendell 1914, de Beer 1926, Matthews 1937, Hoar 1957), has many structural and histological features peculiar o itself and seems to have evolved in its own way (Kerr 1942*a* or *b*). This work is an attempt to further our knowledge of the morphology, histology and the variable features of the pituitary of teleosts inhabiting the tropical fresh-waters.

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II—MATERIAL AND METHODS

Specimens for this study were collected from the river Ganges at Varanasi (U.P.). They were decapitated and the pituitary and a portion of the gonads were fixed in the appropriate fixatives immediately. In cases where the dissection of the pituitary was difficult, it was initially fixed along with a part of the attached bone and connective tissue. Dawson Friedgood's formol-sublimate, Bouin's fluid, Heidenhain's azan stain and Anderson's modified Mallory's triple stain were the fixatives and the stains used in the routine work. Paraffin sections were cut at 4 and 6μ thickness. Since the pituitary-gonad interrelationship is well established, the growth phases of the gonads in relation to the pituitary was also recorded. The gonads were fixed in Bouin's fluid and stained in Ehrlich's haematoxylin.

III—OBSERVATIONS

1. *General features of the teleostean pituitary*

The pituitary is attached to the infundibulum. The infundibular stalk, when present, may be moderately long and slender or short and thick. In forms where a definite stalk is wanting the pituitary is closely applied to the infundibulum. The pituitary is divided into two parts : (i) The *pars glandularis* or the *adenohypophysis* comprising of three components, the *pars anterior*, the Übergangsteil and the *pars intermedia* , and (ii) The *pars nervosa* or the *neurohypophysis* which is the extension of the pituitary stalk or the floor of the infundibulum into all the components of the *pars glandularis*. The main nervosal trunk ramifies profusely in the *pars intermedia*. The occurrence of the nervosal branches in all the constituents of the adenohypophysis is reported to be a secondary development. The most primitive condition is shown by *Acipenser* and *Lepidosteus* (Kerr, 1949) having the pars nervosa and the pars intermedia only. In several fishes the infundibular cavity extends into the pars nervosa as funnels or recesses which are lined by ependymal cells of varied shape. The pars nervosa is fibrocellular in its composition. The fibres are loosely arranged, and the neuroglia nucleii are scattered in their interstices. Blood vessels, colloid-like bodies and sometimes glandular cells are seen in the pars nervosa. The components of the pars glandularis are distinguished by their distinct cell-types. The basophils, acidophils and chromophobes are the basic

cell-types of the pars glandularis. The pituitary is covered by a vascular meninges of connective tissue from which the blood vessels of varying size enter into its substance.

2. *Description of individual species*

Since the pituitary gland is highly variable, depending on its secretory activity, the structure described here denotes the condition of the gland during the particular time of the year mentioned herein. The differential staining of the glandular cells obtained is specific for the fixatives and stains used. The general classification of fishes adopted in this paper is that proposed by Regan (1929).

Order ISOSPONDYLI

Suborder *CLUPEOIDEA*

Family CLUPEIDAE

(i) **Hilsa ilisha** (Ham.)

(Collected during September, when this species migrates upstream with mature gonads.)

The pituitary is attached to the infundibulum by a stalk and is lodged in a distinct *sella turcica* as that of *Polypterus* (de Beer, 1926) and *Epiceratodus* (Griffiths, 1938). In this differs from the other species, reported here in the presence of a well defined sella turcica. The components of the pars glandularis are arranged along an antero-posterior axis (Pl. 20, Fig. 1). The pars nervosa ramifies extensively in the pars intermedia but has only a few branches in the other components. In some specimens the pars nervosa has abundant chromophilic colloid-like substances which are in the form of streaks among the fibres (Pl. 22, Fig. 1). The existence of the oro-hypophysial duct is reported in *Hilsa ilisha* (Misra and Sathyanesan, 1958). This duct is continued into the pars anterior and its diverticula spread all over the component. Thus, in a section the pars anterior looks as though it is made up of tubular structures. The lumina of these tubules are a part of the hypophysial cavity which, in turn, is the cavity of the oro-hypophysial canal. The tubules are lined by acidophils and chromophobes. The pars nervosal branches and blood-capillaries are seen in between contiguous tubules.

The " Übergangsteil " is made up of basophils, acidophils and chromophobes. The chromophobes are very few and ill-defined. The basophils are in a state of degranulation and many of them lack a distinct cell-boundary. The pars intermedia consists of acidophils, chromophobes and a few basophils. Some of the acidophils possess intracellular acidophilic globules (Pl. 22. Fig. 3). These bear resemblance to the 'sphere cells' of *Perca fluviatilis* (Kerr, 1942). Such acidophilic globules, of a varying size, are extruded in the pars nervosa. The pars intermedia is abundantly supplied with blood vessels.

(ii) **Gadusia chapra** (Ham.)

(Collected during September, with ripe gonads.)

The pituitary is structurally similar to that of *Hilsa ilisha*. In *Gadusia* the evidence of the oro-hypophysial duct is less manifest and the sella urcica is less prominent. The presence of colloid-like contents in the

pars nervosa is much less marked. Groups of neuroglia nuclei and few disintegrating chromophils are generally present in the pars nervosa.

The glandular components are arranged in an antero-posterior axis as in *Hilsa ilisha*. The hypophysial cavity in the pars anterior is homologous to that of *Hilsa*. A large cavity occupies three-fourths of the pars anterior (Pl. 20, Fig. 2), which may contain basophilic matter. These tubules have acidophils and chromophobes as their cellular constituents (Pl. 22, Fig. 2), with traversing blood-capillaries. The continuity of the oro-hypophysial duct into the pars anterior is lost, but some times this may be indicated by the prolonged tip of the pars anterior (Pl. 20, Fig. 2). Acidophils, basophils and chromophobes are present in the " Übergangsteil " The basophils are larger than the acidophils and some are vacuolated. Many of them lack distinct cell-limits and are in a state of degranulation. This lobe is fairly well supplied with blood vessels. The pars intermedia is predominantly acidophilic, with scattered chromophobes.

Family ENGRAULIDAE

(iii) **Engraulis telara** (Ham.)

(Specimens collected during October, with 'spent' gonads.)

The pituitary of *Engraulis telara* resembles that of *Gadusia chapra*. The pars nervosa has a prominent infundubular cavity lined with ependymal cells and are completely cut off from the main infundibular cavity (Pl. 20, Fig 3). The hypophysial cavity in the pars anterior is tubular, but no single tubule is outstandingly large as in *Gadusia*. The basophils of the " Übergangsteil " show total degranulation and many of them lack a cellular limit.

Suborder *NOTOPTEROIDEA*

Family NOTOPTERIDAE

(iv) **Notopterus chitala** (Ham.)

(Collected during April, with the gonads in the resting condition.)

The pituitary is closely applied to the brain and is without a distinct stalk and sella turcica. The infundibular cavity is wide (Pl. 21, Fig. 4). The extension of the infundibular cavity in the pars nervosa is in the form of a long narrow channel lined by ependymal cells (Pl. 22, Fig. 6). The pars nervosa is intimately related with the thin floor of the infundibulum and arborisation is largely restricted to the pars intermedia. Colloid-like material and scattered chromophils are present in the pars nervosa. The glandular components are arranged in a regular sequence along the antero-posterior axis.

The pars anterior has acidophils and chromophobes. The acidophils are densely granulated, but sparsely granulated ones are also not uncommon. Chromophobes are few. The Übergangsteil has acidophils, basophils and chromophobes, in that order of their abundance. The pars intermedia is richly vascularised and contains acidophils and

chromophobes. The acidophils are densely granulated and some emigrant ones are in a state of disintegration in the pars nervosa.

Order OSTARIOPHYSI

Suborder *SILUROIDEA*

Family CLARIIDAE

(v) **Clarias batrachus** (Linn.)

(Collected during August, with the gonads fully ripe.)

The pituitary is attached to the infundibulum by a short thick stalk (Pl. 20, Fig. 6). The pars nervosa arborises into all the components of the pars grandularis but the main trunk penetrates the pars intermedia. The pars nervosa may contain a few chromophils belonging to the pars glandularis. Colloid-like material is very scanty and only seen in the main nervosal trunk.

The components of the pars glandularis are arranged in a dorso-ventral sequence. The pars anterior is situated dorsally proximal to the stalk. The pars intermedia is ventral and distal and the Übergangsteil is wedged in between. The pars anterior is made up of acidophils, chromophobes and basophils. The basophils are scattered and few. The acidophils show varying degrees of granulation. Two types of chromophobes are apparent—some are larger with sufficient cytoplasm and a distinct cell-boundary ; others lack a definite cell-wall and, with their meagre cytoplasm, look like naked nuclei. Acidophils, basophils and chromophobes occur in the Übergangsteil. The acidophils are heavily granulated and Ict deeply stained. A large percentage of basophils lack definition and are in different stages of degranulation. The chromophobes resemble groups of nuclei. The pars intermedia is composed of chromophobes, acidophils and dull basophils. The acidophils are smaller than those of the Übergangsteil and some have basophilic inclusions in their cytoplasm. The chromophobes have very little cytoplasm and their rounded nuclei exhibit a distinct nucleolus. Some of the blood-vessels entering the pars intermedia from the vascular envelop are outstandingly large and extend up to the pars anterior dorsally (Pl. 20, Fig. 6).

Family HETEROPNEUSTIDAE

(vi) **Heteropneustes fossilis** (Bloch)

(Collected in August, with fully mature gonads.)

The pituitary resembles that of *Claries batrachus* in its external morphology and relationship with the brain (Pl. 29, Fig. 5). The colloid-like material resembling that found in the pars nervosa is present in the infundibular cavity. Neuron cells, which are often found in the floor of the infundibulum, are occasionally present in the main trunk of the pars nervosa. A few disintegrating chromophils also occur in the component. The pars anterior has acidophils, and cromophobes. The former is predominant and sparsely granulated. The chromophobes

have a well-defined cell-boundary. Basophils, acidophils and chromophobes are present in the Übergangsteil. The basophils are strikingly larger than the acidophils and are heavily granulated ; many of them are vacuolated. These vacuoles contain varying quantities of acidophilic granules or globules (Pl. 22, Fig. 7). The larger blood sinuses of the Übergangsteil contain chromophilic colloid-like matter. The cell-wall of some of the basophils lying closer to the sinuses gives way to liberate their contents into the sinuses (Pl. 22, Fig. 8). This phenomenon is comparable to the observation made by de Beer (1926) in the mammalian pituitary where the acidophils burst to pour out their granular contents into the sinusoids. Some of the sinuses contain disintegrating basophils (Pl. 22, Fig. 5). The acidophils are intensely granulated and are smaller than the basophils. Chromophobes are few and are devoid of distinct cell limits.

The pars intermedia resembles that of *Clarias*, but acidophils seem to lack the basophilic contents. In *Heteropneustes* smaller blood-vessels penetrate into the pars intermedia from outside.

Family SISORIDAE

(vii) **Bagarius bagarius** (Ham.)

(Collected in June after spawning, with the gonads in a depleted state.)

The pituitary is attached to the infundibulum by a distinct stalk. The infundibular cavity extends into the pars nervosa. The arrangement of the components of the pars grandularis is slightly different from those described earlier. In this species though the Übergangsteil is placed in between the pars anterior and the pars intermedia, the former is in continuation with the latter towards the stalk (Pl. 20, Fig. 4).

Many of pars nervosal branches penetrate the pars intermedia and the pars anterior. The chromophils and the colloid-like substances are scarse in the pars nervosa. Acidophils and chromophobes are found in the pars anterior. A rosette-like disposition of acidophils around the blood vessel and nervosal branches is noticeable. The acidophils lying around the blood-vessels are more densely granulated than those occuring around the pars nervosal branches.

The Übergangsteil is the smallest component of the pars glandularis (Pl. 20, Fig. 4.) and is made up of acidophils, basophils, violet-coloured amphiphils and chromophobes. The acidophils outnumber the other cell-types ; they are oval or round and copiously granulated. The amphiphils resemble the acidophils, with a distinct voilet tinge. The basophils are much less in number and some of them have a prominent vacuole which may contain few scattered acidophilic granules. The chromophobes are few in number which may or may not have distinct cell boundaries. The pars intermedia contains light blue basophils heavily granulated acidophils and chromophobes. Deeply staining

acidophilic granules and globules occur in this part. These bodies appear to take their origin from the granulated acidophils.

Family SILURIDAE

(viii) **Wallago attu** (Bl. & Schn.)

(Collected in June, the fish is in the spawning and partly spent condition.)

The pituitary is ovoidal in shape and has an infundibular stalk. The Übergangsteil has a peripheral disposition in the ventro-lateral aspect of the gland and may cover up peripherally nearly three-fourths of the pars intermedia which is situated towards the centre (Pl. 21,Fig. 6). The pars intermedia is in contact with the pars anterior dorsally.

The main trunk of the pars nervosa arborises in the pars intermedia leaving smaller branches into the other components. The chromophils and colloid-like material are scanty in the pars nervosa. A large blood vessel entering the pars intermedia from the vascular connective tissue envelop vascularises the pars nervosa and extends upto the stalk. The pars anterior is formed of sparsely granulated, reddish brown acidophils and chromophobes. The cells lining the pars nervosal branches of the pars anterior are chromophobic, but in specimens collected during May they take up an amphiphilic hue. The Übergangsteil consists of acidophils, basophils and chromophobes. The basophils exhibit different degrees of degranulation ; some possess a prominent vacuole and others lack definition. The chromophobes occasionally look like groups of nuclei. A homogeneous basophilic substance is found in relation with the blood-sinuses penetrating the pars intermedia and the Übergangsteil. Light reddish brown chromophobes and acidophils are present in the pars intermedia.

Family BAGRIDAE

(ix) **Rita rita** (Ham.)

(Collected in November, when the gonads are in the resting stage.)

The pituitary is stalked and the surface of the pars anterior is indented as in *Esox lucius* and *Salmo trutta* (Kerr, 1942). The groove on the surface of the gland demarcates the boundary of the pars anterior from the rest of the gland. The main trunk of the pars nervosa contains the prominent infundibular cavity which is lined by elongated ependymal cells (Pl. 21, Fig. 2), as in *Notopterus chitala* and *Engraulis telara*. Chromophils and colloid-like substances are rare in the pars nervosa. The disposition of the components of the pars grandularis is dorso-ventral, as in *Clarias* and *Heteropneustes*. The pars anterior is situated proximal to the stalk dorsally, and the pars intermedia is distal and ventral, having the Übergangsteil in between them.

The pars anterior has chromophobes and differentially granulated acidophils. The Übergangsteil is made up of acidophils, basophiis and chromophobes. The acidophils are densely granulated and form

the principal cell-type. Some of the basophils are vacuolated. The pars intermedia contain acidophils and chromophobes.

In the pituitary of the specimens collected during July, when the gonads are in the spawning stage, the Übergangsteil is appreciably enlarged and the basophils preponderate. A large number of basophils have acidophilic granules and globules in their vacuoles. Some basophils exhibit degranulation which render them chromophobic.

Suborder *CYPRINOIDEA*

Family CYPRINIDAE

(x) **Rohtee cotio** (Ham.)

(Collected in June, with the gonads fully distended)

The pituitary is attached by a short, thick stalk to the infundibulum (Pl. 21, Fig. 3). Since the stalk passes through a shelf made of bone and connective tissue, removal of the pituitary with the brain is difficult. The glandular components are arranged along the dorso-ventral axis. Chromophils are rare but droplets of colloid-like bodies are present in the pars nervosa. The pars anterior consists of deeply staining acidophils and chromophobes. The chromophobes lack a well defined cell-wall. Acidophils, basophils and chromophobes are present in the Übergangsteil. The basophils are the most numerous ; some are vacuolated (Pl. 22, Fig. 4) but may or may not contain secretory matter. The acidophils are varied in shape and much smaller than the basophils. The chromophobes are few and lack definition. The pars nervosa occupies one-half of the pars intermedia. The chromophobes are the principal cell-type. The acidophils are few in number.

Notable differences are detected in the Übergangsteil of specimens collected during November, when the gonads are in the resting phase. There is conspicuous reduction in the size and number of the basophils and those with secretory matter are rare.

Order PERCOMORPHI

Suborder, *OPHICEPHALOIDEA*

Family OPHICEPHALIDAE

(xi) **Ophicephalus punctatus** Bloch

(Collected during July, with the gonads partly depleted.)

The pituitary is closely applied to the brain, and a definite stalk is wanting (Pl. 21, Fig. 5). Narrow extensions of the infundibular cavity are present in the pars nervosa. The pars nervosa contains small colloid-like patches and a few scattered chromophils. The pars anterior contains chromophobes and sparsely granulated acidophils. This component is adequately supplied with blood-vessels. The chief cell-

type of the Übergangsteil is degranulated. The degranulating basophils render this region frothy, a condition which is comparable to the net-lice appearance recorded in *Xiphias gladius* (Lee, 1942), *Fundulus* (Matthews, 1936), *Cirrhina reba* and *Mystus seenghala* (Sathyanesan, 1958 and 1960). The acidophils of the Übergangsteil look like islands in a reticulum. The granulated basophils are rendered chromophobic to stains. The greater part of the pars intermedia is occupied by the ramification of the pars nervosa. Chromophobes of a light brownish tint form the principal cell-type. Acidophils and basophils are few in number.

In March, when the gonads are in an enlarged condition (pre-spawning phase), the Übergangsteil is compact and with granulated basophils Degranulation of the basophils is not noticed but cytoplasmic vacuoles do occur in some.

Order OPISTHOMI

Family MASTACEMBELIDAE

(xii) **Mastacembelus armatus** (Lacep.)

(Collected during September, with the gonads distended with eggs.)

The pituitary is applied close to the brain and a distinct stalk is lacking, as in *Ophicephalus* and *Notopterus*. The glandular components are arranged in the antero-posterior direction, as in *Notopterus chitala* (Pl. 21, Fig. I). The pars nervosa sends extensive branches into the pars intermedia, and small ramifications in the other components. The pars anterior is the smallest component of the gland and is composed of acidophils. chromophobes and basophils. The basophils are few and resemble those in the Übergangsteil. The Übergangsteil is made up of acidophils, basophils and chromophobes. The acidophils are arranged in a lobular pattern along the dorsal margin, while the basophils lie in the ventral zone. Such an arrangement of the chromophils has been reported in *Zoarces* (Kerr, 1942) and *Centrarchids* (Scruggs, 1939). Groups of brightly coloured acidophilic globules are found among the acidophils of the Übergangsteil and in the pars nervosa. These acidophils which contain in these globules seem to resemble the sphere cells of *Perca fluviatilis* (Kerr, 1942). The pars intermedia is the largest component having lightly stained basophils as its chief cell-type. The chromophobes are much fewer and are scattered among the basophils. The course of the blood-vessels entering the pars intermedia from outside are indicated by the indented nature of its surface.

IV—DISCUSSION

The pituitary of the Teleosts described here can be broadly divided into two types as classified by Kerr (1942). *Type A :* Comprising glands without a definite infundibular stalk ; *Type B :* Including those having a distinct stalk. Pituitaries without a stalk and with a short stalk are closely applied to the brain and can be easily removed in tact with the brain. In species like *Rohtee cotio* a shelf of bony and connective tissue element is formed between the pituitary and the floor of the

infundibulum, which renders the removal of the gland with the brain difficult. Teleosts in general lack a well-defined sella turcica as occurs in the higher vertebrates (Bell, 1938). But in *Hilsa ilisha* a distinct sella turcica is present which was reported earlier by Misra and Sathyanesan (1958). All the species studied have a glandular and nervosal component typical of the teleosts. The surface of the pituitary is in some cases rough. The surface of the pars anterior of *Rita rita* and pars intermedia of *Wallago attu* and *Mastacembelus* are markedly indented. This may be due to the entry of blood vessels from outside.

Three types of arrangements of the various components of the pars grandularis in relation to each other are recorded in this study, as, follows :—(1) The glandular components are arranged one behind the other in a dorso-ventral axis. The pars anterior is dorsal and proximal to the infundibulum, while the pars intermedia is ventral and distal, and the Übergangsteil lies in between, as in *Rita rita* and *Rohtee cotio*. (2) The disposition of the glandular components is along the antero-posterior axis. The Übergangsteil is wedged in between the pars anterior and pars intermedia, as in *Mastacembelus*, *Notopterus chitala* and *Hilsa ilisha*. This arrangement is a little less pronounced in *Ophicephalus punctatus*. (3) The pars intermedia forms the core, and the Übergangsteil and pars anterior are partly peripheral in their arrangement as seen in *Wallago attu* where the pars anterior is in continuation with the pars intermedia dorsally. This tendency is apparently foreshadowed in *Bagarius bagarius*. Type 3, appears to be intermediate between Types 1 and 2. Bell (1938) observed that certain changes in the orientation of various lobes have taken place as a result of the development of the pituitary stalk. Charipper (1937) remarked that a generalisation about the position of the Übergangsteil could not be hazarded because it is central in *Gasterosteus* and *Cyprinus*, while in *Fundulus* it is peripheral.

The extension of the infundibulum into the pars nervosa was recorded by Tilney (1911) and Kerr (1949) in the Ganoids. Kerr (1949) reported that the tubular extensions are present in a reduced condition in the primitive Teleosts such as the eel, but in the great majority of these fishes they have become obliterated by the development of the solid pars nervosa and the stalk. In *Hexanchus* and *Heptanchus* the extension of the infundibular is in the form of an open tube (Charipper, 1937). Such extensions have been observed in *Polypterus* (Gerard and Cordier, 1936), *Anguilla* and *Mugil* (Charipper, 1937) and *Epiceratodus* (Griffiths, 1938).

In *Protopterus aethiopicus*, Dawson (1940) observed irregular and slender outgrowths of the infundibular cavity which he compared to the so-called sinuses of *Lepidosiren* (Kerr, 1943). These infundibular cavities are distinguished from the empty blood sinuses by their ependymal lining. According to Tilney (1911) these channels form the pathway of conduction of the secretory products of the pituitary into the third ventricle. Kerr (1943) cited the absence of such a channel in the higher vertebrates as an argument against the view of Tilney (1911).

In *Engraulis* and *Rita rita* the infundibular cavities appear as prominent closed vesicles in the pars nervosa, completely cut away from the

infundibular cavity. In *Mastacembelus* and *Ophicephalus* the cavities are in the form of funnels in the pars nervosa, having open connection with the infundibular cavity. In *Notopterus chitala* it is in the form of a chocked duct, reminding of the condition obtained in the Ganoids (Kerr, 1949).

The pars anterior is very variable in teleosts. In *Esox niger* the pars anterior is absent (Scruggs, 1939). However, Stendell (1914) recorded a pars anterior in *Esox indicus*. Butcher (1936) could not detect the several lobes in the pituitary of *Fundulus*. Scruggs (1939) remarked that the glandular components are less distinctly defined in *Fundulus* than in other fishes. The homology between the pars anterior of fishes and the pars tuberalis of mammals has been suggested (Charipper, 1937 ; and Bell, 1938). Kerr (1949) stated that such a homology can not be accepted on the structural and histological grounds since the pars anterior is not formed from the lateral lobe during development. Bock (1928) pointed out that no exact homology could be established between the two. A tongue-like prolongation of the pars anterior has been compared with the pars tuberalis of the higher vertebrates by Potts (1942). Scruggs (1939) inferred that the pars anterior of the Teleosts shows much more selective activity than the tuberalis of the higher vertebrates and hence may not form an exact homologue. The pars anterior of the various fishes described here indicate their variable nature from species to species. In the Clupeids, namely, *Hilsa ilishā*, *Gadusia chapra* and *Engraulis telara*, the pars anterior contains tubular structures which are the diverticula of the hypophysial cavity. The presence of such cavities is considered to be a primitive feature, and is characteristic of the pars anterior of *Acipenser*, *Lepidosteus*, *Amia*, the eel and the trout (Kerr, 1949, 1942). Recently, such a cavity has been reported in *Pangasius pangasius* (Sathyanesan, 1960).

The cellular differentiation and their seasonal variations in the Übergangsteil have a close resemblance to the pars anterior of the higher vertebrates. Such a correspondence between the Übergangsteil of Teleosts and the pars anterior of the higher vertebrates have been emphasised earlier by Charipper (1937), Bell (1938), Levenstein (1939), Hoar, (1957) and others. Stolk (1950, 1957) and Bretschneider and de Wit (1947) have used the term "lobus tuberalis" as synonymous with pars anterior. In view of the difference of opinion regarding the homology of this component, Olivereau (1954) and Hoar (1957) have rightly suggested that such homologies should await until more is known about their physiology.

In the review of the vascular supply of the pituitary gland in fishes, Levenstein (1939) stated that the blood supply of the pituitary is intimately connected with the pars nervosa and no sizable vessels are found entering the glands from its surface. A similar condition was reported by Stendell (1914) and Bock (1928) for the many forms which they

studied. Bell (1938) stated that no large blood-vessels were found entering the pituitary body in the goldfish. Further, he found the pars anterior to be the most vascular lobe. In the present work in all cases blood-vessels are detected penetrating the pituitary from the vascular capsular covering, and in some forms like *Clarias batrachus* and *Wallago attu* the vessels are outstandingly large.

Colloid-like materials are present in the pars nervosa and pars glandularis in many forms. They are formed as intracellular granules or globules in the chromophils. Sometimes the chromophils disintegrate as a whole to form such bodies as reported by Stendell (1914), Potts (1942) and Sathyanesan (1960). In *Hilsa ilisha* the colloid-like bodies are seen in large quantities in the main trunk of the pars nervosa and towards the stalk, which suggests their transportation to the infundibulum through the pars nervosa and the pituitary stalk. The chromophils emptying their contents into the blood sinuses and the disintegration of these cells as a whole in the sinuses, as evidenced in *Heteropneustes*, are suggestive of the direct entrance of the secretory products into the circulation. The possible pathways of the secretory products in the higher vertebrates is reviewed by Popjak (1940).

V—SUMMARY

The pituitaries of fresh water fishes described here belong to type A, and type B, as defined by Kerr (1942). In the former the pituitary stalk is absent and the infundibular cavity is wide, whereas in the latter the pituitary stalk is present and the infundibular cavity is reduced.

In species like *Rohtee cotio* the presence of an incomplete shelf between the gland and the brain renders the dissection difficult.

In general the teleosts lack a well defined sella turcica, but in *Hilsa ilisha* it is prominent and may be comparable to that of higher vertebrates.

The pituitary stalk ramifies in the glandular components as the pars nervosa. The main trunk is in association with the pars intermedia. The relative disposition of the components of the pars glandularis may be one of the three types described in the text.

The extension of the infundibular cavity into the pars nervosa is very varied and these cavities are readily recognizable by their ependymal lining.

Acidophils, basophils and chromophobes are the basic cell types present in the pars glandularis. In pars glandularis intracellular granules, globules or liquefied matter may be present. Such bodies are also extruded from the cells. In some cases disintegration of migrated chromophils takes place in the pars nervosa. In *Heteropneustes fossilis*

the disintegrating glandular cells are seen in the blood sinuses. These suggest the secretory activity and the possible methods of absorption of secretory products into the general system.

Although small capillaries are seen in the pituitary stalk, the entrance of the prominent blood vessels from the covering meninges into the glands suggests the main blood supply to the pituitary is not through the brain connection or stalk as opined by Kerr (1942).

VI—REFERENCES

ATZ, E. H. 1953. Experimental differentiation of basophil cell-types in the transitional lobe of the pituitary in the teleost fish *Astyanax mexicanus.—Bull. Bingham oceanogr. Coll.*, New Haven, **14,** pp. 94-116.

BELL, W.R. 1938. Morphology of the hypophysis of the common goldfish (*Carassius auratus*).—*Zoologica*, New York, **23,** pp. 219-234.

BOCK, F. 1928. Die Hypophyse des Sticklings (*Gasterosteus aculeatus* L.) unter besonderer Berücksinchtigung der Jahrescyklischen veranderungen.—*Z. wiss. Zool.*, Leipzig,**131,** pp. 645-710.

BRETSCHNEDER, L. H. and DE WIT. J. J. DUYVENE, 1947. Sexual endocrinology of non-mammalian vertebrates.—*Monogr. Progr. Res. Holland*, Amsterdam, **11.**

BUTCHER, E. O. 1936. Histology of the pituitaries of several fishes.—*Bull. Mt. Desert Island Biol. Lab.*, No. **11.**

CHARIPPER, H. A.1931. Studies on amphibian endocrines. The pituitary gland of *Necturus maculosus.—Anat. Rec.*, Philadelphia, **49,** pp. 345-361.

CHARIPPER, H. A. 1937. The morphology of the hypophysis in the lower vertebrates particularly fish and Amphibia, with some notes on the cytology of the pituitary of *Carassius auratus* (the goldfish) and *Necturus maculosus* (the mud puppy)—*Cold Spring Harbour Symp. Quant. Biol.*, **5,** pp. 151-164.

DAWSON A. B. 1940. The pituitary gland of the African lungfish, *Protopterus aethiopicus.—Biol. Bull.*, Woods Hole, **78,** pp. 275-282.

DE BEER, G. R. 1926. *Comparative Anatomy, Histology and Development of the Pituitary body.*—London (Oliver & Boyd).

FLORENTINE, P. and WEISS. M. 1931. Étude histologique de l'hypophyse d' Anguille (*Anguilla anguilla* L.).—*C. R. Soc. Biol.*, Paris, **107,** pp. 718-720.

GERARD, P. and CORDIER, R. 1936*a*. Sur la resistance d'une connexion bucco-hypophysaire chez les Crossoptery giens adultes.—*Ann. Soc. R. Zool. Belg.*, Brussells, **67,** pp. 87-90.

GERARD, P. and CORDIER, R. 1936*b*. Sur la région infundibulo-hypophysaire de *Polypterus weeksii.—C. R. Ass., Anat.*, Milan, **41,** pp. 160-169.

GRIFFITHS, M. 1938. Studies on the pituitary body. II. Observations on the pituitary in Dipnoi and speculations concerning the evolution of the pituitary.—*Proc. Linn. Soc. N. S. Wales*, Sydney, **63,** pp. 89-94.

HERRING, P. T. 1908. A contribution to the comparative physiology of the pituitary body.—*Quart. J. exp. Physiol.*, London, **1,** pp. 261-280.

HERRING, P. T 1913. Further observations upon the comparative anatomy and physiology of the pituitary body.—*Ibid.*, **6,** pp. 73-108.

HOAR, W. S. 1955. Reproduction in teleost fishes—*Mém. Soc. Endocrin.*, Cambridge, No. **4,** pp. 5-24.

HOAR, W. S. 1957. Endocrine organs. pp. 245-285. In : *Physiology of Fishes*, Vol. I. New York (Academic Press. Inc.).

KERR, T. 1942*a*. On the pituitary of the perch (*Perca fluviatilis*).—*Quart. J. micr. Sci.*, London, **83,** pp. 299-316.

KERR, T. 1942*b*. A comparative study of some teleost pituitaries.—*Proc. zool. Soc. Lond.*, London, **112**A, pp. 37-56.

KERR, T 1943. The evolution of the pituitary with special reference to teleost.—*Proc. Leeds Phil. Soc.*, Leeds, **4,** pp. 75-83.

KEER, T 1949. The pituitaries of *Amia*, *Lepidosteus* and *Acipenser*.—*Proc. zool. Soc. Lond.*, London, **118,** pp. 973-983.

LEE, R. E. 1942. The hypophysis of broad-billed sword fish, *Xiphias giadius*.—*Biol. Bull.*, Woods Hole, **82,** pp. 401-412.

LEVENSTEIN, I. 1939. The cytology of the pituitary gland of two varieties of goldfish (*Carassius auratus* L.), with some reference to variable factors in the gland which may possibly be related to the different morphological types.—*Zoologica*, New York, pp. 47-60.

MATTHEWS, S. A. 1936. The pituitary gland of *Fundulus*.—*Anat. Rec.*, Philadelphia, **65,** pp. 357-369.

MATTHEWS, S. A. 1937. The development of the pituitary gland in *Fundulus*.—*Biol. Bull.*, Woods Hole, **73,** pp. 93-98.

MILLER, R. N. 1944. The hypophysis of teleost, *Corydora paliatus*.—*J. Morph.*, Philadelphia, **74,** pp. 93-98.

MISRA, A. B. and SATHYANESAN, A. G. 1958. On the persistence of the oro-hypophysial duct in some clupeoid fishes.—*Proc. XV int. Congr. Zool.* (*London.*), Section V, p. 27.

OLIVEREAU, M. 1954. Hypophyse et glande thyroide chez les poissons. Etude histo-physiologique de quelques correlations endocriniennes en particulier chez *Salmo salar* L.—*Ann. Inst. oceanogr.*, Paris, **29,** pp. 95-296.

PICKFORD, G. E. and ATZ, J. W 1957. *The Physiology of the Pituitary Gland of Fishes*.—New York.

POPJAK, G. 1940. The pathway of pituitary colloid through the hypothalamus.—*J. Path. Bacteriol.*, London, **51,** pp. 83-89.

REGAN, TATE C. 1929. Fishes. In : *Encyclopaedia Britannica*, 14th ed.

SATHYANESAN, A. G. 1957. Parasitism in relation to the pituitary of *Ophicephalus punctatus* and *Barbus stigma*.—*Nature*, London, **180,** pp. 98-99.

SATHYANESAN, A. G. 1958. Studies on the morphology and seasonal histological changes in the pituitary gland of the fresh-water teleost, *Cirrhina reba* Ham.—*J. veter. Sci. anim. Husb.*, Delhi, **28,** pp. 13-20.

SATHYANESAN, A. G. 1959. Extravasation of blood-cells in and around the pituitary of the teleost, *Chela bacaila* (Ham.).—*Naturwissen*, Berlin, **5,** p. 176.

SATHYANESAN, A. G. 1960*a*. Pituitary-gonad interrelationship in the catfish, *Mystus seenghala* (Sykes).—*Sci. & Culture*, Calcutta. (*In press.*)

SATHYANESAN, A. G. 1960*b*. The occurrence of hypophysial cavity in the pituitary of the teleost, *Pangasius pangasius* (Ham.).—*Ibid.*, **25** (12), pp. 693-94.

SCURGGS, W. M. 1939. The epithelial components of the teleost pituitary gland as identified by a standardised method of selective staining.—*J. Morph.*, Philadelphia, **65,** pp. 187-214.

SCURGGS, W. M. 1951. The epithelial components and their seasonal changes in the pituitary gland of carp (*Cyprinus carpio* L.) and goldfish (*Carassius auratus* L.)—*Ibid.*, **88,** pp. 441-470.

STOLK, A. 1950. Histo-endocrinologische analyse van de graviditeitsverschijnselen bij de Cyprinodontide *Lebistes reticulatus*.—Thesis, Utretcht Univ., Holland.

STOLK, A. 1955. Abnormal distribution of the lobes in the pituitary gland of fishes.—*Kon. Nederl. Akad. Wet.*, Amsterdam, **58,** pp. 443-452.

STOLK, A. 1957. Histo-endocrinological analysis of gestation phenomena in the Hermiramphid, *Dermogenys pusillus*. II. Changes in the pituitary gland during pregnancy.—*Acta. Morphol. Neerlando-Scandin*, **1,** pp. 119-130.

STENDELL, W 1914. Die hypophysis Cerebri. In : Oppel's *Lehrbuch Vergl. Anat.*, **8,** pp. 1-165.

TAMPI, P. R. S. 1951. Pituitary of *Chanos chanos* (Forskål).—*Nature*, London, **167,** pp. 686-687.

TAMPI, P. R. S. 1953. On the structure of the pituitary and thyroid of *Chanos chanos* (Forskål).—*Proc. nat. Inst. Sci. India*, Calcutta, **19,** pp. 247-256.

TILNEY, F. J. 1911. Contribution to the study of hypophysis cerebri, with special reference to its comparative histology.—*Mem. Wistar Inst. Anat. Biol.*, Philadelphia, **2.**

WOODMAN. A. S. 1939. The pituitary gland of Atlantic Salmon.—*J. Morph.*, Philadelphia, **65,** pp. 411-437.