CHAPTER - I

INTRODUCTORY
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GENERAL

Pituitary as the most important endocrine organ.

At the centre of the endocrine system in vertebrates is the pituitary gland or hypophysis. The gland is closely applied to the floor of the brain with or without any stalk (in fishes) derived from the hypothalamus. No part of the body is exempt from its influence.

A reciprocal relationship exists between the hypophysis and other endocrine glands, as well as between the hypophysis and the central nervous system. The number of hormones produced by this endocrine gland is the highest. Some of the hypophysial hormones exert their influence by regulating the functional capacities of other members of the endocrine system. In turn, the secretions of other endocrine glands condition the activities of this organ.
So it appears misleading to refer to the pituitary as the "Master" gland of the body, because all members of the endocrine system are interdependent and tend to influence each other reciprocally. The pituitary and its targets exist in a state of mutual excitation and inhibition, and control each other after the manner of a "serve" or 'feed-back' mechanism even in fishes.

No work has been done so far on this important endocrine gland in Kashmir fishes. There is no record of any work on any aspect of this gland in Kashmir. Work on the pituitary gland of Kashmir fishes was started for the first time in Kashmir in 1965, at the suggestion of Prof. S.M. Das, Head, Department of Zoology, Jammu and Kashmir University. This is the first time that a comprehensive comparative, morphological, histological and histophysiological study of the pituitary gland of Kashmir fishes has been attempted. The pituitary of the following ten fishes has been worked out in the present thesis:

1. Schizothorax esocinus Heckel.
2. Oreinus plagiotomus (Heckel).
3. Cyprinus carpio communis Linn.
4. Cyprinus carpio specularis Linn.
5. Labeo diplostomus McCr.
7. Crossochilus latius diplochilus (Heckel).

**Pituitary terminology.**

The teleost pituitary in general consists of a nervous element, the neurohypophysis, and a glandular element, the adenohypophysis. Difficulties of terminology have arisen in connection with the parts of the adenohypophysis as compared to mammalian pituitary. Among fishes, the relationship of the three regions vary greatly and there is little resemblance to the standard mammalian anterior, middle and posterior pituitaries. Misconceptions have arisen, when it was thought that the conspicuous anterior lobe of the teleostean hypophysis was homologous with the mammalian pars anterior. The true homologue of the pars anterior in fishes is the so-called transitional lobe (Übergangsteil) which lies between the anterior lobe and the region which (from all available evidences) must be homologized with the pars intermedia. It has been suggested that the anterior lobe in fishes represents the pars tuberalis of higher vertebrates. But the confusion remains unsettled. To avoid confusion the terminology adopted in the present thesis is the one suggested for fishes by Pickford and Atz (1957), where the following homologies are suggested:
**Proadenohipophysis**
- anterior glandular region
- anterior lobe
- pars follicularis
- pars anterior
- pars tuberalis
- pars interior
- Hauptlappen

**Mesoadenohipophysis**
- middle glandular region
- transitional lobe
- anterior pituitary
- Übergangsteil
- median zone
- pars distalis
- pars anterior

**Metaadenohipophysis**
- posterior glandular region
- intermediate lobe
- pars intermedia
- posterior lobe
- Zurschenlappen
- pars intermedius

**Neurohipophysis**
- pars nervosa
- Hirnteil
- processus infundibularis
TYPICAL STRUCTURE OF FISH PITUITARY

Gross structure.

The structure of the fish pituitary is remarkable in that "In no other group of vertebrates does the hypophysis present such variation; for in nearly every species within this group a different type of structure is encountered" (PICKFORD AND ATZ, 1957).

BELL (1938), Carassius auratus, stated that the pituitary body lies deeply embedded in the neurocranium. In Carassius it does not occupy a sella turcica in the basisphenoid bone; but in many of the fishes worked out in the present thesis, and, in all the higher vertebrates, the pituitary lies in an enclosed sella turcica on the floor of the brain case (basisphenoid bone). In others it lies in a tunnel like cavity the myodom below the cranium, the cavity being enclosed in the apex of the V-shaped neurocranial floor.

The lateral walls of the teleost neurocranium, in the region of the pituitary are formed by the prootic and alisphenoid bone. Posterior to the pituitary the roof of the myodom forms the floor of the cranium.

The teleost pituitary in general consists of a nervous element (neurohypophysis) and the glandular element (adenohypophysis), divisible into three lobes: Proadenohypophysis, mesoadenohypophysis and the
metaadenohypophysis. The pituitary stalk is continued in the adenohypophysis as neurohypophysis and ramifies extensively in the mesoadenohypophysis and the metaadenohypophysis in most fishes.

In some primitive fishes there is a cavity in the mesoadenohypophysis and neurohypophysis (STENDELL 1914, Acipenser; DE BEER 1926, Amia; BUCKMAN 1940, Hering; KERR 1942, Lepisosteus MISRA and SATHYANESAN 1958, Hilsa, Engraulis and Gadus; and DAS AND KHAN 1962, Rita rita), which has been homologised with remnants of Rathke's pouch.

The arrangement of the three lobes to each other varies greatly in each fish (Linear, Vertical, Lineover-tical); while the attachment may be platybasic (without stalk) and leptobasic (with stalk attachment as crasiobasic dorsobasic and auctobasic).

The Pro-adenohypophysis is the smallest part of the gland and is usually the anterior part. The mesoadenohypophysis is usually the largest part of the gland. This portion of the pituitary gland is the most changeable part of the gland. The neurohypophysis passes through this part. The metaadenohypophysis is the posterior part of the gland, the neurohypophysis usually containing and ending in this part. In a few teleosts it is the largest part of the gland.
Blood supply.

The blood supply of the gland has not been fully studied in fishes. The most constant feature is the poor vascularization of the mesoadenohypophysis. In tetrapods, this region is supplied by the hypophysial portal vein which transports neurohypophysial hormones from the hypothalamus to the adenohypophysis. There is no portal system in fishes; but there is a plexus of vessels between the neurohypophysis and the adenohypophysis which may perform a similar function.

General fine structure.

Although a large body of information relating to pituitary gland fine structure and function in mammals is available, comparatively less is known about the pituitary gland in fishes. The general morphology and histology have been described in many fishes. Detailed histological studies on fish pituitaries are hardly 30 year's old. Only a few fishes have been worked out. (BUCHMAN, 1940; LEE, 1942; RASQUIN, 1949; STOLK, 1950; ATZ, 1953; BARRINGTON and MATTY, 1955, KERR, 1965; LEHRI, 1966; PANT and KHANNA; 1968 etc).

Two main types of cells are present in all fish pituitaries; One the chromophobes and the other the chromophils. The main types of cells present in the pituitary gland are developed from the chromophobes which are regarded as mother cells of chromophils.
The pro-adenohypophysis is mainly formed of acidophils, small chromophobes, Orange-G cells, and sometimes a few basophil cells. (Bell, 1938; Scruggs, 1939; and Matty, 1959). Schreibman (1964) reported that the pro-adenohypophysis consists of acidophils in the main.

The meso-adenohypophysis is composed of both acidophils and basophils. A few chromophobes, blood capillaries and some neuro-strands are common (Bell, 1938; Scruggs, 1939; Matty, 1959; Schreibman, 1964).

The meta-adenohypophysis is composed of acidophils, blood capillaries, neurohypophysial strands, amphiphils and some chromophobes (Mathews, 1936; Bell, 1938; Scruggs, 1939; Kerr, 1942; Matty, 1959; Schreibman, 1964).

**Physiology**

Secondary sex characters such as nuptial colouration, and sex accessories such as gonoducts, showed the expected regression or failed to develop in hypophysectomised fishes (Vivien, 1938, 1941; Burger 1942; Pickford 1953 a,b,).

Gonadotropins also show seasonal variations. Gerbilskii (1940) made extensive tests of the gonadotropins of the pituitary of Lucioperca lucioperke and Abramis brama; and showed that there was a decided reduction in gonadotropins after the fish had spawned.
FUNCTIONS OF THE PITUITARY GLAND

The functions of the fish pituitary gland are the same or analogous to those of mammalian pituitary gland. One of the most important functions of the pituitary gland is the influence on the gonadal system. This influences both in the transition from juveniles to sexual maturity and in the seasonal spawning cycles. The pituitary secretions (e.g., FSH, LH, ACTH) affect the stages of ripening of the eggs, as well as the process of ovulation. Relatively little has been recorded about the effect of pituitary gonadotropins on various stages of spermatogenesis in fishes. The cyclic nature of reproductive activity of viviparous fishes is also under pituitary control.

All organs of the fish-body respond to the growth-promoting action of the pituitary growth-hormone (Somatotropin, STH). After hypophysectomy, there is cessation of growth; while treatment with extracts of teleostean pituitary can elicit a resumption of growth.

The normal regulation of thyroid function is also controlled by the pituitary (Thyrotropin, TSH). On the other hand many teleosts treated with antithyroid drugs show changes in the cytology of the teleostean adenohypophysis. There is marked increase in the number of vacuolated cyanophils in the pituitary. The relation of the thyroid to the thyrotrophin is shown by thyroectomy. Thyroectomy retards both growth and cell differentiation, and leads to a complete disappearance of acidophil cells from the pituitary. Small doses of thyroxine restores the acidophil
cells to normal; and larger dozes are required to restore the normal condition of thyrotrophs. Since the acidophils are believed to be somatotrophs, these results indicate that the formation and secretion of growth hormone may be abolished in the absence of thyroid hormone.

The Proadenohypophysis is the source of a melanophore concentrating hormone (MSH) acting on the melanin-bearing cells in the skin to bring about a permanent background colour.

Pituitary ACTH stimulates the secretion of adrenal cortical steroids by the adrenal cortex. The function of these adrenal cortical steroids is the regulation of salt and water metabolism in the fish. Indirectly, this shows that unlike mammals, the salt regulating function of the adrenal cortex in teleostean fishes is under pituitary control.

**THE HYPOTHALAMO HYPOPHYSIAL COMPLEX.**

The Hypothalamus is closely linked with the anterior pituitary (mesoadenohypophysis). The nerve fibres run from the hypothalamus through the neurohypophysis into the mesoadenohypophysis. Similarly, sympathetic and parasympathetic fibres have been found to enter the mesoadenohypophysis.

From the hypothalamus, there appear to be at least four distinct groups of neurosecretory cells in the brain of fishes, only two of which have been studied in
This neurosecretory apparatus acts as a connecting link between the two major control systems of the body, the nervous system and the endocrine system. The command issued by the nervous system is translated from a nerve impulse into a chemical message by the neurosecretory cells acting as transducers. The command goes to the anterior pituitary (mesoadenohypophysis) which transmits the chemical message to the appropriate destinations by way of endocrine system.

The nucleus preopticus is probably homologous to the nucleus supraopticus as well as the nucleus paraventricularis of reptiles, birds and mammals, which is responsible for the secretion of the posterior lobe (metaadenohypophysis) hormones.

ORIGIN AND EVOLUTION OF FISH PITUITARY.

The origin of the vertebrate pituitary is surprisingly traceable to the neural gland (Hypophysis) of Ascidians, both in formation and function. The presence of the vertebrate type of hormone (gonadotropin) in ascidian "pituitary" is now considered established (DAS, 1958). Induction of mammalian gonadotropic hormones into ascidians was also followed by ovulation and the release of sperms.
The primitive role of the gonadotropic hormones was the chemical transmission of messages from the ciliated pit to the brain, by non-vascular and non-nervous pathways. But during the process of evolution a more rapid afferent nervous segment of the reflex arc was substituted.

In fishes, as in other vertebrates, the pituitary complex is organized during development from two embryologically distinct components, the neurohypophysis and the adenohypophysis. The neurohypophysis is associated with a depression or downgrowth from the floor of the third ventricle, the Infundibulum; while the adenohypophysis differentiates in all teleosts as a solid ectodermal impushing of the buccal epithelium (Rathke's pouch), without cellular differentiation, which extends below the brain and becomes stalked (attached with the neurohypophysis). In many primitive forms this impushing or invagination of the buccal diverticulum persists, even in the adult as hypophysial cavity; and when present, it separates the posterior from the middle and anterior regions of the adenohypophysis (KERR, 1942, Polypterus, Acipenser, Amia, Lepidosteus). A hypophysial cavity is however absent in higher teleosts. An open hypophysial duct, communicating with the pharynx, is retained in some instances, as in Polypterus (GERARD and CARDIER 1936; KERR 1942). When present in fishes it is connected with the most anterior region of the adenohypophysis.
APPLICATION OF PITUITARY KNOWLEDGE TO FISHERIES.

There are many important freshwater food fishes and carps in India which refuse to breed in captivity. In nature all of them spawn in rivers during the monsoon period. The usual practice is to collect millions of carp fry from rivers during the monsoon months and transport them in suitable containers as fish seed. This involves capture and transport at high cost, as also uncertainty of the availability of fry at the proper time and their high mortality in containers. Above all, when conditions are not propitious for successful spawning (as for example when the monsoon fails in India) there results a shortage of fry that presents grave problems.

In order to overcome these difficulties, the urgent necessity of induced breeding in India, (as in Brazil, Israel, Continent, Russia and USA) is therefore now widely accepted. Successful results have been got by pituitary inducement in major carps in India (CHAUDHURI 1958, DAS 1962). Pituitary treatment is absolutely necessary for breeding these fishes in confined waters. The pituitary injections would cause ripe freshly caught fishes to spawn eggs that when fertilized develop into normal young.

HOUSSAY (1930-31) showed for the first time the success of using pituitary injections in the spawning of fish. CHAUDHURI (1958) was the first Indian to obtain large scale fish seed by pituitary inducement in the major carps.
It has been shown that when fishes are injected intramuscularly a much smaller dose of gland is sufficient to induce spawning than when the injections are given intraperitoneally. It is possible to predict rather accurately when a spawn is forthcoming and plan fish-hatchery work to a right schedule. Culture ponds can be stocked with eggs and fry of uniform age, by the pituitary induced method. Besides, artificial fertilisation and hybridisation, to produce hardy fishes with greater food value, becomes an easy tool for fishery development work.