GENERAL SUMMARY
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The present work deals with the "Studies on the functional morphology of some endocrine glands in fresh-water fishes with special reference to their control of reproductive cycle". The general summary of the observations is as follows:

1. The hypothalano-hypophysial neurosecretory system in Indian fresh-water cat-fish *Mystus vittatus* (Bloch) has been described.

   a. The system is on general pattern found in teleost fishes. The nucleus preopticus, tractus preoptico hypophyseus and the nucleus lateralis tuberis and their fibres form the hypothalano-hypophysial system.

   b. The granular neurosecretory material is found in the cell of nucleus preopticus mass. The neurosecretory droplets are altogether absent.

   c. The accumulation of neurosecretory material is found more in the neurosecretory fibres present in the neurohypophyseal processes interdigitating with pars-intermedia. These fibres have also been found terminating over the blood vessels.

   d. The cells of the nucleus lateralis-tuberis are observed along the mid-ventral aspect of the infundibular region near the
pituitary stalk. It is presumed that the secretion of nucleus lateralis tuberis cells travel towards the pituitary gland along with the fibres which get mixed with the preoptico-hypophyseus tract.

(e) The Herring bodies have been observed right from the pituitary stalk to different levels of the neurohypophysis. These structures represent the swollen part of the neurosecretory axons with an accumulation of the neurosecretory material. They help in increasing the area for release of biologically active principles in circulation. The pituicytes non-neurosecretory fibres and blood vessels have also been observed in the neurohypophysis.

(f) The saccus vasculosus, a highly vascular structure lies dorsal and posterior to the pituitary gland. The lumen of saccus vasculosus is filled with a fluid.

(2) The structure of the pituitary gland including its morphology, histology and cytology has been described in Mystus vittatus (Bloch) and Channa punctatus (Bloch).

(a) The pituitary gland of Mystus vittatus is lodged in the neurocranium delimited dorsally by the prootic and ventrally by the parasphenoid bones. A definite pituitary stalk is present. The infundibular processes enter to the pituitary gland through its antero-dorsal end. The gland is,
thus, of cranio-leptobasic type. In *Channa punctatus*, the pituitary gland is situated on the ventral side of the brain in a concavity of the parasphenoid bone and is without a definite pituitary stalk. Therefore, the gland is of platybasic type.

(b) In both the fishes the pituitary gland is constituted of glandular and neural components. The granular component is further divisible in rostral pars-distalis, proximal pars-distalis and pars-intermedia. The neurohypophysis, neural component, sends small branches to the rostral pars-distalis and proximal pars-distalis and the main trunk arborises in the pars-intermedia. In *Mystus vittatus*, the glandular components of the pituitary gland are arranged one behind the other on an anteroposterior axis with rostral pars-distalis being the anterior most proximal pars-distalis in the middle and the pars-intermedia on the posterior side.

In *Channa punctatus* the rostral pars-distalis is antero-ventral, the proximal pars-distalis is in the middle and the pars-intermedia is placed posterior ventrally to the pars-distalis.

(c) With different staining techniques used for this study, 9 different cell types have been distinguished in the glandular region of *Mystus vittatus* and *Channa punctatus*. 
(d) Two types of basophils have been identified in the proximal pars-distalis of both the fishes and have been designated as Basophil I and Basophil II. The basophil I are AF and PAS +ve and are possible source of gonadotropin.

(3) In order to understand the regulatory mechanism of hypothalamic dependence of the pituitary gland, the hypothalamo-hypophysial vascular relationship has been studied in Mystus vittatus.

(a) The blood circulation in the head region is on a typical teleostean pattern with dorsal aorta, lateral dorsal aortae and a set of four efferent branchial arteries.

(b) The ventral hypothalamic artery which runs ventral to the brain supplies to blood to the nucleus preopticus through a pair of nucleus preopticus artery and to the pituitary gland through a pair of hypophysial arteries. It also supplies to the hypothalamus through a pair of hypothalamic arteries. A hypothalamo-hypophysial portal circulation is absent.

(c) The anterior cerebral vein, after receiving the blood from the fore brain including hypothalamus and nucleus preopticus joins with the head vein posteriorly. The pituitary gland is drained off dorso-laterally through a pair of pituitary veins which join with the infraorbital sinus and
supraorbital sinus to form the head vein.

(d) The saccus vasculosus is supplied with the blood through a number of small blood capillaries arising from the common posterior cerebral artery. The blood is drained from the saccus vasculosus through a pair of posterior cerebral vein. Thus, there seems no physiological connection between the saccus vasculosus and the pituitary gland.

(e) Blood vessels are abundant inside the pituitary gland but are restricted to the neurohypophysial extensions in the pars-intermedia and pars-distalis.

(f) In absence of axonal contact with the gland cells of the pituitary gland, the neurovascular way of hypothalamic control over the pituitary gland holds good in the present fish.

(4) The reproductive system and the reproductive cycle of *Mystus vittatus* and *Channa punctatus* habe been studied.

(a) The gonads, in both the fishes, are paired elongated structures resting upon the dorso-lateral side of the air bladder and suspended in the body cavity through dorsal mesentry. The paired gonducts unite posteriorly to form a common gonoduct which open outside through the urinogenital pit. *Mystus vittatus* is a sexually dimorphic fish. The males
are differentiated from the females in having a long, pointed, muscular pseudo-copulatory papilla.

(b) In *Mystus vittatus* seminal vesicles are observed as finger-like structures situated posterior to the testes.

(c) Histologically, the ovaries in both the fishes are covered with a thin peritoneal layer. The ovarian wall consists of tunics albuginea and germinal layer. The germinal layer is dispersed into ovigerous lamellae in which the oocytes of different stages are lodged. The ovarian lumen is continued as the lumen of oviduct as in other teleosts.

(d) Eleven different oogenetic stages have been recognised in the ovaries of both the fishes which are early chromatin nucleolus stage, late chromatin nucleolus stage, early peri-nucleolus stage, late peri-nucleolus stage, early yolk vesicle stage, late yolk vesicle stage, primary yolk stage, secondary yolk stage, tertiary yolk stage, prematuration stage and mature stage.

(e) The yolk-nucleus of Balbiani has been observed in both the fishes. In *Mystus*, it first appears in the late peri-nucleolus stage and persists till early yolk vesicle stage while in *Channa* it appears in the early peri-nucleolus stage and disintegrates in the late yolk vesicle stage. It is suggested that yolk nucleus plays an indirect role in the process of vitellogenesis.
(f) In both the fishes corpora atretica and post-ovulatory follicles have been observed in the ovaries. The corpora atretica are the result of the resorption of the oocytes and post-ovulatory follicles are formed due to the evacuation of the oocytes. The process of resorption of corpora atretica has been described in four different stages in both the fishes.

(g) In both the fishes, testes are enclosed in a thin peritoneal membrane below which lies the tunica albuginea composed of connective tissue. The germinal tissue is disposed into a number of seminiferous tubules which are separated by connective tissue extensions of tunica albuginea.

(h) In both the fishes, six different spermatogenetic stages have been recognised which are primary germ cells, spermatogonia, primary spermatocytes, secondary spermatocytes, spermatids and spermatozoa.

(i) In the testes of Mystus, there is a seriation in the process of spermatogenesis from the periphery to the centre of the tubules while in the testes of Channa, the tubules contain all the spermatogenetic stages without seriation.

(j) The seminal vesicles of Mystus are filled with colloidal secretion which probably helps in spermiation.
(k) Morphological, histological and cytological changes in the gonads, during different months of the year, have been observed in *Mystus vittatus* and *Channa punctatus*. On the basis of these observations the reproductive cycle of the fishes have been divided into various periods. In *Mystus*, they are post-spawning period (Mid-October to January), pre-spawning period (February to May) and spawning period (June to mid-October) while in *Channa* they are post-spawning period (November to February), pre-spawning period (March to mid-April), I spawning period (mid-April to May), preparatory period (June to mid-July) and II spawning period (mid-July to October).

(1) Quantitative study of the reproductive cycle of *Mystus vittatus* and *Channa punctatus* has been made in respect of gonad volume and gono-somatic index during different periods of reproductive cycle. Such a study is found helpful in understanding the seasonal changes of the gonads.

(m) The reproductive cycle of the two fish under present study has also been statistically assessed on the basis of different cell types of spermatogenesis in the testis and the relative number of oocytes of different diameter and relative number of corpora atretica and post-ovulatory follicles in the ovary during different periods.
of the year. The quantitative assessment of the corpora atretica and post-ovulatory follicles reveals that though the number and presence of corpora atretica is not good enough for a precise determination of the spawning periodicity of the fish, the presence and variation in number of the post-ovulatory follicles in the ovaries provides a more reliable evidence in determining the correct spawning periodicity of the fish. It is based on the fact that the post-ovulatory follicles would appear in the ovary soon after the spawning has really begun.

(5) The seasonal changes in the hypothalamo-neurohypophysial system in correlation with reproductive cycle of *Mystus vittatus* have been studied.

(a) In the basis of cytological variations it is noted that the neurosecretory material is sparse during the early post-spawning period. In the late post-spawning period and early pre-spawning period the elaboration of granules takes place. During the late pre-spawning and early spawning period there is an uniform dense granulation in the cells of nucleus preopticus. The vacuolisation in the nucleus preopticus cells starts from the month of June and continues till September when the neurosecretory material remains sparsely distributed in the cells.

(b) The nuclear volume of the nucleus preopticus has
also been found in correlation with its cytological changes and reproductive cycle of the fish.

(c) The intensity of the neurosecretory material in the neurohypophysis found maximum during the late pre-spawning and early spawning period when the gonads are in active phase of maturation and evacuation. During rest of the period the elaboration as well as release of the neurosecretory material is comparatively less when the gonads are either in resting stage or in rebuilding stage.

(d) The cytological variations and karyometric variations in the nucleus preopticus cells and changes in the intensity of neurosecretory material in the neurohypophysis are found closely related with the changes in water temperature.

(6) The seasonal changes in pars-distalis and their correlation with the reproductive cycle of Mystus vittatus and Channa punctatus have been described.

(a) In both the fishes, the cells of rostral pars-distalis and pars-intermedia have not been observed to show any visible changes in their cytology.

(b) The Basophil I of the proximal pars-distalis of Mystus vittatus have been found to exhibit prominent seasonal changes which are in close correlation with the seasonal
variation in the cells of nucleus preopticus and the reproductive cycle. In *Channa punctatus*, the changes in Basophil I have been found in correlation with the reproductive cycle.

The process of granulation in nucleus preopticus and Basophil I of *Mylophyes vittatus* and in Basophil I of *Channa punctatus* closely follow the process of maturation of the gonads and spawning of the fish. The release of the hormones due to degranulation during the spawning period results in the high spawning periodicity.

(c) The cell size variations in the basophils and acidophils of the proximal pars-distalis have been studied. In this study only those cells were taken into account which were found abutted on the neurohypophysial extensions so as to represent their maximum size. The variations in the maximum length of the basophils in different months of the year have been found associated with the reproductive cycle. The increase in the size of basophil I is in close correlation with the maturation process of the gonads in pre-spawning period and trend of spawning in the spawning period.

(d) The seasonal variations in the size of acidophils follow closely the pattern of variations in the basophils which seem to be associated with the high metabolic activity
of the fish implicated with the growth, movements, mating and spawning behaviour.

It is noteworthy here that the changes in water temperature are closely related with the activity of the nucleus preopticus, pituitary gland and the reproductive organs. Thus the extrasecretive field of the fish is working as a very important influencing factor upon the functioning of the nucleus preopticus which in turn stimulates the pituitary gland and then pituitary gland regulate the reproductive cycle of the fish.