GENERAL SUMMARY

1. The morphology, histology and cytology of the pituitary gland has been described in *Clarias batrachus* (Linn.) and *Mastacembelus pancalus* (Ham.) (refer pp. 13-40).

   a. In *Clarias* the pituitary gland lies in a cavity of parasphenoid bone and is attached by a long stalk to the infundibulum (refer p. 13). The pituitary gland in *Clarias* is cranio-leptobasic type. In *Mastacembelus* it rests over the parasphenoid bone just below the infundibulum. It is without a stalk and is of platy-basic type (refer p. 14).

   b. In both the fish the pituitary gland is divided into a glandular component (further divided into rostral pars distalis, proximal pars distalis and pars intermedia) and a nervous component - the neurohypophysis. In both the fish the three glandular lobes show an antero-posterior linear arrangement. In *Clarias* the rostral pars distalis is situated anteriorly, the proximal pars distalis in the middle and the pars intermedia occupies the posterior region. In *Mastacembelus* the rostral pars distalis is antero-ventral, proximal pars distalis is in the middle and extends posteriorly forming dorsal and ventral rim surrounding the pars intermedia (refer pp. 32, 35).

   c. With the help of the various staining techniques used in the present study six different types of cells in *Clarias*
and five different types in *Mastacembelus* have been
distinguished in the glandular regions of the pituitary
gland (refer Table 1, p. 30, Table 2, p. 38).

d. In *Clarias* and *Mastacembelus* the Basophil I of the proximal
pars distalis are PAS +ve showing the presence of
glycoproteins in their cytoplasm. These cells are,
therefore, the possible source of secretion of
gonadotropins in the gland (refer pp. 43-49).

e. The neurohypophysis in both *Clarias* and *Mastacembelus* has
both neurosecretory and non-neurosecretory fibres and sends
out small branches in rostral pars distalis, proximal pars
distalis and pars intermedia (refer p. 29 and 39). The
neurohypophysis is intimately associated with the pars
intermedia, this being a characteristic feature of the
teleosts (de Beer, 1926). In *Clarias* (refer p. 29) and
*Mastacembelus* (refer p. 39) the main trunk of neurohypophysis
reaches the pars intermedia where it arborises extensively.
However, the number of these branches is lesser in
*Mastacembelus* (refer p. 39).

F. The pituicytes, which are identified by their nuclei with
different staining techniques used, are found in the
neurohypophysis in both *Clarias* (refer p. 29) and
*Mastacembelus* (refer p. 39). In *Clarias* these cells are
abundant in the stalk and in *Mastacembelus* in the proximal
region. They are less in number in neurohypophysis of the
central region and are very few in the branches of the neurohypophysis in the region of pars intermedia (refer pp. 29-31 and 39).

g. In both the fish the AF+ve neurosecretory material is heavily concentrated in the branches of the neurosecretory fibres penetrating the pars intermedia (refer p. 31 and 39). In *Mastacembelus* the neurosecretory material gives a beaded appearance to the neurosecretory fibres and the fibres containing the neurosecretory material are seen on the blood vessels in pars intermedia (refer p. 39).

h. In both *Clarias* and *Mastacembelus* the Herring bodies represent swollen parts of the neurosecretory axons. They are abundant in the stalk region in *Clarias* and proximal part of the pituitary in *Mastacembelus* while they are few in the branches of the neurohypophysis in pars intermedia (refer pp. 31 and 39-40).

2. The development of the pituitary gland of *Clarias batrachus* has been studied in nine stages ranging from 5.8 mm. to 152 mm. stage showing correlation with the broad morphological characters of the fish at these stages. In *Mastacembelus armatus* the development of the pituitary gland has been studied in four stages, viz., 8.3 mm., 12.00 mm., 21.8 mm. and 32.4 mm and these stages have been compared with 5.8 mm., 7.3 mm., 9.5 mm. and 20.0 mm. stages of *Clarias batrachus* respectively.

a. In the first stage of development i.e., the pituitary analage, the oral epithelium lies in close contact with the brain floor
in the region of diencephalon (refer p. 56). Later on by the proliferation of epithelial cells near this region a definite ectophyseal analage is formed (refer p. 59). The analage, later on, is lifted up and becomes separated from the buccal epithelium and is ultimately attached to the infundibulum by a definite stalk (refer p. 65).

b. The neurohypophysis starts forming at 9.5 mm. stage in *Clarias batrachus* and at 21.8 mm. stage in *Mastacembelus armatus*. This neuro-ectodermal union is the first stage of a definite pituitary. But the differentiation of various cell types in the glandular regions has not started as yet. Blood vessels start entering the pituitary from the posterior side (refer p. 65). Most of the cells of the developing pituitary are basophilic upto this stage.

c. At 26 mm. stage the differentiation of rostral pars distalis, proximal pars distalis and pars intermedia takes place (refer p. 69). The acidophils and basophils are now clearly recognised by their bright colouration with azocarmine and aniline blue respectively after Azan preparation.

d. The bucco-pharyngeal canal or any such connection between the hypophysis and buccal cavity has not been observed at any stage of development of the pituitary gland in *Clarias batrachus* and *Mastacembelus armatus* (refer p. 74).
e. In the pituitary of the adult *Clarias batrachus*, the rostral pars distalis shows acidophils and chromophobes. The basophils are entirely absent from this region. In the proximal pars distalis acidophils are lesser in number than the basophils which are recognisable into two types on the basis of their shape, size and tinctorial behaviour. Few chromophobes have been observed in this region also. The pars intermedia contains acidophils, basophils and chromophobes (refer p. 70).

3. The blood supply of the pituitary gland and its vascular relationship with the hypothalamus has been described in *Clarias batrachus* (refer pp. 77-89).

a. Blood is supplied to the pituitary gland by hypophysial artery which is a branch of the internal carotid artery (refer p. 82).

b. A hypophysial circulation is absent (refer p. 85).

c. The pituitary is drained off its blood supply posteriorly by the median hypocranial vein and postero-laterally by the paired pituitary veins (refer p. 85).

d. The neurohypophysis is richly vascularised particularly in the region of pars intermedia and the blood vessels always remain confined to the neurohypophysis or its fine branches (refer p. 88).

e. The neurohypophysis is profusely interdigitated with the
glandular regions of the pituitary and the hormones could easily diffuse into or out of the latter through the sinusoids of the neurohypophysis (refer p. 88).

4. The morphology of the gonads and gonoducts has been described in *Clarias batrachus* and *Mastacembelus pancalus* (refer p. 101 and 104). In both the fish the gonads of the two sides run separately throughout the length and posteriorly their gonoducts open separately from the kidney duct into the urinogenital papilla (refer p. 101 and 104).

5. The histology of the gonads has been described in both *Clarias batrachus* and *Mastacembelus pancalus*.

a. The ovary in both the fish is covered by a thin sheath of peritoneal membrane and consists of an ovarian wall (having an outer layer of connective tissue fibres and an inner layer of germinal epithelium) and the ova in different stages of formation (refer p. 104).

b. The earliest visible oogenetic stage of oocyte in *Clarias* is early chromatin-nucleolus stage (refer p. 107) and in *Mastacembelus*, it is the chromatin-nucleolus stage (refer p. 107). Subsequent oogenetic stages common in both *Clarias* and *Mastacembelus* are early and late perinucleolus stages, early and late yolk-vesicle stages, early and late yolk stages, prematuration stage and matured egg stage (refer pp. 108-122).
c. The yolk-nucleus is present in *Clarias batrachus* and its origin, morphology, functional significance and ultimate fate has been discussed. The yolk-nucleus appears as an extrusion from the nuclear membrane in the form of a small vacuole containing some stainable granules (refer p. 108) in the early perinucleolus oogenetic stages. In the subsequent stages the yolk-nucleus enlarges, is detached from the nucleus and starts migrating away from the nucleus towards the periphery of the oocyte (Refer 109). In the early yolk-vesicle stage, three distinct zones are seen in the yolk nucleus (refer p. 112). In late yolk-vesicle stage, it disintegrates and is broken down into its components which disappear in its peripheral cytoplasm (refer p. 113). No such structure has been observed in *Mastacembelus nancalus*.

d. A synezisis stage in which the chromatin material is clumped to one side of the nucleus has been reported in the formation of primary oocytes of *Phoxinus laevis* (Bullough, 1939). No such stage has been observed in *Clarias* and *Mastacembelus*. Instead, there is a centrally placed nucleolus lying on the meshwork of chromatin threads in the chromatin-nucleolus stage (refer pp. 107-108, 187).

e. Nuclear extrusion, other than the formation of yolk-nucleus has also been observed in *Clarias* where a small vacuole is formed from the nuclear membrane into which is extruded the
nuclear mass. This vacuole is later detached from the parent nucleus (refer p. 108).

f. The earliest oogenetic stages (chromatin-nucleolus) are always found associated with the germinal epithelium indicating this as their place of origin (refer p. 191).

g. The processes of resorption of corpora atretica (refer pp. 123-124) and post-ovulatory follicles (refer p. 129) have been described. The process of atresia is fundamentally similar in both the fish and has been described in four stages (refer pp. 122-124). Post-ovulatory follicles are present in both the fish in the spawning and early post-spawning periods.

h. In both the fish, the testis is covered by a thin sheath of peritoneal membrane of epithelial cells and fibrous connective tissue (refer p. 129). It is composed of numerous lobules separated from each other by fine layer of interstitial tissue. In *Mastacembelus* the lobules extend radially from the periphery towards the centre of the testis (refer p. 129) whereas in *Marias* the extensions of tunica albuginea form intricate mass of seminiferous lobules which are closely packed together (refer p. 129).

i. The different stages of spermatogenesis which have been recognised in the present study are primary germ cells,
spermatogonia, primary spermatocytes, secondary spermatocytes, spermatids and spermatozoa (refer pp. 129-140).

6. Seasonal changes (morphological, histological and cytological) in the gonads have been described in Clarias batrachus and Mastacembelus manguelus (refer pp. 140-159).

a. Morphological changes (as regards shape, size and volume) in the gonads of both the fish have been described (refer pp. 140-141). The volume of the gonads decreases in the post-spawning period, increases in the pre-spawning period and reaches the maximum in the spawning period (refer p. 159 and 164).

b. It has been observed that the volume of the gonads is intimately associated with the changes in water temperature in both the fish (refer p. 159 and 164).

c. In both the fish, during the post-spawning period, the ovary mostly contains chromatin-nucleolus and early perinucleolus stages and a few early yolk-vesicle stages. In the late pre-spawning period the ovary consists of mostly perinucleolus and yolk-vesicle stages. In the spawning period the ovaries show a large number of oocytes of yolk stages, premature stages and matured stages (refer pp. 144-151).

d. In the present investigation, the corpora atretica are generally present in spawning period and early post-spawning period in Clarias and Mastacembelus (refer pp. 144, 148).
Based on the observations of the histological details of the ovary in different periods, it is clear that the corpora atretica are formed either from the oolysis of the immature oocytes or unspawned ripe oocytes. Their presence indicates the advanced stage of maturation of the ovary.

e. In the present study, the function of the granulosa cells (cells of follicular epithelium) of corpora atretica seems to secrete the enzymes which digest the yolk and cytoplasm as reported in Carassius (Beach, 1959), Plectognathus (Honma, 1961), Ophiocephalus (Belsare, 1962), Garra, Oxygaster and Nandus (Raizada, 1969) and Rasbora (Raizada, 1971) (refer p. 189).

f. The post-ovulatory follicles, in both the fish studied, undergo resorption without the formation of corpus luteum as in Phoxinus phoxinus (Bhargava, 1966) and in Gobius giuris (Rajalakshmi, 1966). These follicles are, therefore, not comparable to the mammalian corpora lutea. The chromatin-nucleolus stages do not seem to be formed from the cells of post-ovulatory follicles as stated by Wheeler (1924), Bullough (1939), Yamamoto (1956) and Bhargava (1966).

g. In the testes of Clarias the primary germ cells and spermatogonia fill most of the portions of the lobules during the post-spawning period. In the pre-spawning period few primary spermatocytes, large number of secondary
spermatocytes and many spermatids are observed. During spawning period the lobules are packed with spermatids and sperms, however, some lobules contain all the stages of spermatogenesis (refer pp. 151-155) showing thereby that the spermatogenetic activity is continued at a lower rate.

h. In *Clarias* secondary spermatocytes have been found to be present almost in all the months and they probably act as reserve cells (refer Table 7, p. 177).

i. In *Mastacembelus* the sperms are found all the year round. Their number increases from May onwards and reaches its peak formation during July, August, September and October (refer Table 8, p. 181).

7. The quantitative assessment of the seasonal changes in the gonads of *Clarias* and *Mastacembelus* has been made (refer pp. 164-184).

a. Both the fish breed once in a year and show sharp distinction between the general stock and the mature oocyte.

b. In both the fish quantitative study of the corpora atretica and post-ovulatory follicles has been made (refer pp. 164-175). The data obtained from their study indicates that the criterion of the presence of corpora atretica can be related with the spawning activity of the fish as they are abundant during this period but their presence or absence cannot be exclusively relied upon to determine the spawning periodicity.
However, the presence of post-ovulatory follicles can be considered as a useful and reliable criterion to assess the spawning periodicity.

3. Seasonal cytological changes in the pituitary gland of *Clarias batrachus* and *Mastacembelus pancerus* have been studied in relation with the reproductive cycle (refer pp. 206-213).

a. The cells of rostral pars distalis and pars intermedia of the pituitary gland in both the fish do not seem to exhibit any marked changes which could be correlated with the reproductive cycle (refer p. 206 and 212-213).

b. Basophil I of proximal pars distalis of the pituitary gland of both the fish show prominent cytological changes. Their secretory activity is clearly visible in different periods of the reproductive cycle. The degranulation process of the Basophil I in *Clarias batrachus* (refer p. 212) and in *Mastacembelus pancerus* (refer p. 213) seems to be associated with the release of hormones for the maturation of gonads and for the spawning behaviour of the fish.

c. The cytological changes in the acidophils of proximal pars distalis of both fish may be associated with the rebuilding process of the body after spawning and with the growth and general metabolic activities of the fish during pre-spawning and spawning periods (refer pp. 211 and 217).
9. Seasonal changes in the maximum length of acidophils and basophils of the proximal pars distalis have been studied statistically in *Clarias batrachus* (refer pp. 219-229). The maximum length of only those cells was taken into consideration which were found abutting on the processes of the neurohypophysis. The increase in the maximum length of acidophils during pre-spawning and spawning periods appears to be concerned with the high metabolic rate of the fish resulting in the body growth in pre-spawning period (refer p. 227) and reproductive behaviour and body growth of the fish in spawning period (refer p. 228). The increase in the maximum length of basophils in the pre-spawning period appears to be associated with the high metabolic rate and further increase in the maximum length of basophils (and their highly degranulated condition, as observed cytologically) in the spawning period indicates that this activity of the basophils may be responsible for the final maturation process of the gonads and spawning of the fish.