DISCUSSION
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PHACEHFCALON:

Olfactory bulbs are present in the fishes under report. Olfactory lobes seem to extend in the form of olfactory nerves and olfactory bulbs. These are solid structures of nervous matter. The olfactory lobes are sessile in *Amphipnous cuchia* (Saxena, 1967), *Channa punctatus*, *Mastacembelus armatus*, *Nandus nandus* and *Xenentodon cancila* (Khanna and Singh, 1966) while they become differentiated into the olfactory bulbs and olfactory tracts in *Carassius auratus* and *Ictalurus* (Schnitzlein, 1964), *Clarias batrachus* and *Notopterus notopterus* (Saxena, 1965b, 1967). The rhinocoel is obliterated in the fishes, under report, but present in *Amphipnous cuchia* (Saxena, 1967). It is absent in *Scienoides brunneus*, *Nandus nandus* and *Xenentodon cancila* (Karandikar and Thakur, 1951). The olfactory bulbs are similar in shape and size in the fishes under report. The right olfactory lobe is smaller than left in *Pseudorhombus* and *Cynoglossus* (Marthe, 1955). However, the right is larger in *Pleuronectes* (Cole and Johnston, 1901). The greater development of olfactory bulbs and olfactory tracts in *L. dero* and *G. gottle gottle* suggests that the sense of
olfaction is better developed in these fishes which help in the detection of food. According to Sato (1941), the olfactory bulbs in bottom feeders play a role in the selection of food. *C. baceila* and *L. pangusia* being surface and mid-column feeders possess small sized olfactory bulbs and short olfactory tracts. Hence, olfaction plays little role in these fishes.

The telencephalic lobes are symmetrically placed structures separated by an unpaired ventriculus medius telencephali. These are mainly concerned with the sense of smell. However, they may also serve as correlation centre for the nerve impulses received from the different parts of the body. The left lobe is placed slightly anterior to the right in *Pseudorhombus* (Marthe, 1955) and *Cynoglossus* but not in *Pleuronectes* (Cole and Johnston, 1901). It carries a complex furrow, the sulcus in *Pleuronectes* (Cole and Johnston, 1901). Sulcus ypsiformis is formed dorsally as a shallow sulcus in *L. pangusia*. Sulcus limitans is also present in the fishes, under report. No sulcus or fissure is known in *Pseudorhombus* (Marthe, 1955). The telencephalic areas can be divided into five different zones - pars dorsalis, pars medialis, pars lateralis, pars ventralis and pars centralis consisting of a large number of nuclei distinguished by their location, size and staining property. However, nuclear boundaries are indistinct. Schnitzlein (1968) believes that there are rarely boundaries between the nuclear areas of the brain which is in conformity
with the present findings. Drogleever (1961) and Schintzlein (1962) divided the telencephalon into three areas: basal region, septal and lobes regions. Tuge et al. (1968) observed that the amount of development of palaeostriatum (olfacto-somatic area) seems to show the difference in the degree of nervous activities between higher and lower forms of fish.

The axial lobe "cerebral hemispheres" (Cole, 1898) remain coalesced above the anterior commissure in Monopterus, Holocentrus, Amphipnous and Nandus (Saxena, 1967) while below the commissure in Amia, Cyprinus, Mormyrus and Gadus (Meader, 1939a, b). According to them, the coalescence is possibly the result of the disproportionate growth of the brain and skull in the embryo, in which the skull cavity is much less spacious. In Cynoglossus, the commissura anterior is obliquely placed (Saxena, 1969c) but this is not the case in the fishes under report.

Nieuwenhuys (1959) recorded the clusters of cells in the pars dorsalis with a difference in a very definite pattern. Meader (1939a, b) is of the view that there has been apparently a uniform growth and differentiation of forebrain. Johnston (1912) suggested that the sulci on the surface of the telencephalon may be due in part to the binding down of the brain substance by the bundles of the anterior commissure which arise or end in the intervening areas.

Johnston (1911) described the lateral forebrain
bundle as tractus palli in actinopterygians including the Chondrostei and believed that this is an ascending pathway. He found this tract traversing to the nucleus entopeduncularis in *Acipenser* and *Polydon* as in *Polypterus*.

The forebrain bundles are also named as tractus-olfactorius hypothalamicus-et hypothalamo-olfactorius lateralis and tractus olfactorius hypothalamicus et hypothalamo olfactorius medialis after Ariens Kappers *et al.* (1936). The two telencephalic lobes are connected by means of commissura anterior. The cells of pars medialis are more prominent in *L.pangusia* and *G.goltyla gotyla* as compared to other fishes. Sulcus ypsiformis is quite distinct in *L.pangusia*. Pars lateralis is reduced in *C.bacaila* as compared to other fishes. The olfactory impulses are conveyed to the diencephalon through the forebrain bundles which are clearly visible in *L.dero* and *G.goltyla gotyla*. The fibers of commissura anterior are more concentrated in the middle than at the ends as in *C.bacaila* and *G.goltyla gotyla*. It is elongated and sharp in *L.dero* and *L.pangusia*. The nucleus preopticus magnocellularis of the pars medialis is not so prominent in *L.dero* as compared to other fishes, under report. It has relation with the differentiation of olfactory lobe into olfactory tract and olfactory bulbs. In *C.bacaila*, the poorly marked nuclear areas and fiber tracts in the telencephalon seem to be compensated by the presence of well developed optic lobes and large eyes, central acoustic
area, thereby, leading to a better development of 'visual sense'.

The diencephalon consists of epithalamus, thalamus and hypothalamus. The epithalamus includes epiphysis and ganglion habenulae. In the fishes, the epiphysis is a tubular structure. The pineal stalk is long with epiphysis being placed in front of the right olfactory bulb in *Pseudorhombus* (Marthe, 1955) and over pallium near the anterior extremity of the left axial lobe in *Pleuronectes* (Cole and Johnston, 1901). The pineal stalk is long in *Wallago, Mystus, Rite, Claries, Notopterus, Xenentodon, Nandus* and *Amphipnous* (Saxena, 1965b, 1967).

Paraphysis could not be observed in the fishes, under study. Studinicka (1905) could not trace paraphysis in adult animals. The pineal body of the present fishes consists of epiphysis proper. It is a tubular and complex structure in these fishes.

According to Holmgren (1920), the ganglia habenuleae are asymmetrical in *Cyclothone*. Shanklin (1935) found asymmetry, the right habenular nucleus being larger than the left in *Bathypterois*, and Holmgren (1918a,b; 1920) found it in *Osmerus, Clupea* and *Salmo*. Schnitzlein (1962) stated that the habenuleae may be large or small and comparable in size on the two sides depending on the fish to be studied. Schnitzlein (1964) stated that the relative size of the nucleus habenularis appears to be related with the relative size of the olfactory portion of the
telencephalon. In the present study, the degree of development of ganglia habenulae varies depending on the degree of olfactory sense utilized in locating the food. Ganglia habenulae are better developed and occupy greater area of the diencephalon in *L. dero* and *G. gotyle gotyle* as compared to *C. bacaila* and *L. pangusia*. They appear to be definitely concerned with olfaction. Thus, olfactory sense seems to be well developed in the bottom dwellers e.g. *L. dero* and *G. gotyle gotyle* than surface and column feeders viz. *C. bacaila* and *L. pangusia*. The concentration and compactness of the nuclei is more in *L. dero* and *G. gotyle gotyle*. The commissura habenularis connects the two ganglia habenulae. The fibrous connections described by Ariens Kappers (1906), Sheldon (1912) and Schnitzlein (1964) have also been observed during the course of present studies. Brickner (1929) termed the major portion of the 'Post habenulare Zwischenchirnggebiet' of Goldstein (1905) and eminentia thalami of Holmgren (1920) as the inner segment of the thalamus. Johnston (1911) described the right habenula of *Acipenser* as the larger. The difference in the size of ganglia habenulae is related to other centres, including olfactory portions of the telencephalon. It may act as olfactory centre. The ganglia habenulae make their appearance with the differentiation of the diencephalon and are situated on the dorsal part of the thalamus constituting the greater part of the epithalamus, usually at its rostral extremity. Tuge et al. (1968) stated that
in some fishes the nucleus habenulæ differ in size between the right and the left e.g. *Scomberomorus niphorius*. They also studied that the nucleus habenulæ are well developed in fish with well developed olfactory lobe.

Nucleus geniculatum is prominent in *C. bacaila* and *L.pangusia* as compared to *L.dero* and *G.gotyla gotyla*. It is situated dorso-lateral to the optic tract. Its position in the present fishes indicates that it is definitely related with the visual centres. Its size and development vary with the development of optic tectum. A correlation of optic impulses appears to be established by the proximity of the optic nerve fibers with the nucleus. According to Ariens Kappers *et al.* (1936), this nucleus related to the dorsal thalamus functionally if not morphologically. The nucleus found in the lateral portion of the dorsal thalamus, may be small and undeveloped, relatively large and considerably developed or contain a high degree of complexity so that the nucleus is laminated. Franz (1912) stated that it is difficult to identify the nucleus in fishes living near the bottom of streams (*Ameurus, Centronotus, Lophius*). Shanklin (1935) found this nucleus to be highly developed in the deep sea fishes, *Diaphus, Saurida* and *Bathypterois*. Charlton (1933) believes that the presence of nucleus geniculatum lateralis in blind fishes suggests that it has other functions in addition to visual correlation. Schwassmann and Kruger (1968) described that the degree of development, size and differentiation of this nucleus
and that of nucleus pretectalis and corticalis, are correlated with the development of the visual system. Shanklin (1935) showed that the optic tectum and the optic tracts are atrophied in *Bathypterois* (a blind fish) but the lateral geniculate body is large. Jansen (1929) noted atrophy of right nucleus in *Idus idus* which was blind of one eye. Schnitzlein (1952) observed this nucleus in *Hypostomus plecostomus*, goldfish and brook trout and showed the relation between the degree of development of lateral geniculate body and the relative advancement of the visual system. It is the corpus geniculatum ipsum of Meader (1934). Singh (1971) studied the nucleus of four species and described it to be more developed in *Puntius ticto*, *Channa striatus* and *Tetradon oblongus*, than in *Pangusia bilineata*. First three species have a strong vision as indicated by well developed visual centres in them (Khanna and Singh, 1966). The reduced size of nucleus geniculatum in *L. dero* - bottom feeder and its comparative well developed size in *G. gotyla gotyla* - another bottom dweller, indicate that the nucleus is related to functions other than visual centres. It may be stated here that *L. dero* has a fusiform body, therefore, swims actively. On the other hand *G. gotyla gotyla* has depressed head although the trunk is fusiform, the fish is adapted to live near stony bed to which it attaches by its sucker. Relationship with gustation has also been suggested by Charlton (1933), Shanklin (1935) and Ariens Kappers *et al.* (1936). A prominent nucleus in
C. bacaila and L.pangusia is indicative of their well
developed sight.

The connections of the nucleus have been described
by Catois (1901), Franz (1912), Shanklin (1935) and Ariens
Kappers et al. (1936). Catois (1901) traced the connection
with the cerebral hemispheres and described it as fasciculus
geniculo-cerebellaris. The nucleus is connected to the
optic tectum by tractus geniculo-tectalis. Charlton (1933)
who named this tract, observed that it is not dependent on
primary optic influences. Ariens Kappers (1906) described
this tract as brachium tectum.

Catois (1901), Goldstein (1905), Franz (1912), Holmgren
(1920), Ariens Kappers (1921), Burr (1928), Charlton (1933),
Shanklin (1935), Ariens Kappers et al. (1936) and Schwassman
and Kruger (1968) described the structure of nucleus
pretectalis giving different views but agree that the
nucleus lies laterally at the base of the optocoel, surrounded
by the fibers of the optic nerve. It is well marked in the
fishes under study. Catois (1901) described nucleus
pretectalis as made up of stellate or oval neurons while
Goldstein (1905) observed two types of cells. Nucleus
pretectalis was named as nucleus preopticus by Herrick
(1892) and Ariens Kappers (1906). Fritsch (1878), Ariens
Kappers (1906), Holmgren (1920) and Ariens Kappers et al.
(1936) reported the nucleus corticalis in the form of a
thin plate of cells lying at the base of the tectum, lateral
to the nucleus pretectalis. Nucleus corticalis of some fishes may be comparable to nucleus latiformes mesencephali, pars magnocellularis of higher forms including man (Kuhlenbeck and Miller, 1949). According to Charlton (1933), it is supposed to have visual function because he could not trace out the nucleus in blind fishes like Troglicthys rosae and Typhlicthys eigenmanni. In the present studies, it can be observed as a plate of single type of cells in the ventro-lateral side of the optic tectum. The nucleus pretectalis is developed in proportion with the nucleus corticalis and nucleus geniculatum. It appears that it acts as a relay centre for visual senses. Schnitzlein (1962) described nucleus pretectalis as an area of variable cells. According to him, this area is included in nucleus tegmenti motorius dorsalis of Brickner (1929). Schwassmann and Kruger (1968) could not observe this nucleus clearly in catfish and carp and believed that it might be represented by a cluster of cells which were observed in the caudo-medial region of the nucleus geniculatum.

Nucleus rotundus has been discussed in detail with its connections by Fritsch (1878), Ariens Kappers (1906), Franz (1912), Sheldon (1912), Holmgren (1920) Burr (1928), Brickner (1929), Jansen (1929) and Ito and Kishida (1975). There had been a lot of controversy over the terminology of nucleus rotundus. According to Franz (1912), the nucleus is the posterior part of corpus glomerulosus and is connected with the anterior part. Holmgren (1920) and Kato (1959)
included this nucleus in the ventral thalamus. Fritsch (1878) described that it receives the commissura horizontalis and the tractus rotundo-lobaris. The tractus rotundo-lobaris has not been identified in the fishes under report. Holmgren (1920) described the nucleus as rotundus complex because it appears in the form of a nucleus prerotundus, nucleus rotundus and subrotundus. Goldstein (1905) described nucleus rotundus as nucleus lateralis valvulae. Singh (1971) described a very large nucleus rotundus in *Channa striatus*. In the present studies nucleus rotundus is characterized by the presence of a round mass situated in the diencephalon. The recessus lateralis lies just ventral to the nucleus and extends laterally into the recessus inferior. When viewed under high power, a number of large sized neurons can be observed arranged on the periphery than the centre. The size of the nucleus rotundus varies according to the size of lobi inferiores. It is well developed, rounded and ovoid mass in *L. dero, L. pangusia* and *G. gotyla gotyla* but small in the form of an inverted comet in *C. bacaila*. The commissura subhorizontalis has also been seen in the present studies. In the fishes, under report three types of cells are present i.e. small, medium and large sized cells. The "non-laminated type" of organization of nucleus rotundus is present in *L. dero, C. bacaila* and *G. gotyla gotyla*. An 'Incomplete type' of organization is present in *L. pangusia*. The area of the nucleus rotundus occupying the diencephalon is more in *L. dero* and *G. gotyla gotyla* as compared to other two.
fishes. The commissura subhorizontalis is observed in all the fishes from the dorso-lateral side of the nucleus rotundus and pass into the diencephalon. It appears that commissura horizontalis and rotundo-lobaris are essential tracts. The commissures connect the optic tectum or tegmentum with the nucleus rotundus. Its cell type sorts out the visual impulses and then pass them on to the inferior lobe or lobus inferior of its side through rotundo-lobaris. From the hypothalamus, message (feeding impulses) pass to the medulla oblongata. Thus, coordination between visual and feeding behaviour is brought about. Presence of commissura subhorizontalis and absence of rotundo-lobaris in the fishes under report lead to infer that visual impulses concerned with feeding are perhaps passed directly to the lobi inferiores.

The position of the nucleus tegmenti motorius dorsalis is same in all the fishes, i.e. it is situated in the dorsal part of the proper thalamus and is in the form of a bundle of neurons with a small number of fibers in this region. It is said to be the nuclear centre for the coordination of visual impulses and their transmission. The nucleus tegmenti motorius dorsalis is the nucleus pretectalis of Catois (1901), Goldstein (1905) and Holmgren (1920). Fritsch (1878) and Ariens Kappers (1906) named it as 'nucleus latiformes' due to its position and connections. Brickner (1929) has given it the present name and differentiated two cell groups viz., the ventral and the lateral cell groups. The medial cellular
area of 'pars lateralis' of the former to the lateral cell group of the latter. Holmgren (1920) showed various connections of this nucleus and segmentum internum. In the present studies the nucleus tegmenti motorius dorsalis corresponds to the structure described by Brickner (1929), Shanklin (1935) and Tandon and Sharma (1963).

The nucleus tegmenti motorius ventralis is large and well developed in C.bacala and L.pangusia while poorly formed in L.de ro and G.gotyla gotyla. According to Brickner (1929), this nucleus along with its connections plays an important role in elaboration of visual functions. He described this nucleus as a large complex connected with visual apparatus, lobi inferiores (olfactory centres) and cerebellum on the one side while with the motor regions on the other side. He stated that this fibrocellular mass is a centre of coordinating olfactory and visual impulses with cerebellar ones. Jeener (1930) and Shanklin (1935) named it as 'pars ventralis thalami'. The name nucleus tegmenti motorius ventralis was given by Brickner (1929). Ariens Kappers et al. (1936) and Miller (1940a,b) included this nucleus in ventral thalamus. Schnitzlein (1962) described that the nucleus dorso-lateralis pars medialis may be included in the inner segment of Brickner (1929).

The origin and differentiation of the fibers of the commissura posterior, according to Nieuwenhuys and Bodenheimer (1966), are difficult to make out. Holmgren and Vander Horst (1925) stated that some fibers of commissura
posterior run latero-ventrally and are lost in the tegmentum. Shanklin (1935) described the commissura posterior consisting of a pars dorsalis and a pars ventralis in Diaphus and Saurida whereas in Bathypteroïs, a single component is present. No such division into parts is observed in the present work, however, it is quite distinct structure. Ariens Kappers (1921) believed it to be a commissural connection for the lateral geniculate nuclei in Amia and Pleuronectes.

Sulcus medius is present in the fishes, under report. Sulcus medius of Herrick (1911), Ariens Kappers (1921) and Brickner (1929) appears to separate the dorsal thalamus from the ventral thalamus. According to Nieuwenhuys and Bodenheimer (1966), it is not one sulcus but rather a complex of sulci. Sulcus medius shows a varied development and corresponds to sulcus medius of Schnitzlein (1962). Singh (1971) observed sulcus medius to be well developed in all the species studied by him.

The lobi inferiores are well recognised structures in the fishes under study. Their nuclei diffusus are well marked. In between the lobes of the infundibulum of the lobi inferiores hangs the saccus vasculosus. A recessus infundibuli is also seen in the lobi inferiores. The recessus situated in the lobus inferior is termed as recessus lateralis. Caudally, nucleus diffusus is comparable with the nucleus mammilaris of Tuge et al. (1968). Lobi inferiores probably act as coordination centres of the
impulses between the diencephalon and the mesencephalon. It is also likely that some telencephalic centres are directly connected with lobi as is evident from the presence of tractus hypothalamus.

Saccus vasculosus is well developed structure hanging between the lobi inferiores in L.dero and C.zoylep zoylep, moderately formed in L.pengusia and poorly developed in C.bacila. It is a highly vascular protrusion of ventral wall of diencephalon. Johnston (1911) and Boeke (1901) gave the first description of the cellular structure of saccus vasculosus. The folded nature of saccus vasculosus is a device to increase the secretory surface area (Herring, 1908). Demmerman (1910) propounded a theory describing the saccus as a sensory organ to perceive water pressure. He stated that saccus vasculosus is well developed in fresh water fishes and least developed in shallow water forms. It may be sensitive to intracerebral liquid pressure changes. In deep sea fishes and shallow water fishes, this organ is not well developed. The coronet cells of the saccus were assigned secretory function by Bargmann (1954), and Vande Kamer (1960). Emanuelson, Jansen and Mackenburg (1972) described an active role of saccus in osmoregulation. Singh and Sathyanesen (1964) stated that saccus epithelium consists of supporting cells and coronet cells. In the present work, similar cell structure has been recognised. Singh (1966) stated saccus vasculosus to be secretory in
function. It is also present in *Notopterus notopterus* (Saxena, 1969a), *Ompok, Mystus, Bagarius* (Singh and Sethyanesen, 1964) but absent in *Clarias batrachus, Amphipnous cuchis, Xenentodon cancila* and *Nandus nandus* (Saxena 1965b, 1967). *C. baccala*, a surface feeder, has poorly formed saccus vasculosus recognised only histologically. Its well developed appearance in *L. dero* and *G. gotyla* indicates that the fishes often move between the surface and bottom. The moderately formed saccus vasculosus in *L. pengusia* is indicative of its not so frequent sojourn to the surface and bottom. Hence, in surface dwellers, it is poorly formed or absent. Its complete absence is reported in larvivorous *Gambusia affinis* by Sharma (1979).

**Mesencephalon:**

Mesencephalon is comprised of the tectum and the tegmentum. The tectum forms the superior border of the opto coel whereas the tegmentum, the inferior border of the opto coel. Optic tectum in non-mammals is also known as corpora bigemina which is considered to have visual centres. Non-mammalian auditory centre, comparable in function to the mammalian inferior calliculus, lies just deep to the optic ventricle as a gross swelling - the torus semicircularis, which also contains sensory centres (Webster and Webster, 1974).

A great deal of controversy regarding the number of layers of neurons and fibers has been discussed by various
workers. Stieida (1873) and Fritsch (1878) described eight
two
layers in different fishes. Sanders (1886) described layers
in the brain of Scyllium and Rhine. Van Genhuchten (1894)
and Ramon Y Cajal (1899) observed ten layers. Ariens Kappers
et al. (1936) described six layers. In the present work,
the number of layers of optic tectum is found to be five.
Leghissa (1955) demonstrated seven layers in the optic
tectum of fishes studied by him. Tandon and Sharma (1963)
divided the optic tectum into four main zones. Schwassman
and Kruger (1968) divided the optic tectum into six strata.
Ito (1970) described five layers with their fine structure.
C. bacaila and L. penguine are surface, mid-column feeders
and utilize their large eyes to locate food. Optic lobes
are well developed in them. L. dero and G. gotyla gotyla,
bottom dwellers, have moderately developed optic tectum
and use the sense of sight coupled with highly developed
olfactory sense for the location of food. In L. dero, the
moderately formed eyes suggest that the fish may be visiting
surface quite often though not in search of food. Similarly,
G. gotyla gotyla, though lives under stones does come to
the surface. The saccus vasculosus may be helpful to make
frequent visits. The optic nerve and tracts are absent
in blind fishes (Charlton, 1933). Bernstein (1970) described
the optic tectum as the major centre for the integration of
visual information. Vanegas, et al. (1974) described four
layers with their neuronic and fibrous structure in a
perciform teleost. Laufer and Venegas (1974) gave a detailed
account of the fine structure of six layers of optic tectum. Sharma (1977) described six layers in the optic tectum of C. punctatus, H. fossilis and L. rohita. Martha and Sharma (1979) classified neurons of the optic tectum of the goldfish on the basis of the orientation of the primary dendritic processes within the tectum. Ito, et al. (1980) presented an ultrastructural study of the normal synaptic organization of the optic tectum. The degree of development of optic tectum is directly related to the visual system of the fish.

Tori longitudinales are typical paired structure in these fishes hanging in the optocoel and are the extension of tectal gray matter. A number of views have been given by different workers regarding the size and shape of the tori longitudinales. In the present studies, the tori longitudinales are well defined structures with some differences in their shape. The neurons are concentrated along the peripheral area. They appear as a granular mass of irregular shape in the frontal sections but assume a definite shape in the mesial sections of the mesencephalon. Remsay (1901) observed poorly developed tori longitudinales in cave dwelling fishes. Similar studies have been made by Sargent (1903) in Siluridae, Cyprinidae and Salmonidae have well developed tori longitudinales. Trojan (1906) described them to be poorly developed in deep sea fish, Leucicosus leucicosus. Kudo (1923) related tori with the gravistatic function of mid brain roof. Charlton (1933) assigned them the photostatic or gravistatic function. Shanklin (1935)
showed the complete absence of tori in blind fishes. The torus longitudinalis has been thought to play a role in the optico-static correlation judging from anatomical studies of normal fishes (Ariens Kappers et al., 1936), and from the absence or the lesser development of the structure in some deep sea fishes (Tuge and Shimamura, 1958). Singh (1966) regarded tori longitudinales as a correlation centre between the photostatic and gravistatic centres of the mid brain rather than assigning only photostatic or gravistatic function. He found the cells of torus equally distributed in *Channa striatus* or may be more concentrated towards periphery as in *Puntius ticto*. He observed that the size of the torus is maximum when it fuses with dorsal part of the commissura posterior but diminishes caudally. This is in conformity with the observations of Kudo (1923), Ohta (1959) and Ariens Kappers et al. (1936). Ito (1971a) described three types of cells in tori longitudinales and stated them to play a role in optico-static correlation. He emphasized that small cells packed in the sub-ependymal region of the torus longitudinalis are quite similar to the granular cells in the cerebellum. There is a similarity between the sub-ependymal region of the torus longitudinalis and the granular layer of the cerebellum. Thus, it may be inferred that the torus longitudinalis has some relation with the sense of vision, gustation as that of cerebellum. Tandon (1978), Tandon and Kaur (1979, 1980) stated that tori can be used as additional taxonomic characters for fishes which are morphologically alike.
In the present work, three kinds of cells in the tori longitudinales can be distinguished when viewed under high power. They are large, medium and small sized cells which are probably arranged from peripheral regions to the inner areas. This observation is in conformity with that of Ito (1971a). At the rostral end, the fiber connections are well recognised between the tori longitudinales and the commissura posterior, and the tori longitudinales and the optic tectal layers. Caudally, the tori longitudinales taper off keeping the relationship only with the optic tectum. The comparative size of the tori in the mesencephalon is greater in *C. bacaila*, *L. pungusia* and *L. dero*. However, it is reduced in *G. guttata guttata* due to its bottom dwelling habit. The impulses concerned with vision are transmitted to and from tori longitudinales by the inter-tectal commissure. The latter originates as a fibrous bundle from the stratum griseum periventriculare layer of optic tectum and connects the two tecta and tori longitudinales. It is prominent in *C. bacaila*, *L. pungusia* and *L. dero* while stumpy in *G. guttata guttata*. In the mesial sections the tori assume definite configuration which can be helpful in taxonomy. Their relationship with optic tectal layer indicates that they compensate for the absence of true optic chiasma in teleosts. They may thus perform the function of relaying and sorting impulses from right and left tori or vice-versa as in higher forms where true optic chiasma is present.
Torus semicircularis is thought to be the subtectal region of the tegmentum. From the dorso-lateral part of the tegmentum, the torus semicircularis protrudes into the mesencephalic ventricle. Ariens Kappers et al. (1936) stated that the form and size of torus vary in different teleosts with the degree of development of the lateral line system. They assigned gravistatic functions to it. Shanklin (1935) described a large torus semicircularis in deep sea fishes. Tuge et al. (1968) stated that the tori are well developed in fishes with well developed acoustico-lateralis system. Their function seems to be gravistatic. Gorzinger (1967) and Page (1970) demonstrated electrophysiologically that torus semicircularis responds to auditory stimulation. Singh and Khanna (1972) explained that the form and spatial relation of torus semicircularis vary greatly with form and extent of development of valvula cerebelli. According to Ito (1974), the form and size differences in tori semicircularis also seem to reflect their different behavioural activity in feeding. Kuhlenbeck (1975) described that the mesencephalon is vital from taxonomic point of view. The tori semicircularis act as a terminal centre of the fasciculus longitudinalis lateralis. Most of the fiber tracts and fasciculi pass through it. The torus semicircularis in the fishes under report, has been observed to receive a few fibers from the commissura transversa because the latter runs for the greater part of its course in its zonal layer. It is
connected with the cerebellum by the mesencephalo-
cerebellaris tracts. Tori semicirculares occupy greater
area of the mesencephalon in \textit{C. bacaica} and \textit{G. zotyla gotyla}
as compared to \textit{L. dero} and \textit{L. pangusia}. Keeping in view
the above findings, it may be suggested that the torus
semicircularis acts as a centre of relaying gravistatic
impulses. It may also be presumed that the size of the
torus varies with the size of valvula cerebelli. Its
size and form vary with the relative development of the
lateral line system.

The nucleus lateralis valvulae of Herrick (1905)
develops in the zone median to the tori semicirculares.
The tractus mesencephalo-cerebellaris posterior arises
from this nucleus establishing a connection between the
tegmentum and the granular valvula cerebelli. This
nucleus is 'Ubergangsganl' of Stieda (1868), Franz (1911a,b),
or the nucleus lateralis valvulae of Herrick (1905), Ariens
Kappers (1906), Addison (1923), Burr (1928), and Shanklin
(1935). Ariens Kappers \textit{et al.} (1936) described that the
size of the nucleus varies in accordance with the degree
of development of the acoustico-lateralis system. This
nucleus is well developed in these fishes varying in the
concentration of neurons. It is a distinct and important
nucleus in the region of tegmentum. It acts as a cephalic
connection between the valvulae and tori semicirculares.
The excessive development of the tractus mesencephalo-
cerebellaris posterior in these fishes suggest a well
developed lateral line system. The tractus mesencephalo-
cerebellaris posterior is located with compact fibers in
*L. dero* and *G. potyia potyia* while loosely arranged in other
two fishes.

Ganglia isthmi is known to act as a correlation centre
and is concerned with the photostatic and gravistatic
functions. Its position and location is same in all the
fishes under report. The nucleus is also believed to have
maintained its connections with the optic tectum,
fasciculus longitudinalis lateralis and medialis and
nucleus lateralis valvulae.

*Valvula cerebelli* is the characteristic feature
of the teleostean brain and is not found in any other
vertebrate. The main fiber connections of the cerebellum
pass through the valvula cerebelli. Spenkel (1915) and
Suzuki (1932) correlated the extent of valvular development
with lateral line system. The valvula acts as a centre to
establish connections between the mesencephalon and the
cerebellum. The development of the tractus mesencephalo-
cerebellaris posterior is directly related with the
development of the valvula (*Ariens Kappers et al.*, 1936).
The tractus was earlier regarded as carrying gustatory
impulses (*Ariens Kappers*, 1921). Banarescu (1957) reported
nine types of valvulae in fishes and traced their development
from primitive ganoid type of valvula. According to him,
valvula of *Channa* species belongs to salmoid type with
dorsal and ventral sacs. The valvula of cyprinoids acts
as a gustatory centre. Singh (1970) described a large valvula in fishes with a well developed gustatory and lateral line system. In the present fishes, the valvula cerebelli is well developed. It almost fills the optocoel. The size of valvula is also associated with the size of tori semicirculares. The extent of the development of valvula and its configuration can be correlated with the degree of development of the acoustico-lateralis system. It also works as a relaying centre for the various types of impulses between the corpus cerebelli and many other areas of the brain. Its degree of development also influences the size of torus longitudinalis. In the mesial sections of the mesencephalon it assumes characteristic shape which appears to be species specific. The general outline of the valvular configuration though is on typical cyprinid plan yet is different in different fishes. In L. dero and G. gotyla gotyla, the central molecular zone is elliptical in shape but is somewhat circular in L. pangusia and G. pecaille. Tandon (1978) and Tandon et al. (1979) emphasized the use of valvular configuration as additional taxonomic character. The author is in agreement with their observations.

**RHOMBENCEPHALON**

The cerebellum is well defined structure in the fishes under report. However, the degree of development varies due to their feeding behaviour. It is said to be
responsible for the interrelation of gustatory and tactile impulses and the maintenance of body postures. A lot of work has been done by different workers in this region of brain such as Purkinje (1837), Golgi (1886) and Addison (1923). Purkinje (1837) described Purkinje cells in the granular layer of the cerebellum of mammals. He described those as large cells each with a broad base and fine branched apex like the shape of a small plant. Golgi (1886) gave an account of granular cells. According to Worthington (1906), the cerebellum consists of two small symmetrical looses. These are divided by the dorso-medial line. Ariens Kappers (1921), Addison (1923), Herrick (1924a,b), Burr (1928) and Brickner (1929) described different tracts in cerebellum. The anterior mesencephalic cerebellaris tract is in the form of two bundles, each lying on the lateral side in the medullary region of the cerebellum. Addison (1923) stated that cerebellum is made up of corpus cerebelli, valvula cerebelli and the laterally placed eminentia granularis. Burr (1928) mentioned the tractus mesencephalo-cerebellaris anterior under the name tractus pretecto-cerebellaris. He called tractus mesencephalo-cerebellaris posterior as tractus mesencephalo cerebellaris. According to Brickner (1929), the mesencephalon cerebellaris anterior is in the form of two bundles each lying laterally in the medulla region of cerebellum as observed in Gadus. He also observed tractus mesencephalo-cerebellaris posterior running from the region a little posterior to that of the
middle region of granular part of cerebellum flanked on both the sides by bundles of tractus mesencephalo-cerebellaris anterior. Evans (1932) designated lower part of cerebellum as central acoustic lobe which contains a mass of gray cells, mostly rounded which take deep stain with haematoxylin, like the cells of stratum granulosum of cerebellum. Bhimachar (1945a,b) stated that the cerebellum is the centre for static and muscular tone. Saxena (1967, 1969a, 1970a,b) suggested that the cerebellum is related directly with the agility of the fish and with the perception of its position in the space. According to Tuge et al. (1968), the fish which moves sluggishly do not have well developed cerebellum with the exception of Mormyrids which have an enormously large cerebellum. The cerebellum also plays a role in maintaining muscle tone and posture parallel with other functions.

Cerebellum is well developed in Cyprinus and Clarias batrachus, moderately developed in Notopterus notopterus and Xenentodon cancila (Saxena, 1969a) and poorly formed in Carnoids and Ictibus (Miller and Evans, 1965), Amphipnous cuchia and Nandus nandus (Saxena, 1969a).

Purkinje cells and eurydendroid cells are present throughout the ganglionic layer. Coel et al. (1981) described the occurrence of eurydendroid cells in the corpus and valvula cerebelli of Notopterus notopterus and observed giant cells scattered irregularly in the vicinity.
of the Purkinje cells. They stated that the eurydendroid cells may be acting as powerful transmitters whose dendrites synapse with neurons of other layers forming intercommunicating system for the transmission of nervous impulses.

The impulses of sight, gustation and cutaneous are conveyed to the cerebellum by tractus tecto-cerebellaris, tractus bulbo-cerebellaris and tractus spino-cerebellaris. In particular, impulses from audition and lateral line system are directly conveyed to the cerebellum through the acoustico-lateral area. Impulses from the cerebellum are sent to the medulla oblongata, the mesencephalon and the diencephalon principally through tractus cerebello-motorius and tract cerebello-mesencephalicus. The cerebellum of the fish is regarded not only as an organ of controlling the functions relating to vestibular and lateral line organs, but also an area of higher nervous correlation into which impulses from various kinds of sensory modalities enter.

The central acoustic area is known to be related with perception of atmospheric sounds and is more developed in surface dwellers (Evans, 1940). The acoustic tubercles are two prominent structures which are the enlargements over the cerebellum in the fishes, under report. The former are joined by central acoustic lobe lying above the 4th ventricle and the area around it is the central acoustic area. The central acoustic lobe is also well developed in C.bacaila and L.pangusia. In fact, the central acoustic area and the central acoustic lobe are similar in position
as the two acoustic tubercles are joined by a sort of lobe. This lobe is also termed as central acoustic area.

The tractus mesencephalo-cerebellaris posterior of the present fishes corresponds to the same tract of Franz (1911), Ariens Kappers (1921), Addison (1923), Herrick (1924a, b), Shanklin (1934) and Pearson (1936a, b), and to the tractus tegmento-cerebellaris of Burr (1928). A direct relationship between the size of this tract and the development of the lateral line system in fishes has been accepted by a number of workers (Sprenkel, 1915; Addison, 1923). That the tractus mesencephalo-cerebellaris posterior brings gustatory impulses to the valvula in Cyprinidae, can be explained to the well developed gustatory sense in these fishes. L. dero, L. panguia and G. gotyla gotyla have a large valvula and prominent tractus mesencephalo-cerebellaris posterior.

The tractus mesencephalo-cerebellaris anterior of the present fishes corresponds to the tractus tecto-cerebellaris of Johnston (1902a, b), Goldstein (1905) and Suzuki (1932). It is the tractus pretecto-bulbaris of Burr (1928), Holmgren (1920), and Hocke Hoogenboom (1929). This tract also corresponds to the tractus mesencephalo-cerebellaris anterior of Ariens Kappers (1906, 1921), Franz (1911a, o, 1912, 1913, 1920), Addison (1923), Herrick (1924a, b), Charlton (1933), Shanklin (1934), and Pearson (1936a, b). According to Franz (1911), the size of the tractus mesencephalo-cerebellaris anterior
parallels the degree of development of the visual system. This hypothesis was further supported by Addison (1923) who described a large tract in *Gadus* which has large eyes. However, Charlton (1933) has described a large tractus mesencephalo-cerebellaris anterior in some totally blind fishes and some of the cat fishes. According to him, this tract may parallel the development of the secondary visual centres from where it originates and it can not be said to run parallel to the visual system only. In *C. bacaia*, the large size of this tract accords with the fact that the fishes have large eyes. Singh (1978) observed a larger tractus mesencephalo-cerebellaris anterior in *P. ticto* which is an active surface feeder and feeds by sight and mouth taste (Khanna and Singh, 1966). The observations on *C. bacaia* and *L. penguia* are in conformity with those of Singh (1966) and in general with earlier workers.

The medulla oblongata is the hinder most part of the brain and is broad anteriorly but narrows posteriorly when it passes into the spinal cord. It is marked by two types of lobes: facial and vagal. The shape and size of these lobes vary depending upon the feeding behaviour in the fishes under report. A number of researchers such as Burr (1928), Brickner (1929), Ariens Kappers (1921, 1936), Evans (1930) and Herrick (1936) have focussed their attention on this aspect.

Burr (1928) studied the histology of the brain of the fish *Orthogoriscus mola* and marked motor nerve nuclei
of V to X cranial nerves. Herrick (1905) worked out the gustatory paths in the fishes and correlated the supply of vagal lobes with taste buds of pharynx and back part of mouth. Similarly, he correlated the supply of facial lobes with taste buds of mouth and outer skin of face. Evans (1940) described the histology of cyprinoid fishes and traced laterally placed gustatory tracts calling these as great longitudinal secondary gustatory tracts. Some fibers connecting these tracts with facial lobes are seen on each side and these are known as descending gustatory fiber tracts. Both these tracts are easily traceable in all the fishes under report.

The somatic sensory lobes are much developed in predatory fishes and indirectly proportional to the size of facial lobe. The somatic sensory lobes are formed by the extension of the acoustic tubercle over the 4th ventricle behind the cerebellum. The somatic sensory lobes are concerned with the tactile sense, receiving fibers from the skin. These lobes hide the vagal lobes in the Bleak and meet each other medially behind in the Hake whereas their presence only in sagittal sections has been found in carps and catfishes (Evans, 1940). The somatic sensory lobes are prominently developed and extend beyond the cerebellum in C. bacaila, Nuria dendrica, Glossogobius giuris, Channa punctatus, Trichogaster fasciatus (Saxena, 1970), Hippoglossus, Lepidornombus and Solea (Evans, 1940) and Notopterus distinct in Aspidoperia
morar (Saxena, 1970), Gadus and Malwe (Evans, 1940), Mastacembelus, Xenentodon and Nandus (Khanna and Singh, 1966) and are indistinct and hard to make out superficially in Ambassis range, Mystus tengara, Heteropneustes fossilis, Puntius ticto, Cyprinus carpio, Amphipnous cuchia (Saxena, 1970) and Claras batrachus (Saxena, 1965b, 1967). The present observations in C. bacia are in conformity with those of Saxena (1970).

The facial lobes are prominently developed in Ameiurus (Wright, 1884), Anguilla (Evans, 1937), Noemachilus and Nemachilichthys (Bhimachar, 1935), Rhinichthys (Evans, 1952), Claras, Mystus and Heteropneustes (Saxena, 1965b, 1970), Glyptosternum (Khanna and Singh, 1966) Platygobia and Macrobiopsis (Davis and Miller, 1967), Pleuronectes (Cole and Johnston, 1901), Labeo (Mukerjee et al., 1950) and Pseudorhombus (Marthe, 1955). They are distinctly present in Ambassis range, Aspidoparia morar, Puntius ticto, Cyprinus carpio and Amphipnous cuchia (Saxena, 1970), Solea and Abramis (Evans, 1940), Mastacembelus (Khanna and Singh, 1966), and very difficult to demonstrate in Chela bacia, Nuris dendrica, Glossogobius giuris, Chenna punctatus and Trichogaster fasciatus (Saxena, 1970) and Notopterus notopterus (Saxena, 1967). According to Evans (1940), the facial lobes are related with the taste buds present on the barbels, lips and body and are directly proportional to the inclusion of crustaceans, molluscs and worms in diet. The two facial lobes meet
mesially between the vagal lobes in *Scianoidea* (Karandikar and Thakur, 1951) and fuse to form a single lobus impar between the vagal lobes in *Labeo* (Mukerjee et al., 1950) and *Cyprinus* (Ping et al., 1959) and *Puntius, Tor, Shizothorax* and *Noemachilus* (Khanna and Singh, 1966). Ito (1975) described the fine structure of carp facial lobe and found three types of neurons, small, medium sized and large. According to Sriwestawa (1975), the somatic sensory lobe is much developed in fishes of active habit, the facial and vagal lobes are least developed in the carnivorous fishes and vagal lobes are reduced structures. Singh and Khanna (1978) found a large prominent facial lobe in *Noemachilus rupicola*. Facial lobe is highly developed in *C. gotyla gotyla* than the vagal lobes, moderately formed in *L. dero* and *L. pangusia*. The facial lobe is not easily recognizable structure in *C. secele*. This observation is in conformity with that of Saxena (1970).

The vagal lobes are well developed in *Barbus, Clarias* and *Carassius* (Mukerjee, et al., 1950), *Aspidobaria moror, Puntius ticlo* and *Cyprinus cervio* (Saxena, 1970), *Notemigonus, Semotilus* and *Rhinichthys* (Evans, 1952), *Carpoides, Erimyzon* and *Catostomus* (Miller and Evans, 1965) and *Hybopsis* (Davis and Miller, 1967). They are of the size of facial lobes in *Rutilus, Sardinus, Abramis* and *Tinca* (Evans, 1940) and *Amphipnaeus* (Saxena, 1967), smaller than the facial lobes in *Pseudorhombus* (Marthe, 1955),
Gadus (Evans, 1935), Lepidocephalichthys (Shimacher, 1935), Barbus, Gobio and Noemacheilus (Evans, 1940), Clarias (Saxena, 1965b) and Channe, Mastacembelus, Mystus, Glyposternum and Noemacheilus (Khanna and Singh, 1966). The facial and vagal lobes are reduced and not superficially distinct in Engraulicypris (Evans, 1940) and Xenentodon and Nandus (Saxena, 1967). The vagal lobes are related with the taste buds present in the buccal cavity for extracting nutrients from mud. Exceptions in relation to medulla in the feeding habits are found in Apistus and Acheilognathus as the bottom feeding Apistus has minute facial and vagal lobes and Acheilognathus sorts out food largely by mouth taste buds, though vagal lobes are very small (Sato, 1941). Vagal lobes are well defined structures in L. dero, L. panzusie and G. goyle goyle as compared to G. bacaila. The two small knob-like protuberances on the antero-lateral sides of the corpus cerebelli constitute the acoustic tuberces. In G. bacaila, the tubercles are better developed as compared to other fishes. The tubercles are concerned with the degree of development of the lateral line organ for finding the prey perhaps by perception of slow frequency vibrations.

Some of the important histochemical tests performed reveal a very good picture regarding the localization, of various metabolites, such as proteins, carbohydrates, lipids and nucleic acids in these fishes. Such studies on the localization of these metabolites in the brain are
mostly confined to the mammals. The literature on the
distribution and nature of carbohydrates in higher
vertebrates is of quite importance and the contributions of
Bevanlevds (1889), Taft (1938), Schnizmizu et al. (1952,1957),
Hess (1955, 1955a,b,c), Bayrs (1955), Vyskotl and Young
(1956), Brante (1957), Lumsden (1957), Woolman (1957) and
Ozzelot et al. (1958) deserve special mention. Stahl and
Siite (1960), 8argmann and Knoop (1961), Jansen and
Vande Kamer (1961), Aetagishi (1961), Singh and Sathyenesan
(1964), Sundorarad and Prasad (1963,1964), Saxena (1970),
Sukheja (1972) and Tandon and Sukheja (1974) and few others
however studied carbohydrates in the fiah brain. Casamajor
(1910) showed the intra and extra cellular presence of
glycogen in the cerebral cortex of the humber brain.
Chesler and Himwick (1943) contended that the amount of
glycogen is less in the oldest parts of the brain than in
the newest phyietic parts. Schnizmizu et al. (1957) reported
the glycogen in nervous tissue of brain in mammals.
Woolman (1957) showed the presence of f:2 glycol groups
in the myelin sheath of the nerves. Jansen and Vande
Kamer (1961) observed glycogen in the apical protrusion,
hairs and globule of the coronet cells of the saccus
vassculosus. Saxena (1970c) reported the presence of
glycogen in the optic nerve fibers and sheath of
Notopterus, the neurons however, were devoid of any
glycogen, but in Puntius, glycogen was absent in brain.
Tandon and Sukheja (1974) showed the presence of glycogen
in *Sarilius bendelisis* and *Sarilius vagrus*. They observed dark pink globules in the neuronal regions of the diencephalon and the mesencephalon, while negative staining in the fibrous regions. According to them, 1:2 glycol groups were present in all the myelinated fibers, whereas reaction was completely negative in the neurons. It has been observed that the neuronal regions of the brain were deeply stained after PAS technique particularly in case of *L. aer*. A positive reaction was seen in most of the neurons. The fibers revealed an unspecific staining. Glycogens were found to be poorly localized. Acid mucopolysaccharides were not present in the brain areas of fishes under report.

The localization of acid mucopolysaccharides was studied by alcian blue method and was found that the brain areas in the fishes were feebly stained with light blue colouration. It may, thus, be suggested that mucopolysaccharides are not acidic in nature.

Very little is known about the localization of proteins in the fish brain. In the present studies the presence of proteins has been indicated by applying bromphenol blue method. It has been observed that the nuclear areas of the brain showed concentration of protein, which was more in the fibrous and nuclear regions with dark staining. The proteins thus studied were not rich in tyrosine as is evident from light staining after Millon's reaction.

However, Sundararaj and Prasad (1963, 1964), Saxena (1969a), Tandon and Sukheja (1974) and Kaur (1983) seem to be some of the few workers who have attempted to study lipids in fish brain. Sundararaj and Prasad (1964) have described the presence of lipids in the saccus vasculosus of Notopterus chitale. Saxena (1969b) and Saxena and Johri (1970) during their studies showed the distribution of lipids in the brains of Notopterus notopterus and Puntius ticto. According to Tandon and Sukheja (1974), the neutral lipids were dominant over the phospholipids and this was confirmed by nile blue sulphate reaction. Kaur (1983) found that most of the lipids present in the fiber tracts were neutral in nature. The neurons were devoid of lipid contents whereas the myelinated fibers were rich in them. In the present studies, the fibers were deeply stained as compared to the neuronic regions. So, it is evident that the neurons were poor in lipids while the myelinated fibers were rich in them.
The cytochemical patterns and above all the enzyme activity located in particular region of the brain were obviously connected with its metabolic pathways and consequently with its functional activity. Very few workers e.g. Wawrzynisk (1962), Kusunoki and Masei (1966), Urano (1971), Weke (1973), and Vachtler (1979-) have done histochemical work on the brains of lower vertebrates and in particular of fishes. It is quite difficult to have a comprehensive idea of enzyme distribution in the brain of fishes.

Great variations have been observed as regards the degree of acid phosphatase activity (Tewari and Rajbanshi, 1972). In the present work, acid phosphatase was seen localized in the neurons whereas fibers revealed very little activity. It has been observed that neuronal regions of telencephalon, recessus lateralis, recessus infundibuli, the optic layers - the stratum opticum and the stratum griseum periventriculare, the granular layers of valvula and cerebellum revealed intense activity. Alkaline phosphatase activity has been observed to be localized in the neuronal areas of stratum griseum periventriculare, granular layers of valvula and cerebellum. Fibers did now show positive reaction.

Contestabile (1979a), stated that the encephalic centres in the vagal and facial lobes of Carassius auratus were hypertrophic corresponding to the dominance of gustatory function. According to him, the reaction for
G-6-Pase was nearly absent in these lobes. In the present work, these lobes showed inconsistent activity due to poor staining. However, the telencephalic and the diencephalic regions of the brain showed moderate reaction.

According to Hanson and Clark (1959), the motor neurons contained large quantity of Nissl substance. Lavell et al. (1964) conjectured a direct correlation between the level of acid phosphatase activity and the amount of Nissl substance in nerve cells.

Tewari and Rajbanshi (1972) described that the distribution of adenosine triphosphatase in the medulla oblongata was just opposite to that of acid phosphatase and 5-nucleotidase during their studies on the brain of Saccobranchus fossilis. During the course of present investigations, the stratum fibrosum externum and the stratum fibrosum internum of the optic tectum showed intense staining indicating the localization of adenosine triphosphatase while the neurons around recessus lateralis and recessus infundibuli of lobi inferiores showed light staining. The lobes of medulla oblongata also revealed intense activity. It may, therefore, be suggested that ATPase activity was confined more to fibers than the neurons. This is in conformity with the observation of Tewari and Rajbanshi (1972).

Conte stabile (1975b) has described that AChE distribution in the vagal lobes of Cerassius showed a characteristic succession of layers in which the histochemical reaction was alternatively absent, weak or
strong. According to him, monoamine oxidase activity was mainly evident in the fibrous tracts while lactic dehydrogenase (LDH) and succinic dehydrogenase (SDH) exhibited distribution patterns similar to those observed for AChE and MAO. In the present observations, SDH activity has been seen in the neuronal regions but not in fibers. The stratum opticum and the stratum griseum periventriculare layers show moderate reaction. Granular layers of valvula and cerebellum showed positive activity while moderate to intense activity has been observed in the regions of medulla oblongata. Inconsistent or poor activity of the lactic dehydrogenase (LDH), monoamine oxidase (MAO), cholinesterase and cytochrome oxidase has been observed in the brain of fishes under report.

It is, thus, evident that ecological niche can play a very important role in shaping the structure and development of various brain parts. In C. bacaila, the optic lobes, optic nerves and eyes are large and well formed. The large size and better development of stratum griseum centrale and stratum griseum periventriculare of optic tectum, tractus mesencephalo-cerebellaris anterior accord with the fact that this fish possesses large eyes which play a significant role in surface feeding. The facial and vagal lobes are indistinct and the central acoustic area is well developed, showing thereby the poor development of gustatory sense but well formed acoustic system indicating surface feeding habit. The
olfactory sense is poor due to the small size of the olfactory bulbs.

Intense protein concentration has been revealed in the stratum griseum periventriculare, tori longitudinales, granular layers of valvula and cerebellum. 1:2 glycol groups are not recognised in the brain region. Lipids are confined only to the stratum fibrosum externum, stratum fibrosum internum and tori semicirculares. Acid phosphatase activity is intense in tori longitudinales, granular layers of valvula and cerebellum. Alkaline phosphatase shows moderate to poor activity in the brain parts. G-6-Pase activity is inconsistent in all the regions. ATPase activity is intense in the stratum fibrosum externum and stratum fibrosum internum. Moderate to weak activity of succinic dehydrogenase is seen in all brain regions. All the above brain areas showing distribution of various metabolites and enzymes suggest a close correlation of the visual impulses with the auditory impulses, which are essential for a surface feeder.

Lebeo pangusia is a mid-column feeder. The better development of the olfactory bulbs, lateral forebrain bundle, and marked differentiation of pars dorsalis from pars lateralis and nucleus geniculatum give an idea that olfactory sense is well developed in this fish. The cerebellum, valvula and tractus mesencephalo-cerebellaris posterior are comparatively less formed. The protein
and 1:2 glycol groups are also less. Intense lipid concentration has been observed in tractus mesencephalo-cerebellaris posterior, tori semicirculares. Acid phosphatase and ATPase show moderate activity in the valvula region. Alkaline phosphatase, G-6-Pase and succinic dehydrogenase indicate inconsistent activity. These observations may be correlated with the proportionate development of acoustic-lateralis system. But, the stratum griseum centrale, stratum griseum periventriculare, tori semicirculares, tori longitudinales and nucleus lateralis valvulae are well developed. Nucleus isthmi is also well recognised. It, thus, seems that gravistatic and photostatic functions are well developed. The better development of eyes and optic tecta may be considered as responses to its partial surface mode of life. Vagals show better formation than facial lobe giving an idea that gustatory senses are equally developed.

Labeo dero and Garra gortyla gortyla are the inhabitants of fast moving streams with stony beds. The position of the mouth is inferior in both the cases but G. gortyla gortyla has also an adhesive disc immediately below the lower lip. The small maxillary barbels are scarcely visible to the outside. Labeo dero is a bottom feeder while G. gortyla gortyla has the habit of getting under stones and adhering to them on the slightest danger. The excessive development of valvula cerebelli, cerebellum, nucleus lateralis valvulae and tractus mesencephalo-cerebellaris
posterior indicate well developed acoustico-lateralis sense and hence the agility of the fish. In *G. gotyla*, the small size of the optic tectum, tori longitudinales, scattered nucleus valvulæ and highly developed facial lobe may be related with the habit of seeking refuge under stones and consequent development of the ventral sucker. Eyes are quite reduced in *G. gotyla* indicating the lesser use of vision. Proteins and lipids are confined to the stratum fibrosum externum and internum and tractus mesencephalo-cerebellaris posterior. \(1:2\) glycol groups show poor localization in the brain regions. Acid phosphatase and G-6-Pase activities are recorded in stratum griseum periventriculare, valvula and cerebellum. While moderate to inconsistent activity has been observed regarding other enzymes. In *L. dero*, the proportionate development of all the above structures has been indicated. In *L. dero*, \(1:2\) glycol groups are found in stratum griseum periventriculare, granular layer of valvula and nucleus lateralis valvulæ. Lipids concentration has been observed in the stratum fibrosum externum, stratum fibrosum, internum, tori longitudinales, tori semicirculares, molecular regions of valvula and cerebellum and tractus mesencephalo-cerebellaris posterior. Alkaline phosphatase activity has been revealed in the optic tectum. ATPase and SDH activities have been indicated in the valvula cerebelli and cerebellum regions of the brain. Thus, in *L. dero*, the gustatory and tactile senses are
highly formed. Presence of palatal organ in the buccal cavity confirms these observations.

In conclusion, it may be stated that the size, configuration, placement and development of various brain areas can provide a good clue to the ecological niche of the fish. The cytochemical studies on the fish brain can be very useful tool in comparative neurochemistry. It may also be suggested that the brain parts showing the localization of various metabolites and enzymes may be acting as correlation centres, playing a vital role in the coordination of multifarious activities of the animal body.