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Habitat dependant variations in the brain lobes in teleost

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Abstract

Ecological parameters have influence on the size of brains and its anatomical parts. The environmental milieu of the fish during development is important. This study establishes the effect of one ecological parameter- habitat. A surface habitat feeding fish namely *Etroplus suratensis* has been observed and analysed in comparison with a bottom feeding habitat fish *Mystus gulio*. Both fishes were the inhabitants of fresh water, habituating diverse ecological milieu. *M. Gulio* possessed large brains with a well developed cerebellum compared to *E. Suratensis* inhabiting the bottom strata possessing large eyes at the bottom to aid its feeding nature. In the present study, the variations in brain lobe during the maturing stages were more significant than in the later stages.

Keywords: *E. Suratensis, M. Gulio,* Habitat, Evolution, Fish brain.

Introduction

Ecological and social factors have an important role in the evolution of the shape of the brain. Relative brain size and gross brain structure reflect the adaptation to a given environment. An animal's life style influences the structure of the central nervous system (Niewenhuys *et al.,*1998). The life history of teleost fishes shifts its habitat during metamorphosis from larval to juvenile form. This often involves a vertical or horizontal habitat shifts and changes in feeding behaviour and diet. These shifts enable the fish to acquire new biota results in anatomical, physiological, behavioural and ecologic adaption.

Habit and diet aspects are related to be teleostean brain which reflects the ecological base (Davis & Millaer, 1967; Lagler *et al,*1971; Huber & Rylander, 1992; Kostrschal & Palz enberger, 1992). The mechanism of habitat preferences is very complicated and the stimuli for feeding were perceived by senses like smell, taste, sight and lateral line system. The nature of feeding reflects brain structure.

Environmental feedback on brain development in teleost fishes is likely to influence its individual behaviour and habitat preference during adult life (Zaunreiter *et al.,* 1991; Kostrschal & Palzenberger, 1992). Huber *et al.* (1997) has shown a correlation with vision and taste influencing feeding habits. Similarly turbidity and depth are closely associated with differences in eye size.

Ecological factors influence brain evolution in diverse taxa as reported by various studies. Both sexes are influenced by selective pressure and specific challenges of ecological factors. Gonzalez *et al.* (2010) have analysed the brains in 43 cichlid species on their sex and ecology of sexual dimorphism. Earlier, studies on African cichlids on the influence of diet and habitats were made (Hubert *et al.,* 1997; pollen *et al.,* 2007) and established a close relationship between the relative size of various brain structures varying in relation to habitat and prey.

Rebacca & Gabriella (2006) reported the brains in salmons which were reared among stones had significantly larger cerebella than genetically similar fish reared in conventional tanks. Gonda *et al.* (2011) established variation in brain size in nine spined stickleback from different habitats confirming earlier studies. Sherly (2011) reported the effects of habitats on the structure of the vagal lobe in two teleost and attributed it to gestation in fishes. This study has been undertaken with the aim of getting information on brain structure in two freshwater fishes from diverse habitats represented by *Etroplus suratensis and Mystus gulio*.

Materials and methods

The fishes for the present study includes a surface dwelling habitat fish namely *Etroplus Suratensis* and bottom dwelling habitat fish *Mystus* gulio and both were procured from natural water bodies. Various sexually mature males and females were brought to the laboratory in live condition. This included 118 specimen belonging to *E. Suratensis* and 113 specimens of *M. Gulio.* The brains were dissected out and the different parameter, like length of brain, length of cerebral

Fig.1. Morphology of brain in E. suratensis

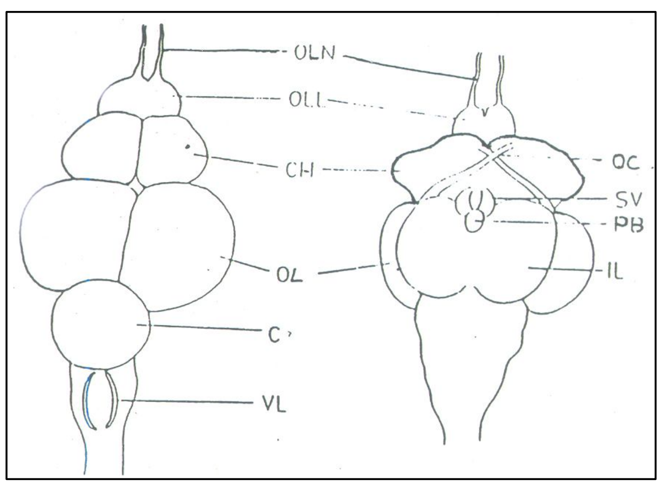

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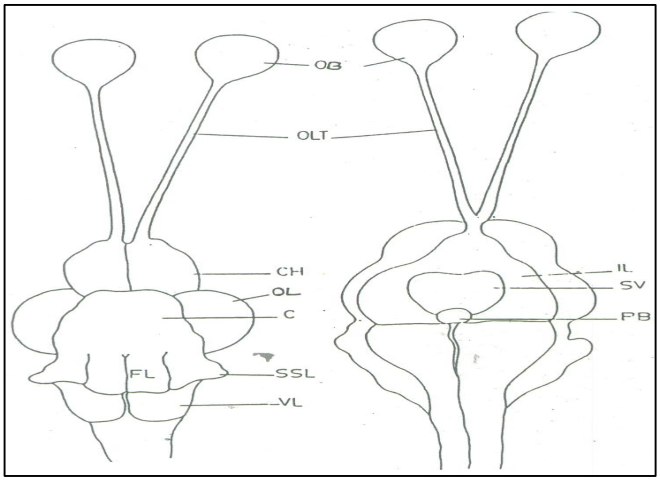
Fig.2. Morphology of brain in M. gulio



hemisphere, length of optic lobes, length of cerebellum were measured to the nearest 0.01mm. The relative volume of each structure (cerebral hemisphere, optic lobe, cerebellum) were analysed using students test, based on the morphology of different brain lobes as carried out by Hubbz & Lagler (1947).

Observations

A significant phenotypic variation was noticed in the brain lobes of surface and bottom habitat fishes. Brain of *M.gulio* a surface feeder revealed a larger size in comparison with, a bottom feeding fish *E. suratensis*. A significant difference in brain lobes in both habitats were noticed and the morphology of brain is shown in (Fig. 1 & 2)

Increased brain size is attributed to an increase in the number of neurons and not in neuron size. Changes in whole brain size reflect selection acting on one or multiple lobes within the brain. In *E. Suratensis* telencephalon and optic lobes shows a positive correlation to surface habitat than *M. gulio* and negatively correlated to depth (Fig.3.).The cerebellum volume shows a positive correlation to depth in *M.gulio* whereas optic lobes and telencephalon negatively correlated to depth.(Fig.4.). Being an actively feeding fish and a bottom feeder the cerebellum would be highly developed. (Fig. 5) showing effects of habitat on (1) Relative telencephalic volume, (2) Relative optic tectal volume and (3) Relative cerebellum volume.

Discussion

Brain morphology in *E. suratensis* and *M. gulio* vary considerably in configuration and size. The marked distinctiveness suggests the presence of different mechanisms based on diverse habitats. There is a large variation in absolute brain volume, relative brain volume of telencephalon, optic tectum and cerebellum in surface and bottom habitat fishes. Higher brain size was found in bottom habitat species compared to surface habitat in this study. The environmental factors are all known to be important in shaping brain evolution (Gonda *et al*., 2011) correlate with this study. Again it is confirmed that

Fig.3.Telencephalic volume in E.suratensis & M.gulio(%)

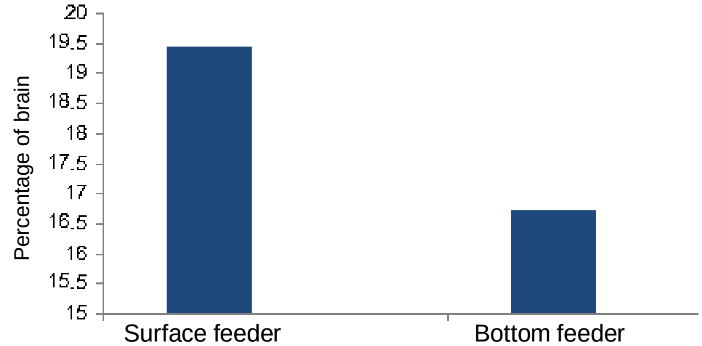


Fig.4. Optic tectal volume in E.suratensis & M.gulio(%)

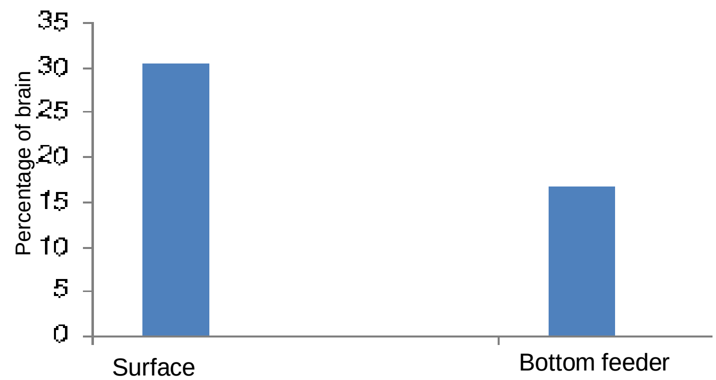
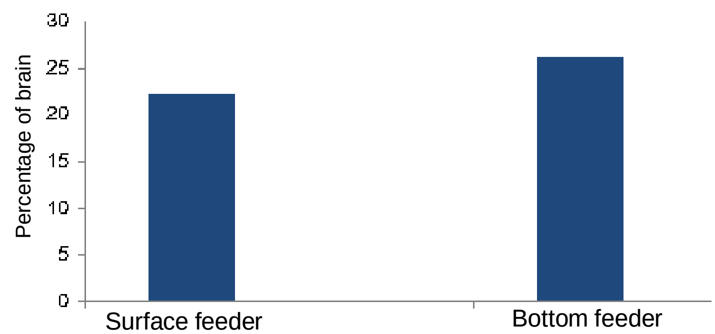


Fig.5. Cerebellum volume in E.suratensis & M.gulio(%)



environment can shape the expression of different brain lobes. Visual conditions of the habitat reveal large amount of variation in the structure of the cichlid brains observed by (Huber *et al.,*1997). His observations clearly showed both turbidity and depth significantly impact brain morphology, particularly the size of the visual structures. In the present study not only the optic treta but cerebellum also reveals a clear cut difference.

Cerebellum is highly developed in turbid and bottom feeders and has been confirmed in the comparative study of *M. gulio* and the highly developed optic tecta in *E.suratensis.* Kotrschal *et al.* (1990) observed the hypertrophy of the eyes in planktivores and detritivores is true in *E.suratensis,* though in our earlier studies on other fishes do not support this view. The piscivores hunt fast moving prey, with the help of direction sensitive cells aiding motion, present in the optic tetum (Gutherie, 1990). But piscivores characterised by large optic lobes does not supports the present observations in *E.suratensis*, usually feeding on slow moving prey, even though possessed large optic treta. Gonda *et. al.* (2011) predicted a positive association between telencephalic volume and diet as the species feeding on sessile prey had larger brain than species feeding slow motile prey do not support this study due to the recorded lesser telencephalic volume in *E.suratensis*.

Cerebellum volume size among different species correlates strongly with habitat type, prey size, swimming ability (Huber *et al.,*1997). In *M.gulio*, the positive correlation of brain was due to its benthic habitat and swimming ability supports the finding. The structural variability in fish brain is determined by local environmental conditions as well as some genetically fixed mechanism (Davis & Miller, 1967). In this study, it has been noticed that most of the modification in the brain lobes occurred in the maturing stages of fishes and after that, stage variations were not significant. Gonzalez - Voyer & Kolm (2010) reported the brain size did not correlate significantly to habitat supporting these study findings. Again, he had correlated habitat and diet but in this study, no such correlations exist. In Tangayikan cichlids, habitat complexity was found to be associated with larger brains and larger cerebella supporting the findings in *M.gulio* for its large brain size and larger cerebella.

However, brain size is not an index of habitat complexity but the brain lobes shows a significant correlation in surface and bottom habitats because habitat plays a crucial role in shaping brain.

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