The Pharma Innovation Journal 2019; 8(6): 316-320

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2019; 8(6): 316-320

www.thepharmajournal.com
Received: 16-04-2019
Accepted: 20-05-2019

Soumya Hilal
Dept. of Zoology, BJM Govt. College, Chavara, Kollam, Kerala, India

Fouzia Hilal
Dept. of Botany, MSM College, Kayamkulam, Alappuzha, Kerala, India

Correspondence
Soumya Hilal
Dept. of Zoology, BJM Govt. College, Chavara, Kollam, Kerala, India

Morphological variations in the brain of some selected Teleosts

Soumya Hilal and Fouzia Hilal

Abstract
Brain are the substrate for sensory perception, processing and behavioural output. Structural variation of the "command headquarter of the body" may be used to predict niches better than any other structure of an organism .The vertebrate brain is the main part of the central nervous system in vertebrates (and most other animals).The brain is at the front, in the head. It is protected by the skull and close to the main senses of vision, hearing, balance, taste, and smell. As an animal moves forward, its senses, collect data about the surroundings, and that data goes directly to the brain. Brains are extremely complex. The structure of all vertebrate brains is basically the same. There were notable differences in the rates of evolution of the different brain structures.The present study focuses on morphological variations in the brain of some teleosts: *Anabas testudineus, Aplocheilus lineatus, Arius nenga, Carassius auratus and Clarius batrachus.* Marked differences in the hind brain lobes of fishes were clearly reflected. The hind brain is equipped with well developed cerebellum, facial lobe, vagal lobe and somatic sensory lobes. Highly developed cerebellum is observed in *Arius nenga*. In *Clarius batrachus,* facial lobe is bilobed, in *Arius nenga* and *Carassius auratus* it is single lobed while it is absent in *Anabas testudineus* and *Aplocheilus lineatus*. Vagal lobe is bilobed in all the species studied except in *Aplocheilus lineatus*.Somatic sensory lobe is absent in *Anabas testudineus* and *Aplocheilus lineatus* ,bilobed in *Arius nenga* and *Carassius auratus* while well developed in *Clarius batrachus*. Generally the brain showed a high degree of structural diversity in fishes taken for the study.

Keywords: Hind brain, Anabas testudineus; Aplocheilus lineatus; Arius nenga; Carassius auratus; Clarius batrachus

Introduction

Fishes have been found advantageous as experimental animals for biological research under simple laboratory conditions owing to their short generation time and availability. Number of factors governs the fish life and other aquatic organisms. Brain is the seat of mental faculties of a fish. Parallel changes in the size of specific brain parts and ecological adaptations have been demonstrated in many vertebrate taxa ranging from fish [1, 2] to bats [3] and primates. Fishes are primarily useful for comparative studies because the primary target of sensory modalities are distinct brain divisions which can be measured in the intact brain (eg-Facial and Vagal lobe concerned with taste, the Optic lobe for vision and Olfactory lobe for smell). The nervous system of fishes consists of central nervous system and peripheral nervous system. The central nervous system consists of brain and spinal cord. The peripheral nervous system consists of Cranial nerves and Spinal nerves.

The brain of fishes is divisible into forebrain or Prosencephalon, Mid brain or Mesencephalon and Hindbrain or rhombencephalon. The Prosencephalon is further constricted into two subregions namely the telencephalon and diencephalon. The prosencephalon consists of olfactory lobes, cerebrum and diencephalon. The telencephalon differentiates to from the cerebrum and in most vertebrate groups, the olfactory bulbs. The diencephalon contains thalamus and hypothalamus. The pituitary gland hangs from hypothalamus. The cerebrum is divided into right and left cerebral hemispheres, they are concerned with olfaction receiving fibres from the olfactory bulbs. The telencephalon is regarded as the "nose brain". The midbrain or mesencephalon consists of optic lobes and cruracerebri. The midbrain is designated as "eyebrain". The hind brain or rhombencephalon consists of metencephalon and myelencephalon, the former is regarded as "skin brain" and latter the "Visceral brain" Metencephalon consists of cerebellum and myelencephalon consists of medulla oblongata. The walls of medulla oblongata are thick and made up of nerve tracts that connect the spinal cord with various parts of brain.

Cerebellum coordinates muscular activity and is responsible for muscle tone, posture and equilibrium.

The principal factor that brings about variations in the structure of hind brain is widely regarded as their feeding habits [4]. Primary divisions of the brain which consists of the medulla oblongata with the cerebellum and other less constant appendages in fishes is called “epencephalon” is relatively larger, occupies a greater portion of the cranium and is more complex and diversified in this than any of the higher class of vertebrates [5] . The important lobes of the medulla oblongata are the vagal and facial lobes, which are the terminal centres for the nerve fibres of the vagal and the facial nerves respectively. The size of these lobes depends upon the extent to which their nerve fibers supply taste buds.

1. Fishes that feed with help of sight

In the present study fishes like *Aplocheilus lineatus* and *Anabas testudineus* feed with help of sight. They have well developed optic lobes which occupies the largest portion of brain.

2. Fishes that feed with help of barbels

In the present study cat fishes which are both bottom feeders *Clarius batrachus* and *Arius nenga* feed with the help of barbels.

3. Fishes that feed with help of olfaction

In the present study fishes such as *Carassius auratus, Anabas testudineus, Arius nenga, Clarius batrachas* feed with help of olfaction.

4. Fishes that feed with help of taste

The present study includes fishes such as *Carassius auratus, Clarius batrachus, Arius nenga* feed with help of taste. They are capable of taste discrimination.

Materials and Methods

The research reported herein has largely utilized live specimens of five fishes belonging to 5 different families collected from ponds, lakes, aquarium and nearby places of Kollam district in Kerala. The following specimens were studied.

Type	Family
Anabas testudineus	Anabantidae
Aplocheilus lineatus	Cyprinodontidae
Arius nenga	Arridae
Carassius auratus	Cyprinoidae
Clarius batrachus	Claridae

Identification of the specimens was done according to the method of Day [6]. The brains were dissected out and fixed in 10% neutral buffered formalin solution and morphology were studied [7].

The length of fishes and weight of fishes was measured using millimeter scale and weighing pan. Brains of fishes were inspected by making incision with a single edge razor blade in the cranium across the nasal region. The incised area was picked up with forceps. Soft tissue was removed from the brain using fine forceps. The brains were dissected out and the different parameters like length of brain, weight of brain, length of cerebellum, length of Vagal lobe, length of facial lobe and length of somatic sensory lobe were measured carefully using millimeter scale.

Results

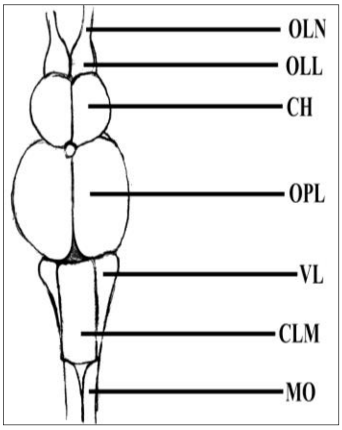
The morphology of brain of *Anabas testudineus* is shown in figure 1 and observationsare shown in table II and IV. The brain of *Anabas testudineus* is divided into five regions namely:- Telencephalon, Diencephalon, Mesencephalon, Metencephalon and Myelencephalon. The metencephalon represents a single large elongated and flattened lobe cerebellum (CLM). It is median in position. It measures about 25% of total brain length. It helps in maintenance of the body posture during swimming. The myelencephalic part of brain consists of vagal lobes (VL), rudimentary facial lobes (FL) and medulla oblongata (MO). The vagal lobes are situated below each optic lobes on either side of cerebellum. The vagal lobes represents 16% of total brain length. It denotes mouth tasting nature of the fish. Since the vagals are well developed this fish is herbivorous and makes use of sense of taste in an abundant measure. The medulla oblongata occupies about 8.3% of the total brain length.

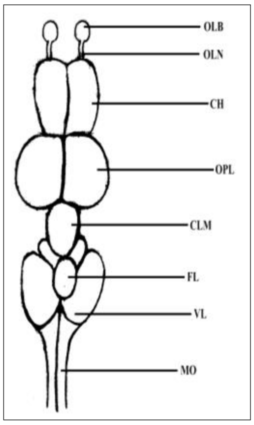
The morphology of brain and hind brain of *Carassius auratus* is shown in figure 2 and observations are shown in table II and IV. The brain of *Carassius auratus* is well developed and divided into five main parts namely:- Diencephalon, Telencephalon, Mesencephalon, Metencephalon and Myelencephalon. The metencepahlon and myelencephalon comprises the hind brain of fish. The metencephalon represents a single circular small lobe, cerebellum (CLM). It constitute about 28.57% of the total brain length. It is responsible for maintenance of body posture during swimming. The myelencephalic part of *Carassius auratus* is better developed with chemosensory lobes. The myelencephalon consists of paired vagal lobes (VL), a facial lobe (FL) and medulla oblongata (MO). The paired vagal lobes are relatively larger than facial lobe. It occupies about 30.09% of the total brain length. The single facial lobe is situated below the cerebellum. The facial lobes constitute about 19.04% of the total brain length. The external and internal tastes are of different importance in different species as judged by the relative volume of vagus lobe and facial lobe. The facial and vagal lobes are chemosensory in function. Facial lobes are concerned with skin tasting nature. Vagal lobes are concerned with mouth tasting nature. The medulla oblongata occupies about 14.25% of the total brain length.

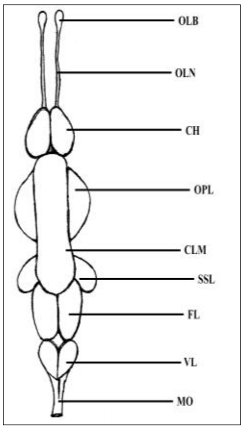
The morphology of brain of *Clarius batrachus* is shown in figure 3 and observations are shown in table II and IV. The brain of *Clarius batrachus* is divided into five parts namely:- Telencephalon, Diencephalon, Mesencephalon, Metencephalon and Myelencephalon. The hind brain of fish is divided into metencephalon and myelencephalon. The metencephalon is represented by a large elongated lobe cerebellum (CLM). It occupies about 25% of the total brain length. It is responsible maintenance of body posture during swimming. The modification of brain in response to feeding habits in *Clarius batrachus* have been found in the myelencephalic part situated at the posterior region of the brain. The myelencephalon comprises paired somatic sensory lobes (SSL), paired facial lobes (FL), vagal lobes (VL) and medulla oblongata(MO). The somatic sensory lobes are seen projecting sideways at the posterior region of cerebellum (CLM) anterior to facial lobes. It occupies about 12.5% of the total brain length. The facial lobes lies posterior to somatic sensory lobe and anterior to vagal lobe. Facial lobe occupies about 10.41% of the total brain length. The vagal lobes located below the facial lobes and extends downwards as medulla oblongata. The vagal lobes constitute about 10.41% of the total brain length and medulla oblongata constitutes about 4.16% of the total brain length. The vagal lobes, facial lobes and somatic sensory lobes accounts for chemosensory in function.

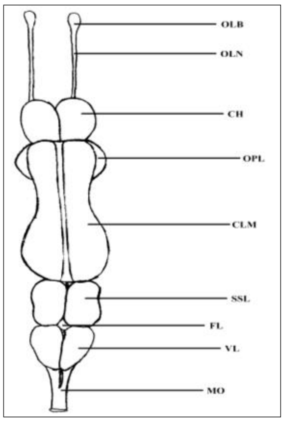
The morphology of brain of *Arius nenga* is shown in figure 4 and observations are shown in table II and IV. The brain of fish is divided into five parts namely:- Telencephalon, Diencephalon, Mesencephalon, Metencephalon and Myelencephalon. The metencephalon and myelencephalon forms the hind part of the brain. The metencephalon represents a single large and an elongated lobe cerebellum (CLM). The cerebellum constitutes about 22.22 % of total brain length. It is responsible for maintenance of body posture during swimming. The Most of the modifications in response to feeding habits in *Arius nenga* have been found in the myelencephalic part situated at the posterior region of the brain. It consists of paired somatic sensory lobes (SSL), a facial lobe (FL), paired vagal lobes (VL) and medulla oblongata (MO). The somatic sensory lobes occupies anteriorly to facial lobe and constitute about 6.94% of the total brain length. The single facial lobe is prominent and occupies centrally to somatic sensory lobe and vagal lobe. It represents 7.69% of the total brain length. The paired vagal lobes lies at the posterior part of somatic sensory lobe constitute about 6.94% of the total brain length. The medulla oblongata occupies 2.7% of total brain length. The somatic sensory lobes, facial lobes and vagal lobes are chemosensory in function.

The morphology of brain of *Aplocheilus lineatus* is shown in figure 5 and observations are shown in table II and IV. The brain of *Aplocheilus lineatus* is well developed and is broadly divisible into five parts- Telencephalon, Diencephalon, Mesencephalon, Metencephalon and Myelencephalon. The brain of *Aplocheilus lineatus* is small and completely fills the entire cranium. The hind brain of fish is divided into metencephalon and myelencephalon. The metencephalon represents a cerebellum (CLM) which is almost rounded lobe partially hidden by optic lobes. It measures about 16.6% of total brain length. Its function is to maintain body posture during swimming. The myelencephalic part is represented by poorly developed vagal lobes (VL), rudimentary facial lobes and medulla oblongata (MO).Vagal lobes denote mouth tasting nature. The medulla oblongata is cylindrical and dorsoventrally compressed. It represents 25% of the total brain length.









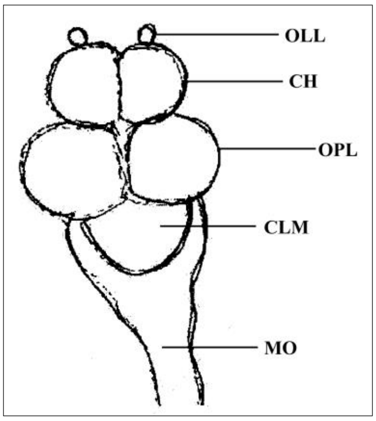


Table 1: Showing different brain lobes in some teleosts

Name of fishes	Cerebellum	Somatic Sensory lobe	Facial lobe	Vagal lobe
1. *Anabas testudineus*	+	–	–	+
2. *Aplocheilus lineatus*	+	–	–	–
3. *Arius nenga*	+	+	+	+
4. *Carassius auratus*	+	+	+	+
5. *Clarius batrachus*	+	+	+	+

(+) Presence; (–) Absence

Table 2: Showing measurements of various brain lobes in teleosts

Name of fishes	Total length of fish (mm)	Total length of brain (mm)	Cerebellum (CLM)	Somatic sensory lobe (SSL)	Facial lobe (FL)	Vegal lobe (VL)	Medulla oblongata (MO)
Anabas testudineus	80	12	3	–	–	2	1
Aplocheilus lineatus	43	6	1	–	–	–	1.5
Arius nenga	185	36	8	2.5	2	2.5	1
Carassius auratus	125	10.5	7	2.5	1.5	1	1
Clarius batrachus	250	24	6	3	2.5	2.5	1

Measurements are in 'mm'

Table 3: Showing variation of brain lobes in percentages

Name of fishes	Total length of brain in %	Cerebellum lobe in %	Somatic sensory lobe in %	Facial lobe in %	Vegal lobe in %	Medulla oblongata volume in %
Anabas testudineus	12	25	–	–	16	8.3
Aplocheilus lineatus	6	16.6	–	–	–	25
Arius nenga	36	22.22	6.94	7.69	6.94	2.77
Carassius auratus	10.5	28.57	–	19.04	30.09	14.25
Clarius batrachus	24	25	12.5	10.41	10.41	4.16

Table 4: Showing relationship between brain and brain weight

Name of fishes	Total length of brain in mm	Weight of brain in mg
1. *Anabas testudineus*	12	0.23
2. *Aplocheilus lineatus*	6	0.12
3. *Arius nenga*	36	0.99
4. *Carassius auratus*	10.5	0.21
5. *Clarius batrachus*	24	0.24

Abbreviations used

CH - Cerebral Hemisphere , CLM – Cerebellum , FL - Facial Lobe , MO - Medulla Oblongata , OLB - Olfactory Bulb, OLL - Olfactory Lobe, OLN - Olfactory Nerve, OPL - Optic Lobe, SSL - Somatic Sensory Lobe, VL - Vagal Lobe.

Discussion

The present study reveals the morphological variation in brain of some teleosts like *Aplocheilus lineatus, Anabas testudineus, Arius nenga, Carassius auratus, Clarius batrachus* belonging to 5 different families.

Several authors attempted on ecomorphological classification of teleostean brain. Evans [8, 9] distinguished the cyprinid brain types as mud feeders, sight feeders, barbel feeders accordingly. Evans [10] used the same topology and distinguished between "mouth feeders", "sight feeders" and "skin feeders" (large vagal, optic and facial lobes respectively). The presence of olfactory nerves and well developed olfactory organs indicates better sense of smell in fishes [11]. The telencephalon in brain is mainly olfactory in function [12]. The size of cerebellum is associated with the habitats [13]. The lobes of medulla oblongata are an index of feeding behaviour of fishes. The lobes of medulla oblongata may be single, bilobed or multilobed.

Brain morphology varies considerably in configuration and size. The marked distinctiveness suggests the presence of different mechanisms based on diverse habitats. There exists large variations in absolute brain volume and cerebellum volume in fishes taken for this study. The environmental factors are all known to be important in shaping brain evolution [14] correlate with this study. The cerebellum of fishes is associated with the muscular activities of fishes. Highly developed cerebellum is found in *Carassius auratus, Clarius batrachus* and *Arius nenga*. They are bottom feeders. This agrees with the findings of Karamian who stated that size of cerebellum is associated with habitats [13].

Large and well developed cerebellum indicates the active feeding habits of these fishes. In *Anabas testudineus* the cerebellum is moderately developed. The lobes of medulla oblongata constitute an index of feeding behaviour of fishes and they are variable according to the variability of taste buds on the body, lips, barbels and buccal cavity. *Arius nenga* and *Clarius batrachus* use their long barbels for searching food and correspondingly their facial lobes are enlarged. Sato found highly developed facial lobes in mouth feeders and skin tasters [15]. Facial lobes are enlarged in fishes possessing dense external buds [16] or in the barbel taste feeders [11, 17].

From the phenotypic observation of the different brain lobes shown in Table I. It is clear that *Arius nenga, Carassius auratus* and *Clarius batrrachus* possess facial lobes. Facial lobes may be single, bi and multi lobed. Single lobed facial lobe is found in *Arius nenga and Carassius auratus. Bilobed facial lobes are found in Clarius batrachus*.

Vagal lobes are related with mouth taste and taste buds present in the IX and X nerves [8, 4, 11, 18, 19]. *Aplocheilus lineatus* have poorly developed vagal lobes. In this study well developed vagal lobes are seen in teleosts: *Anabas testudineus, Arius nenga* and *Carassius auratus*. Vagal lobes are concerned with mouth tasting nature of fishes.

The enlarged somatic sensory lobe is due to a more active habit of the fish [4]. In this study *Arius nenga, Carassius auratus* and *Clarius batrachus* possess somatic sensory lobes. It is well developed in *Arius nenga*. Somatic sensory lobes are correlated with an aggressive feeding habit. It is active as well as sensitive in perceiving the movements of objects in water.

Conclusion

1. Highly developed cerebellum indicates active feeders. It is found in brain of *Carassius auratus, Clarius batrachus* and *Arius nenga*.
2. The presence or absence of barbels is an important factor influencing the brain structure and consequently their feeding habits
3. The development of facial lobe was associated with skin

tasting in fishes. It was well developed in *Arius nenga*, *Carassius auratus* and *Clarius batrachus.*

4. The development of vagal lobes is related to mouth tasting in fishes. Well developed vagal lobes are shown by *Arius nenga*, *Anabas testudineus* and *Carrassius auratus*.
5. Somatic sensory lobes are found in *Arius nenga*, *Carassius auratus* and *Clarius batrachus* This testifies its aggressive feeding habit.

Acknowledgement

We are thankful to the head of the Department of Botany, MSM College, Kayamkulam for providing laboratory facilities for carrying out our work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

References

1. Kishida R. Comparative study on the telestean optic tectum. Lamination and Cyto architecture. J Hirnforsch. 1979; 29:341-352.
2. Kotrschal K, Junger H. Patterns of brain morphology in Mid European Cyprinidae. J Hirnforsch. 1988; 29:57-67.
3. Baron, Jolicoeur. Brain Morphology and Turbidity Preference in Notropis and Related Genera (Cyprinidae, Teleostei, 1980, 153-154.
4. Bhimachar BS. A study of medulla oblongata of Cyprinoid fishes with special reference to their feeding habits. Proc. Roy. Soc. London B. 1937; 123:59-68.
5. Owen R. Anatomy of Vertebrates. Long mans, Green London, 1866, I.
6. Day F. The fishes of India, being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon. The text and atlas in 4 parts. London. 1958; XX + 778:195pls.
7. Hubbs CL, Lagler KF. Fishes of the great lakes region. Bull. Cran. Brook. Inst. Sci. 1947; 8:1-95.
8. Evans HM. Comparative study of brains in British Cyprinoids. Proc. Roy. Soc. London. 1931; B108:233-257.
9. Evans HM. A study of brain pattern in relation to hunting and feeding in fish. The Blakistan Co., Philadelphia. 1940, 164.
10. Evans HM. The correlation of brain pattern and feeding habits in four species of cyprinoid fishes. J Comp. Neurol. 1952; 97:133-142.
11. Khanna SS, Singh HR. Morphology of teleostean brain in relation to feeding habits. Proc. Nat. Acad. Sci. India. 1966; 36(III):306-316.
12. Ariens Kappers CU, Huber GC, Crosby EC. The comparative anatomy of the nervous system of vertebrates including man, Hafner Pub. Co. N.Y. 1936; reprinted in, 1960, 3.
13. Karamian A. Evolution of functional interrelation between cerchellum and cerebral hemispheres in bony fishes (in Russian). Fiziol zhurner. 1949; 35:167-181.
14. Gonda A, Herezeg G, Merila J. Population variation in brain size of nine spined stickle backs BMC Evol. Bio. 2011; 11:75. Doi: 10. 1186 / 1471.
15. Sato M. A comparative observation of the hind brain of fish possessing barbels with special reference to feeding habit. Sci. Rep. Tokyo Imp. Univ. 1941; 16:157-164.
16. Miller RJ, Evans HE. External morphology of the brain and lips in Catastomid fishes. Copeia. 1965; 4:467-487.
17. Saxena PK. Structural variation of medulla oblongata and their correlation with the feeding habits in some Indian teleosts. J. Research (Punjab Agri. Uni, Ludhiana). 1970; 3:339-342.
18. Bhimachar BS. A study of the correlation between feeding habits and structure of hind brain in South Indian Cyprinoid fishes. Proc. Roy. Soc. London B. 1935; 117:258-272.
19. Sinha M. Observation on the biology of featherback Notopterus notopterus. Indian journal of fishes. 1969; 13(1-2):232-250.