International Research Journal of Biological Sciences ___________________________________ ISSN 2278-3202
Vol. **4(1),** 6-10, January **(2015)** *Int. Res. J. Biological Sci.*

Relative Importance of Vision estimated from the Brain pattern in African catfish *Clarias gariepinus,* river catfish *Pangasius pangasius* and red tilapia *Oreochromis* sp.

Ching F.F., Senoo S. and Kawamura G.
Borneo Marine Research Institute, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, MALAYSIA

Available online at: www.isca.in, www.isca.me
Received 16th January 2014, revised 11th November 2014, accepted 20th December 2014

Abstract

Present study was aimed to specify the relationship between intervention in sexual functioning and Quality of Life in patients with Coronary Artery Bypass Graft (CABG) surgery. The study was a casual comparative research type. The sample size was 100 people who were all married men among which 50 ones were patient and remaining were normal. Pearson correlation coefficient was used due to quantitative variable of Quality Of Life (QOL) and sexual dysfunction. Given the analysis results, there is a negative significant correlation between sexual dysfunctions and Quality of Life in tow groups (P<0.05). Furthermore, here was a significant difference in a comparison between normal and patient groups in terms of Quality of Life indicator. Findings indicated that the patients who had undergone CABG were with lower Quality of Life and the higher sexual dysfunction. Therefore, successful treatment for sexual disability can improve sexual satisfaction and enhance QOL and life expectancy in patients with Coronary Artery Bypass Graft.

Keywords: Coronary Artery Bypass Graft (CABG), sexual functioning, sexual dysfunction, Quality Of Life (QOL).

Introduction

While several evidences indicate important roles of vision in catfish species, many information lead to an idea of a limited importance for vision. Since teleost brains reflect life styles, this study conducted a quantitative comparison of brain pattern of African catfish Clarias gariepinus, river catfish Pangasius pangasius and red tilapia Oreochromis sp. to estimate the relative importance of vision in behaviour of catfish species. The brain of African catfish and river catfish is characterized by the large cerebellum and presence of the electro-sensitive lateral line lobe which is absent in red tilapia. The bulged optic tectum is well developed (16 % of brain volume in African catfish, 14% in river catfish) and forms the second largest part of the brain while the optic tectum is the largest part of the brain in red tilapia (20% in red tilapia). However, African catfish and river catfish have much larger optic tectum than red tilapia. Red tilapia lack the electro-sensitive lateral line lobe and have small cerebellum which make the brain volume smaller and the proportion of the optic tectum larger. By taking into consideration that the size of each lobe depends on the extent to which its nerve fibers project information from receptor cells, it is concluded that vision is important sense in African catfish and river catfish as well as in red tilapia.

Keyw0rds: African catfish, river catfish, red tilapia, vision, brain pattern.

Role of vision in catfishes has received little direct attention in behavioural studies, because catfishes have extraordinary nonvisual senses which play important roles for catching their prey. The entire body of catfishes is covered with taste buds, with the highest distribution density on the whisker like barbells around its mouth[1]. In the taste sensitivity of channel catfish *Ictalurus punctatus,* the threshold concentration for the more effective amino acids was estimated to range between 10^{-9} and 10^{-11} M, the lowest electrophysiological thresholds reported for taste in any vertebrate, and the taste buds act as distant sense such as sense of smell[2]. Laboratory experiments by Pohlmann *et al.*[3] revealed that wels catfish *Silurus glanis* have highly sensitive lateral line with which the fish track the wake left by a swimming prey fish and locate it.

Freshwater catfishes populate the bottom of ponds, lakes and rather stagnant parts of rivers. Generally, visibility is low and vision is nearly useless. Catfishes are generally considered to be nocturnal scavengers[4,5]. They have small eyes[6]. Bullhead *Ameiurus natailis* feed mostly at night, largely on benthic invertebrates and plants[7]. Radiotelemetry studies showed marked nocturnal mobility patterns in European catfish *Silurus glanis*[8] and Lake Biwa catfish *Silurus biwaensis*[9]. Laboratory experiments demonstrated better growth or feed ingestion in the dark than in the light in African catfish *Clarias gariepinus* larvae[10,11]. All these information led to an idea of a limited importance for vision. However, major items consumed by large brown bullhead *Ichtalurus nebulosus* were fish[12]. Spataru et al.[13] analyzed intestine contents of 264 African catfish from the Lake Kinneret (Israel) and reported that preyed fish were the most abundant food component (81%). Foraging swimming fish would not successfully be achieved only by chemosenses or mechanosenses. Fatollahi and Kasumyan[14] reported that African catfish preferred blue pellets to red and green pellets in the light, indicating the involvement of vision in feeding and African catfish juveniles have colour vision[15].

Sine teleost brains reflect life styles[16-18], the involvement of senses in fish behaviour can be referred by external brain pattern. The size of each lobe depends on the extent to which its nerve fibers project information from receptor cells. The present study examined the external anatomical features of brains of African catfish, river catfish, and red tilapia. The two catfishes exhibit similar behavior. Vision is well developed in the cichlid fish species[19,20] and *Oreochromis* have four visual pigments[21]. Visual communication between sexual partners modulates reproductive behaviour of Nile tilapia *Oreochromis niloticus*[20,22]. This study may serve as a background reference for understanding of visual behaviour of African catfish and river catfish.

Material and Methods

Material fishes: Animal care and handling was carried out according to the guidelines set by the World Health Organization in Geneva, Switzerland, Malaysian Animal Handling Code of Conduct and National Research Council guide for the care and use of laboratory animals[23].

African catfish (13.2 cm TL), river catfish (16.8 cm TL) and red tilapia (11.7 cm TL) were obtained from the Fish Hatchery of Borneo Marine Research Institute, Universiti Malaysia Sabah. Since the general brain pattern is developed to adult form during juvenile stage[24,25], the external brain form of specimens used in the present study might resemble the adult form.

Each fish was anesthetized in ice-water until it stopped moving and then the head was cut. After removing the skull and lipid tissues covering the brains were removed, the brain with head was photographed with a digital camera (PANASONIC Lumix, DMC-FX100) and preserved in 10% formalin for more than one day. The brain hardened in 10% formalin solution was removed from the head for further observations with a dissection microscope (NIKON, SMZ645), and pattern of the brain was then illustrated.

Relative brain volume calculation: Regarding the brain as an ellipsoid, its volume V is calculated by the formula

$$V = 4abc/3$$

where a, b, c are a half of height, length and width respectively. Each lobe is also regarded as an ellipsoid, and its volume V' was calculated by the formula

$$V' = 4a'b'c'/3$$

Where a', b' and c' are a half of height, length and width of respective lobe. And the volume ratio (VR) of a lobe to the brain is calculated as

$$VR = V' / V = (4a'b'c'/3) / (4abc/3) = a'b'c'/ abc$$

Since the development of a lobe is characterized by its length and bulge rather than its width[16,24], the ratio was represented as

$$\text{Ratio} = (b'c'/ bc) \times 100$$

The length of the brain was measured from the nasal end of olfactory lobe to the caudal end of the vagal lobe (in catfishes) or cerebellum (in red tilapia).

The size of the eye was represented by the diameter of the eye, and the ratio of the eye size to the brain length was calculated.

Results and Discussion

The brains of the three species were covered with the thick lipid tissue. Figure 1 illustrates dorsal views of the brains without the lipid tissue. The olfactory bulbs located close to the olfactory rosette are not shown in African catfish and river catfish in figure 1. The size of lobes measured and its volume ratio to the brain volume calculated are shown in table-1.

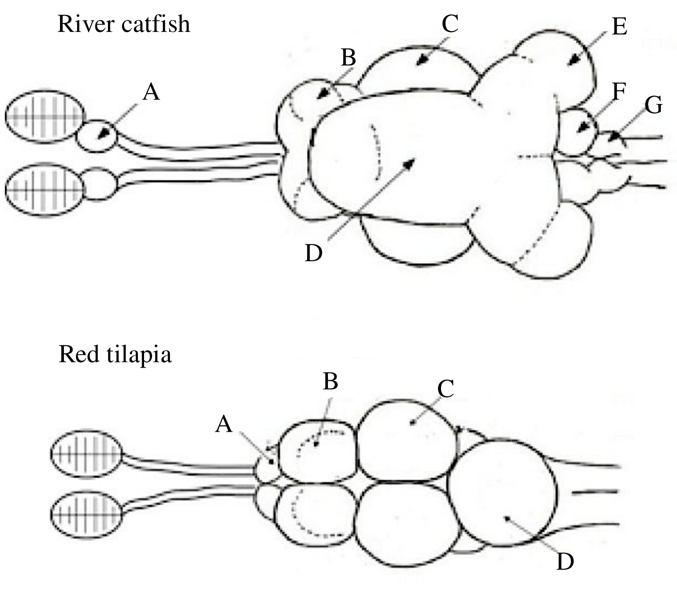

Figure-1
Dorsal view of African catfish, river catfish, and red tilapia. C, cerebellum; ELL, electro-sensitive lateral line lobe; FL, facial lobe; OB, olfactory bulb; OL, olfactory lobe; ON, optic nerve; OT, optic tectum; VL, vagal lobe. The olfactory bulbs located close to the olfactory rosette are not shown in African catfish and river catfish. Scale bar, 5 mm

Table-1
Measurements of brain and lobes and volume ratio for African catfish, river catfish and red tilapia

Brain and lobe	African catfish			River catfish			Red tilapia		
	Half of length and height (mm)	Volume *b'c'*	Volume ratio (%)	Half of length and height (mm)	Volume *b'c'*	Volume ratio (%)	Half of length and height (mm)	Volume *b'c'*	Volume ratio (%)
Brain	9.05, 3.48	31.49		7.35, 3.74	27.49		5.85, 2.61	15.27	
Cerebllum	5.20, 1.50	7.80	25	3.67, 2.04	7.49	27	2.22, 1.08	2.38	16
Optic tectum	2.95, 1.68	4.96	16	2.73, 1.40	3.82	14	2.22, 1.40	3.11	20
Olfactory love	1.74, 1.61	2.80	9	2.40, 1.59	3.82	14	1.58, 0.89	1.41	9
ELL*	3.28, 0.96	3.15	10	2.24, 1.37	3.07	11	not present		

* Electric-sensitive lateral line lobe

African catfish: The largest and most prominent part is the cerebellum (volume ratio 25%). It is oval in shape and extends to the middle part of the olfactory lobe. The optic tectum is well developed (volume ratio 16%) and the second largest part of the brain. The brain is characterized by the presence of the well-developed electro-sensitive lateral line lobe (volume ratio 11%) forming the caudal cerebellar region and the third largest part of the brain.

The facial lobe is bulged, well developed and located on the electro-sensitive lateral line lobe. The vagal lobe is located caudal to the facial lobe. It is bulged and lobulated. The olfactory lobe is bulged and relatively well developed (volume ratio 9%). The olfactory bulb is directly attached to the olfactory rosette and connected with the olfactory lobe by means of long olfactory nerve (not shown in figure-1).

River catfish: The cerebellum is well developed and forms largest part (volume ratio 27%) of brain. It covers the optic tectum and extends to the middle part of olfactory lobe. The electro-sensitive lateral line lobe is well developed (volume ratio 11%) and forms the caudal cerebellar region. The optic tectum is bulged, relatively well developed (volume ratio 14%) and forms the second largest part of the brain. The olfactory lobe is bulged, well developed and it is as large as the optic tectum. The olfactory bulb is directly attached to the olfactory rosette and connected with the olfactory lobe by means of long olfactory nerve. The facial lobe is bulged, well developed and located caudal to the electro-sensitive lateral line lobe. The vagal lobe is slightly bulged but non-lobulated.

Red tilapia: The optic tectum is bulged well and forms the largest part of the brain (volume ratio 21%). Cerebellum is large (volume ratio 16%) but compressed and smaller than the optic tectum. It covers the facial lobe which is small and located under cerebellum. The bulge of the vagal lobe is not recognized. The electro-sensitive lateral line lobe is absent in this fish. The olfactory lobe is bulged and well developed. The olfactory bulb is directly attached to olfactory lobe.

Discussion: It is documented that African catfish and river catfish have the bulged olfactory lobe (the central nervous system, CNS, for olfaction), the facial lobe, and the vagal lobe (the CNSs for gustation), indicating that these lobes are well developed. The optic tectum (the CNS for vision) is also bulged and well developed and forms the second largest part of the brain of these catfishes. The optic tectum volume ratios 16% and 14% of the brain of African catfish and river catfish respectively are smaller than that of red tilapia of which the optic tectum is the largest brain part (volume ratio 20%). This seems to support the idea of a limited importance for vision in the catfish species. However, not only the volume ratio but also the volume should be taken into consideration. African catfish and river catfish have much larger optic tectum than red tilapia. These catfish species have much larger brain than red tilapia due to the larger cerebellum and the electro-sensitive lateral line lobe which is absent in red tilapia. Due to these, the volume ratios of the optic tectum in the catfish species are smaller than in red tilapia. As stated above, the size of each lobe depends on the extent to which its nerve fibers project information from receptor cells. The optic tectum of large volume indicates the large dependence on vision in these catfish species.

In red tilapia, the olfactory lobe and the optic tectum are well developed, and the cerebellum and the vagal lobe were less developed, which is a typical characteristics for fish with poor movement perception which is important for feeding by sight[16]. While cichlid fish species are typical visual feeders[19, 20], red tilapia have well developed olfactory lobe and less developed cerebellum. There is a negative relationship between the development of the olfactory lobe and the cerebellum indicating that feeding by olfaction does not require swift swimming[16].

The brain of African catfish and river catfish is characterized by the large cerebellum. The cerebellum has an important role in control and coordination of movements[26]. Large cerebellum is a typical pronounced feature of the brain of active swimmers[16]. Possession of the large cerebellum and the well-developed optic tectum, as well as the bulged facial lobe and olfactory lobe is a characteristic feature for fish that active during day and night[16]. This feature coincides with the radiotelemetry studies on catfish relocations which showed active movements during day and night. In African catfish, there were two peaks in home range size, during midmorning (10h00) and after midnight (0h00) in the Great Fish and Sundays Rivers, Eastern Cape, South Africa[27]. Eventhough most feeding of Afrian catfish takes at night but they also feed during day at the water surface in Lake Sibaya, South Africa[28]. A telemetry study of swimming depth striped catfish *Pangasianodon hypophthalmus* exhibited similar occupation of swimming depth during day and night in a Pangasius pond in the Mekong Delta[29]. The movement activity of flathead catfish *Pylodictis olivaris* was significantly greater during dusk and dawn as well as at night in the Lower St. Joseph River, Michigan[30], and 24 hours active with a peak before midnight in the Grand River and the Cuivre River, Missouri, Columbia[31]. In European catfish *Silurus glanis*, three of five specimens were active during day and night in a reservoir of the River Ebro, Spain[8]. In Mekong giant catfish *Pangasianodon gigas*, horizontal and vertical movements were much larger in scale during daytime than at night in Mae Peum Reservoir, Thailand[32,33]. Thus, based on the feature of the brain patterns and the radiotelemetry studies, the activity of African catfish and river catfish would not be confined within nighttime and they are also active during daytime when vision is fully functional.

Conclusion

Red tilapia have the well-developed optic tectum occupying the largest part of the brain indicating an important role of vision in their behaviour. African catfish and river catfish have the well-developed optic tectum which is the second largest part of the brain and much larger than red tilapia's optic tectum. This quantitative comparison of the brain pattern leads to a conclusion that vision is an important sense in African catfish and river catfish as well as in red tilapia. The radiotelemetry information published indicate that these catfishes are active even in daytime when vision is fully functional and support this conclusion.

References

1. Atema J., Structures and functions of the sense of taste in the catfish, *Brain Behav. Evolut*., **4**, 273-294 **(1971)**
2. Caprio J., High sensitivity of catfish taste receptors to amino acids, *Comp. Biochem. Physiol. A*, **52**, 247–251 **(1975)**
3. Pohlmann K., Atema J. and Breithaupt T., The importance of the lateral line in nocturnal predation of piscivorous catfish, *J. Exp. Biol*., **207**, 2971-2978 **(2004)**
4. Rodriguez M.A., Richardson S.E. and Lewis W.H. Jr., Nocturnal behavior and aspects of the ecology of a driftwood catfish, *Entomocorus ganeroi* (Auchenipteridae), *Biotropica*, **22**, 435-438 **(1990)**
5. Pohlmann K., Grasso F.W. and Breithaupt T., Tracking wakes: The nocturnal predatory strategy of piscivorous catfish, PNAS, **98**, 7371–7374 **(2001)**
6. Weisel G.F. and McLaury E.L., Blind catfish (*Ictalurus nebulosus*) from Dog Lake, Oregon, *Copeia,* **1964**, 687-689 **(1964)**
7. Rubec P.J., Age, growth, distribution, reproductive behavior, food habits and mercury concentration of the brown bullhead *Ichtalurus nebulosus* (Le Sueur) in sections of the Ottawa River and Hawkesbury, Canada, M.S. Thesis, Univ. of Ottawa **(1975)**
8. Carol J., Zamora, L. and García-Berthou E., Preliminary telemetry data on the movement patterns and habitat use of European catfish (*Silurus glanis*) in a reservoir of the River Ebro, Spain, *Ecol. Freshw. Fish.,* **16**, 450-456 **(2007)**
9. Takai N., Sakamoto W., Maehata M., Arai N., Kitagawa T. and Mitsunaga Y., Settlement characteristics and habitats use of Lake Biwa catfish *Silurus biwaensis* measured by ultrasonic telemetry, *Fish. Sci*., **63**, 181-187 **(1997)**
10. Britz P.J. and Pienaar A.G., Laboratory experiments on the effect of light and cover on the behaviour and growth of African catfish, *Clarias gariepinus* (Pisces: Clariidae), *J. Zool*., **227**, 43-62 **(1992)**
11. Mukai Y. and Lim L.S., Larval rearing and feeding behavior of African catfish, *Clarias gariepinus* under dark conditions, *J. Fish. Aquatic Sci*., **6,** 272-278 **(2011)**
12. Moore J.W., Piscivorous activities of brown bullhead in Lockhard Pond, Ontario, Canada, *Prog. Fish Cult.*, **34**, 141-142 **(1972)**
13. Spataru P., Viveen W.J.V.R. and Gophen M., Food composition of *Clarias gariepinus* (= *C. lazera*) (Cypriniformes, Clariidae) in Lake Kinneret (Israel), *Hydrobiologia,* **144**, 77-82 **(1987)**
14. Fatollahi M. and Kasumyan A.O., The study of sensory bases of the feeding behavior of the African catfish *Clarias gariepinus* (Clariidae, Siluriformes), *J. Ichthyol*., **46,** 161-171 **(2006)**
15. Lee C.K., Kawamura G., Senoo S., Ching F.F. and Luin M., Colour vision in juvenile African catfish *Clarias gariepinus, Int. Res. J. Biological Sci*., **(2013)** (in press).
16. Uchihashi K., Ecological study of Japanese teleosts in relation to the brain morphology, *Bull. Jap. Sea Regional Fish. Res. Inst.*, **2**, 1-166 **(1953)**

17. Brandstätter R. and Kotrschal K., Brain growth patterns in four European cyprinid fish species (Cyprinidae, Teleostei): roach (*Rutilus rutilus*), bream (*Abramis brama*), common carp (*Cyprinus carpio*) and sabre carp (*Pelecus cultratus*), *Brain Behav. Evolut.,* **35**, 195-211 **(1990)**

18. Kotrschal K., van Staaden M.J. and Huber, R., Fish brains: evolution and environmental relationships, *Rev. Fish Biol. Fisher.,* **8**, 373-408 **(1998)**

19. Douglas R.H. and Hawryshyn C.W., Behavioural studies on fishvision: an analysis of visual capabilities. *In* The Visual System of Fish, Edited by Douglas R.H. and Djamgoz M.B.A., Chapman and Hall, London, 373-418 **(1990)**

20. Castro A.L.S., Gonçalves-de-Freitas E., Volpato G.L. and Oliveira C., Visual communication stimulates reproduction in Nile tilapia, *Oreochromis niloticus* (L.), *Braz. J. Med. Biol. Res*., **42**, 368-374 **(2009)**

21. Lisney T.J., Studd E., Hawryshyn C.W., Electrophysiological assessment of spectral sensitivity in adult Nile tilapia Oreochromis niloticus: evidence for violet sensitivity, *J. Exp. Biol*., **213,**1453-1463 **(2010)**

22. Jalabert B. and Zoar Y., Reproductive physiology in cichlid fishes, with particular reference to Tilapia and Sarotherodon, The Biology and Culture of Tilapias, ICLARM, Manila, **(1984)**

23. NRC (National Research Council)., Guide for the care and use of laboratory animals, Edited by Institute of Laboratory Animal Resources, National Academy Press, Washington, DC **(1996)**

24. Uchihashi K. and Yamaguchi M., Changes in external form of brain of *Mylio macrocephalus* (Basilewsky) during growth, *Ann. Rep. Japan Sea Regional Fis. Res. Lab.,* **2**,75-80 **(1955)**

25. Masuda R., Behavioral ontogeny of marine pelagic fishes with the implications for the sustainable management of fisheries resources, *Aqua-BioSci. Monogr.*, **2**, 1-56 **(2009)**

26. Paulin M.G., The role of the cerrebellum in motor control and perception, *Brain Behav. Evol*., **41**, 39-50 **(1993)**

27. Kadye W.T., Assessing the impacts of invasive non-native African sharptooth catfish *Clarias gariepinus,* Ph.D. Thesis, Rhodes University **(2011)**

28. Bruton M.N., The food and feeding behaviour of *Clarias gariepinus* (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids, *T. Zool. Soc. London*, **35**, 47–114 **(1979)**

29. Lefevre S., Huong D.T.T., Ha N.T.K., Wang T., Phuong N.T. and Bayley M., A telemetry study of swimming depth and oxygen level in a Pangasius pond in the Mekong Delta, *Aquaculture*, **315**, 410-413 **(2011)**

30. Daugherty D.J. and Sutton T.M., Seasonal variation in home range size and habitat use of flathead catfish in Buffalo Springs, Texas, *N. Am. J. Fish. Manage.*, **25**, 256–269 **(2005)**

31. Vokoun J.C. and Rabeni C.F., Summer diel activity and movement paths of flathead catfish (*Pylodictis olivaris*) in two Missouri Streams, *Am. Midl. Nat.,* **155**, 113–122 **(2005)**

32. Mitamura H., Mitsunaga Y., Arai N., Yamagishi Y. and Khachaphichat M., Vertical movements of a Mekong giant catfish (*Pangasianodon gigas*) in Mae Peum Reservoir, northern Thailand, monitored by a multi-sensor micro data logger, *Zool. Sci*., **24**, 643–647 **(2007)**

33. Mitamura H., Mitsunaga Y., Arai N., Yamagishi Y., Khachaphichat M. and Viputhanumas T., Horizontal and vertical movement of Mekong giant catfish *Pangasianodon gigas* measured using acoustic telemetry in Mae Peum Reservoir, Thailand, *Fish. Sci*., **74,** 787–795 **(2008)**