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The Cichlidae Fishes of Otamiri River, Imo State Nigeria: A Model System of Adaptation Evolution

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Abstract

The adaptative evolutionary trend of the fishes – Cichlidae was evaluated using the body morphometric, the feeding ecology and environmental factors controlling the distribution of the fishes in Otamiri River, Imo State in relation to the growth biology and adaptation to aquatic life were studied between February and April 2021. Two hundred and twenty-two (220) samples were collected and identified. The fish identified were *Tilapia zilli, Tilapia mariae, Oreochromis niloticus, Tilapia guineensis, Sarotherodon melanotheron, Pehiachromis taeniatus,Tilapia aurea, Tilapia melaontheron, Sarotherodan galibeeas,Tilapiadigati, Hemicronus fasciatus, Hemicronus elongates.* The standard length felled between the range of 13.35cm and 16.40cm, average of 14.55 cm. Body weight between153.00g and 168.50g, average of 163.76g. Length ratio ranged between 1.1:1 to 10.20:1 which showed omnivorosity. The fishes fed mainly on detritus and plant materials. Detritus constituted about 23%, Spirogyra 7%, Diatoms 10%, higher plant materials about 17% and unidentified 17%. The fishes are omnivorous feeders and with availability of food and nutrient the fishes display sustenance growth and abundant fishery production in Otamiri River.

Keywords: Species, Cichliformes, Mouth-brooding, Egg, Frys,

Introduction

Fryer and Iles (1972) and Olaosebiken, and Raji, (2004) described the Cichlids fishes to belong to the family of fish known as Cichlidea in the Order Cichliformes. Fryer and Iles (1972), one of the earliest researchers on the Cichlids fishes of the Great Lakes of Africa stated that the Cichlids are known to have evolved rapidly into many closely related but morphologically diverse species. The study of the Cichlids' evolution is largely and greatly inspired by the classic monographs of Fryer and Iles (1972) and Greenwood (1974) whose efforts towards categorizing the nature of Cichlid radiations have progressed on multiple forms as evidenced by several recent reviews including Kornfield and Smith (2000);Danley& K ocher (2001); Turner *et.al.* (2001); Kocher (2004); Salzburger & Meyer (2004), Olaosebiken, and Raji, (2004). Most recently, Koblmuiiller *et al* (2004) explained that about 3,000 species of Cichlids species are known with about 1,300 already described. The researchers noted that Cichlids represent an important species-rich family, close to the species of Cyprinidae family and account for 13% of exant fresh water fish diversity, naturally distributed in all freshwater bodies. Koblmuiiller *et al* (2004) also noted that the Cichlids represent the most species-rich family of vertebrates and account for about 10% of extant teleost diversity. Throughout the distributional range, the Cichlids have repeatedly demonstrated the capacity to form adaptive radiative speciation with niche partitioning and generating an outstanding variation of body shapes, colour patterns, behaviour and ecomorphological speciations (Danlay and Kocher,2001; Joyce *et. al.* 2005; Barluenga *et al,*2006; Lopez-Fernandez *et. al*. 2013; Schliewen *et al,*1994; Joyce, *et al* 2011). Olasebikan and Raji (2004) stated that as a group, Cichlids exhibit a striking diversity of body shape, strongly laterally compressed species such as *Tylochronuis sudanensis*, cylindrical and highly elongated body such as *Pelmatochronuistaeniatus,* and noted thatthe Cichlids of *Tilapia*species are important food stock,that have great parental care for their eggs and frys by guarding them through mouth-brooding.

Cichlids have evolved different types of feeding habits but generally, are omnivorous feeders (Onimisi and Ogbe, 2015a). Onimisi (2018) quoting Chalkia and Bobori (2006) explained that morphological characteristics as the mouth and intestines of fish species are used to relate the feeding habits and fractional trophic levels of evolution of fish species. The authors showed that variations in morphology are due to differences in the ability of different fish species to catch and consume their food, which affects the overall diet composition. In the same vein, Wootton (1998); Helfman *et al*., (2009) showed that the length of the intestine largely varies in fish correlating generally with their feeding habits, and gut lengths vary from one-third to one-quarter of the body length in some carnivores to two to twenty times body length in herbivores and the detritus feeders. However, Karachle and Stergiou (2010a) and Karachle and Stergiou (2002b) stated that in fish species, for a given body length, the intestine in herbivores is longer than in omnivores and omnivores, longer than in carnivores. Falayi (2009) submitted that gut length can be less than one-half of the body length especially in carnivores and about six to eight times the body length in herbivores. Orosaye and Nakpodia (2005), RamaRao (2017); Gupta and Banerjee (2014) explained that adequate knowledge of food and feeding habits of any fish species is essential for the development of a successful fisheries management programme both in the wild, under culture and in captivity. Many research works have been carried out on the morphometric and feeding ecology in relation to adaptation to the aquatic life of fishes. For example, Omoniyi *et. al.* (2011) reported on the morphometric variation and food habits of *Ctenopoma pethereci* Guntherin River Oluwa, Ondo State, Nigeria, Lawal *et.al* (2010) worked on the morphometry and diet of *Chrysichtys nigrodigitatus* in Epe Lagoon; Onimisi and Ogbe (2015a) gave a morphometric account of three Cichlids *Tilapia zillii, Orechromis niloticus* and *Chromidotilapia gruntheri* from River Okura.

Cichlids exhibit a unique pattern of oval-shaped, colour dots on their anal fins. Olasebikan and Raji, (2004) showed that these features are for sexual attractions and further explained some important characteristics that distinguish the Cichlids within the family, including a single nostril on each side of the fish head, and division of the lateral line into two. Onimisi (2018) explains that morphometric measurements are a major biological tool for identifying fish populations. Also, morphological characteristics such as body length and weight and structure of feeding apparatus have been used to determine the growth rate and abundance of fish and relate same to feeding habits (Karachle and Stergion; 2010b). Knowledge of morphometric adaptation and food and feeding habits of fish species is useful for a proper understanding of the fishery. Onimisi (2018) quoting Oronsaye and Nakpodia (2005): Gupta and Banerjee(2014) explain that studies on the feeding ecology of fish in a habitat are useful to determine the population level of the species since the number of individuals of a fish population depends on the amount of food available to the population.

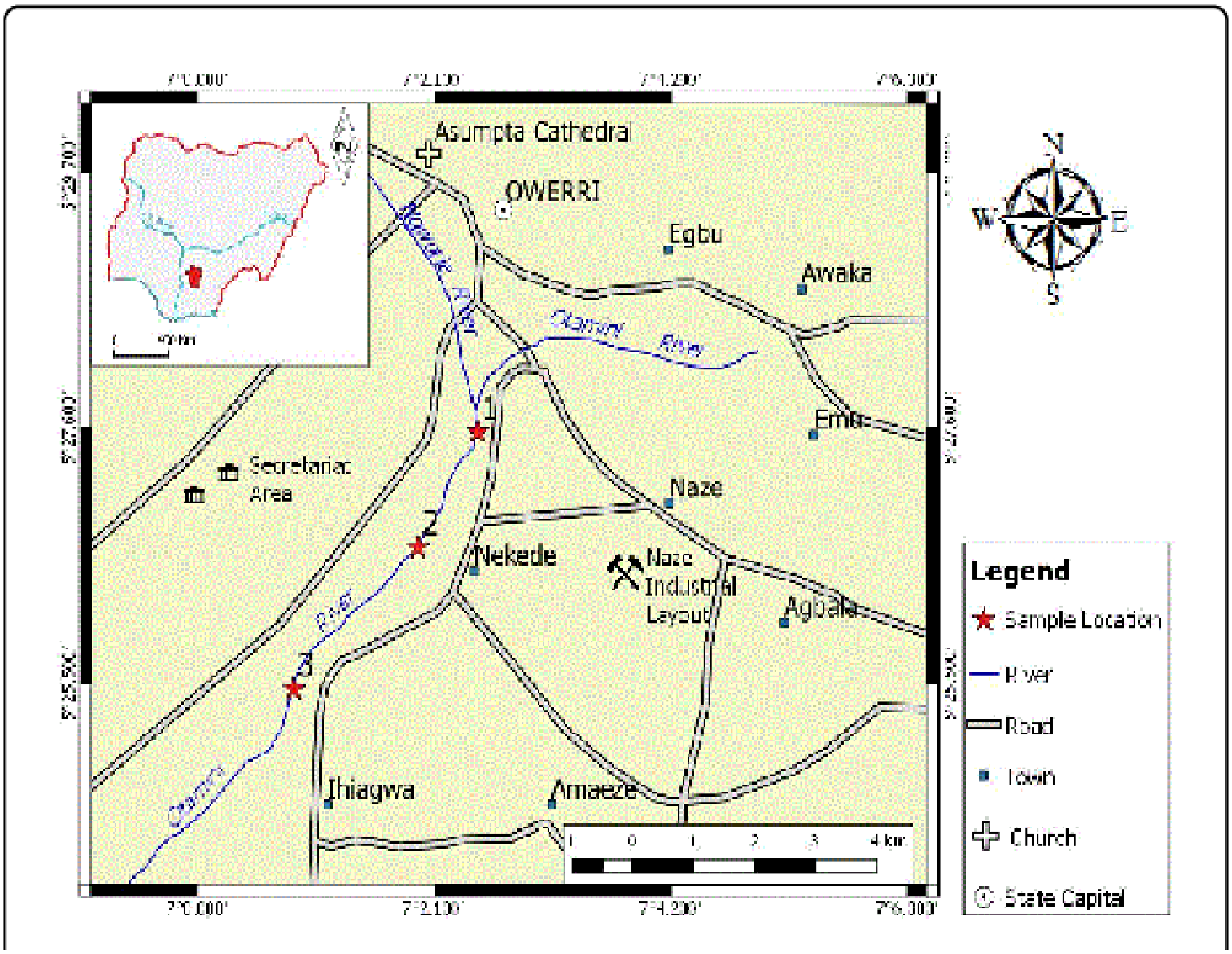
The Cichlids are a common fish in the fisheries catch of Nigerian waters as found out by Nwadiaro and Okereke (1993); Ohaturonye *et. al.* (2018). Correlating the food and feeding habits of the Cichlids to their morphology and ecology to aquatic adaptation would be a successful agenda for their fisheries with an adequate understanding of the morphology and feeding habits. This present research is therefore aimed at studying the ecomorphological adaptations of the Cichlid fishes in relation to their feeding habits to aquatic life and elucidating the salient factors that support their success in Otamiri River.

Materials and Methods

Description of Study Area

The study and fish sampling were done at Otamiri River axis within Umuagwoareabehind the Department of Fisheries and Aquaculture of the University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria.

Otamiri River originated at Egbu, in Owerri North LGA and confluences with Nworie Stream in Owerri Muncipal area. The River lies between the longitude 06º57' to 0.11º46' E and latitude 05º20' to 0.35º, 66'N' spanning 2 kilometres (Urban and Regional Planning, Imo State Polytechnic, Umuagwo as described by Nwadiora and Okereke, 1993). The entire area lies within the Guinean Equatorial rainforest zone of Nigeria, 61-122m above sea level. The river starts as a first-order stream, then flows westward for about 7km to receive another first-order stream Nworie. From that point, it flows southwards as a second order river for 28 kilometres and receives a major tributary, River Oramiruka. At the Oramiruka input, it continues southward for another 21km before it reaches the Ogochia River, its third tributary in Etche LGA in Rivers State. It finally continues for another 26km downstream to the south near Owaza in Ikwerre LGA of Rivers State, where it discharges into the Imo River. The length from source to mouth is approximately 82 kilometres.



Map of the Study Area

Fish Sampling

- This project was carried out for a period of three months (February to April 2021), fishing once in a week, thusing departmental fishermen who fished with hooks, line and conical nets.
- The fish of Cichlidae family were identified by the method described byOlasebikan and Raji(2004) and sorted out.
- All laboratory protocols were observed e.g. morphometric measurement such as Standard length, Total length, and Weight.

- Dissection was done to expose the gut and the stomach, and the food materials identified.
- The length of the gut was then measured from the tip of the pharynx to the anus
- Stomach content analysis was done using Frequency of Occurrence, volumetric methodand Numerical Method.
- All parameters to justify the success of the class Cichlidae in Otamiri River were determined.

Morphometric Data

Body length, gut length and weight were measured to the nearest cm and gram. The standard length, total length gut length, and weight were measured. The lengths were measured using the metre rule while the weights were measured using the Mettler weighing balance.

Gut Length

All the fish samples were dissected for stomach content analysis. The gut from the pharynx to the anus was cut off and brought out from the cavity and measured to the nearest cm on a metre rule. Hence on each fish sample, the relationship of the gut length to the standard length was taken by dividing the gut length by the standard length of each particular fish, as determined by Odum (1968).

Stomach Content Analysis

The analysis was carried out in two different approaches. The qualitative examination of the gut content comprised a complete identification of the food items in the gut which was done by the frequency of occurrence method, while the quantitative examination of food items was done using a numerical method and volumetric method.

Frequency of Occurrence Method

Frequency of occurrence method as described by Hynes (1950) and adopted by Fagade and Olaniyan (1972); Sarker *et.al*, (1980) was used in the qualitative assessment of the food and feeding habit of the fish. The number of stomach samples containing one or more of a given food item was noted, computed and expressed as a percentage of all stomachs examined containing a particular food item. This process was carried out for all the stomachs that were investigated. It is expressed with the formula: Frequency of Occurrence method:

$$\text{\% of Occurrence of food item} = \frac{\text{No. of stomach with food items}}{\text{Total No. of stomach with food items}} \times \frac{100}{1}$$

Numerical Method:

The number of individual food types in every stomach is counted and expressed as a rate of the aggregate number of food items in each sample study or as a rate of the stomach contents of every sample analyzed, from which the aggregate rate structure is then evaluated. The number of each food item was expressed as the percentage of the total number of food items found in the stomachs (Windell and Bowen, 1978) and adopted by Sarker *et al*(1980) with the formula:

$$\text{\% No. of food item} = \frac{\text{Total No. of a particular food item in the stomach}}{\text{Total No. of all food items in the stomach}} \times \frac{100}{1}$$

Thus, the stomach was removed and the content extracted, blotted dry and weighed on a Mettler analytical balance to the nearest 0.1mg for small extracts and with ohms triple beam balance for big samples. The stomach contents were subsequently preserved in a separate labelled petri dish containing 10ml of 5% formalin. For microscopic examination, the content of each Petri diss was agitated and a drop taken out with a dropping pipette and diluted to aid identification and counting for each sub-sample that is each dish representing one fish sample, three drops of the stomach contents were taken and placed on a haemacytometer slide, a counting chamber with each cell or division measuring 0.2mm X 0.0025mm, and the content examined. This procedure was repeated three times. The individual food items found in the sixty-four (64) cells of the haemocytometer slide were enumerated with the aid of a tally counter by counting the 25 cells and then multiplying by 64 by the average count of the 25 cells. The mean number of food counted for the average of the 64 cells was multiplied by the haemocytometer factor (×4000) to obtain the equivalent number of the food item in the 1ml volume of the stomach contents. The total number of the same food item e.g. leaf of a plant in the 10ml food sample was sequentially determined by multiplying the number of each organism counted in the 1ml sample by 10. Results were expressed in relative diet composition only.

Volumetric Method

This followed the techniques adopted by Arowomo (1976) and Ikisemiju and Olaniyan (1977). Each of the food items recognized was drained of excess moisture using blotting paper and immediately displaced in a partially filled graduated cylinder, at the same time as sand, dust and debris were estimated through sedimentation. This technique involves measuring the volumes of different food items found in the stomach and expressing them as a percentage of particular food items. This procedure was carried out for all the food items identified. Hence,

$$\text{Volumetric \%} = \frac{\text{Total volume of food item}}{\text{Grand total volume of all food items}} \times \frac{100}{1}$$

Relative Gut-index (RGI)

The relative gut index (RGI) is the ratio of the gut length to the standard length of the fish, Odum (1968). The ratio is used for the classification of different size fish as carnivores, herbivores or omnivores a main morphological variable for determination of feeding intensity. To evaluate this ratio, twenty fish samples were randomly selected from the three-month samples. They were dissected through the abdomen and the gut; from the oesophagus to the caeca and used for the analysis. The parameter was calculated as follows:

$$\text{Relative Gut – Index} = \frac{\text{Gutted length (cm)}}{\text{Standard length (cm)}}$$

Result

Morphometric Data

Table 1: Morphometric Data of Cichlid fishes sampled in Otamiri River between 03/02/2021 and 30/04/2021

No. of samples	Weight	Mean $\bar{X}$	Total length	Mean $\bar{X}$	Standard length	Mean $\bar{X}$	Gutted length	Mean $\bar{X}$
11	1769.11	160.86 ± 11.40	178	11.18±1.6	1507	13.7±1.8	13.2	12±1.70
20	3126.2	156.31± 10.2	410	20.5±204	323	16.15±1.7	230	11.5± 50
11	1857.68	168.88± 12.7	168.19	15.29±1.7	147.40	13.40±1.5	13.20	12.0± 2.70
14	1320.90	161.76± 10.2	232.96	16.64±1.8	186.90	13.35±1.7	148.96	10.64± 4.1
23	3784.65	164.55± 10.4	384.79	16.73±1.9	291.87	13.69±1.7	296.70	12.90± 2.5
12	1961.40	163.43± 13.4	198.63	16.55±1.8	168	14.0±1.9	135	11.25± 1.6
15	2295	153.0± 10.9	247.40	16.50±1.7	202.5	13.50±1.8	187.5	12.50±2.8
11	1768	160.80± 12.1	178.20	16.20±1.5	150.7	13.70±1.27	114.40	10.40±2.4
11	1769.68	160.88±12.4	178.20	16.20±1.2	147.40	13.40±1.4	121	11± 3.1
20	3126.34	156.31± 13.4	324	16.60±1.4	274	13.70±1.2	228	11.4± 2.5
21	3539.34	168.54± 15.4	378	18.00±2.8	294	14.00±1.5	273	13± 1.60
14	3539.34	168.54± 17.4	238	17.00±1.9	196	14.00±1.7	143.96	10.64± 1.70
15	2461.95	164.13± 12.4	255	17.00±1.8	195	13.00±1.2	150	10.00± 1.2
12	1956	163.00± 11.4	204	17.00±1.8	168	14.00±1.4	134	11.00± 2.4
11	1771	161.00± 10.2	178.20	16.20±1.7	147.4	13.40±1.6	110	10± 1.4
221	31050.75							

Table 1 shows the number of Cichlid fishes sampled during the fifteen-week sampling period. Two hundred and twenty Cichlids were sampled and used for the investigation. The highest number of Cichlids caught in a particular sampling period was 23 during the period 08/02/2021 while the lowest number was 11 caught during the period 11/02/2021, 13/03/2021 and 20/03/2021 respectively. The average mean weight of the fish caught was 168.54g average mean total length was 384.79cm and the standard length was 294cm. The gutted length average mean was 12.90cm.

Stomach Content Analysis

Table 2: Summary of food items in the stomach of 220 Cichlid fishes sampled in Otamiri River between 03/02/2021 and 30/04/2021.

Food items	**Frequency of Occurrence**		**Volumetric method**		**Numerical method**	
	No of fish stomach	**Percentage frequency**	**Volume (ml)**	**Diet Composition**	**Number of food items**	**(%) number**
Detritus	153	72	11	25.0	11	4.0
Higher plant Dead plants, leaves, shaft	114	53	4.0	9.0	16	5.0
Unicellular Green Algae (chlorophyceace)						
Scenedesmus	46	22	8.0	18.0	20	7.0
Eudorina	21	10	4.0	9.0	65	22.5
Closterium	85	40	3.0	7.0	36	12.5
Filamentous green algae						
Spirogyra	46	22	3.0	7.0	52.	18
Diatoms	71	33	4.0	9.0	65.0	22
Rotifera						
Kerallera	16	8	3.0	7.0	8	3.0
Unidentified	112	53	4	9.0	8	7.0
Total			44	100	295	100

Table 2 shows the analysis of the stomach content of Cichlid fishes sampled for investigation. Two hundred and twenty (220) specimens of Cichlid fishes from Otamiri River were sampled and examined, out of which One hundred and fifty-three (153) contained food items. The dominant food items were detritus, phytoplankton, leaves of plants and shafts were dominant in the stomach of the fish. Detritus occurred in 153 of the stomach with 72% occurrence and contributed 25% by volume of the diet composition. Unicellular green algae identified included *Eudorina*which occurred in 46 of the stomachs, and constituted 8% by volume of the diet. *Closterium* occurred in 85 of the stomach and contributed 50% of the diet. *Spirogyra*species occurred in 45 and contributed 22%. On the whole, in Otamiri River the Cichlids feed on food materials namely detritus, sandy muds, leaves of plants, blue-green algae, unicellular green algae, and filamentous green algae. Leaves of plants and unicellular green algae mostly the Chlorophyceae are the highest diversity of organisms including *Scenedesmus, Eudorina.* and *Closterinum* contributing 22%, 10%, and 40% respectively of the total diet composition. The next in order of importance is filamentous green algae which included *Spirogyra* and *Diatoms* which account for 22%, 33% respectively of the diet composition. Others of little consequence were unidentified and digested items which make up 53% of the diet. Rotifers contributed 8% by the volume of the food items. Table 2 shows the analysis of stomach contents.

Relative Gut Index

Table 3: Relative Gut Index of Cichlid fishes sampled in Otamiri River between 03/02/2021 and 30/04/2021.

Mean Standard length	Mean Gutted length	Ratio
13.7	12	1.1:1
16.15	11.5	1.3:1
13.40	12.0	1.1:1
13.35	10.64	1.3:1
13.69	12.90	1.2:1
14.00	11.25	1.2:1
13.50	12.50	1.1:1
13.70	10.40	1.2:1
13.40	11.00	10.2:1
13.70	13.00	1.1:1
14.00	10.69	1.2:1
14.00	10.00	1.3:1
13.00	11.00	1.2:1
14.40	10.00	1.2:1
13.40	10.00	1.2:1

Table 3 shows the gut length / standard length radio of the fish samples under investigation. The gut length for the sample fish ranged between 10.00cm to 13.00cm with a mean of 10.40cm generally the ratio of gutted length to the standard length of 1.2:1 was observed for the majority of the samples.

Discussion

The highly complex social behaviour and diverse morphology, Cichlid fishes exhibit a striking variation in body form and structure. Early work (Fryer and Iles, 1972) identified numerous selective forces involved in the origin of a divergence of Cichlid adaptation to aquatic life. As noted and observed in the study, Cichlids have distinct body shapes and sizes which help them in aquatic adaptation. Cichlids span a wide range of body sizes from species as small as 2.5cm (0.98g).A single nostril on each of the forehead, no bony shelf below the orbit of the eye; division of the lateral line organ into two sections, on the upper half of the flank and a second along the midline of the flanks from about halfway along the body to the base of the tail. All these body characteristics help for dexterity in water. Omimisi (2018) submitted that all fishes vary tremendously in morphology and physiology of digestive tract and in feeding behaviour, and noted that some fish have gut lengths less than one-half of their body length, especially carnivores fishes and others have got about six to eight times of their body length (Falayi, 2009 and Kalachle and Stergiou, 2010a). For example, Falayi (2009) observed that *Heterobranchus longifilis* in river Okura was an Omnivore material like fish remains and insects. In this research the Cichlid fishes eat mostly plants and plant remains which made them omnivores, in comparison to *H. longifilis,* which tended towards carnivores. The gut length ranged between 0.6 to 1.3 as the standard length of the fish is patterned after its carnivores habit. The diet of H. *longifilis* included animal remains. All Cichlids have some form of parental care for their eggs and frys. Parental care comes in the form of guarding the eggs and fry in mouth-brooding. The omnivorous nature of the cichlid fish endows it with many niches known in freshwater ecosystems. The structure of the body with well-defined lateral line endows the fish for active life in water. This is very important as it enables the fish for great abundance and biodiversity, Falayi (2009).

Conclusion

The study reveals the great importance of the Cichlid fishes in Otamiri River. The success of this class of fish in the River is evidenced by their morphometric adaptation with well defined streamlined body with a coordinating digestive tract that adulates to eating available food items and with the omnivorous gut system that support their feeding habit. The types of food and their reproduction potentials. The Cichlids are known to have great parental care, even as far as mouth-brooding. This ensures high protection of the young ones and thus ensures a great abundance of the fish in the water. In addition, they are known to lay large number of eggs which are jealously protected till they are hatched, ensuring great protection of the young ones.

Recommendation

The fishers in Otamiri river decry the obnoxious activities of sand dredgers in the rivers whose activities destroy the river ecosystem and make fishing unsustainable agricultural business in the river. Therefore it is recommended that the activities of the sand dredgers are checked. All stakeholders particularly fisheries professionals and government agencies are required to formulate laws that will check mate the activities of the sand dredgers. Also breeding eco system areas may be mapped out as breeding ground and preserved for such purposes in Otamiri river to ensure uninterrupted breeding cycle.

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