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Reproductive Structure of Invading Fish, *Oreochromis niloticus* (Linnaeus, 1757) in Respect of Climate from the Yamuna River, India

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Abstract

Fish is a rich source of protein, vitamins and minerals. New knowledge on the role of omega-3 fatty acids in human physiology and their high contents in fish has added a new dimension to their importance in health and nutrition. *Oreochromis niloticus* (Nile tilapia) is one of the fish species of great economic importance in the globe. Reproductive biology of *O. niloticus* in the Yamuna was studied. Samples of *O. niloticus* were collected monthly during August 2011 to July 2012. The fishes breed in months of March to June and September to November. Sex ratio of male and female fishes was equal in 43.1-46.0 cm size group. Male proportion was higher in all size groups except 43.1-46.0 cm size group. In 10.1-13.0 cm, 25.1-28.0 cm and 28.1-31.0 cm size groups' female proportion was half as compared to male fishes. Observed difference was not significant in all size groups, except 19.1-22.0 cm size group. Chi-square values were recorded maximum in 19.1-22.0 cm size group with 4.56 and minimum in 31.1-34.0 cm size group with 0.02. Higher proportion of male was observed in the stock, sex ratio of male and female was 1:0.78 and Chi-square value was 7.94 and the difference was significant. The fecundity and breeding frequency of *O. niloticus* indicated that the climate condition of the Yamuna river most suitable for *O. niloticus*.

Keywords: Fecundity; Sex ratio; Yamuna River; Climate; *Oreochromis niloticus*

Introduction

The large network of inland water masses will continue to provide great potential for economic capture fishery which consequently will compete well with fast growing fish culture practices. The freshwater inland water bodies fall into five major categories, the Ganga, the Brahmaputra, the Indus system, the East and the West coast of India. These water bodies have certain characteristics of their own with respect to their ecology, climatic conditions and fish populations of commercial food fishes.

Oreochromis niloticus (Nile tilapia) is an African native fish species. This species is naturally distributed in the Nile River as well as most parts of African rivers, reservoirs and lakes. It is exotic fish species for India. It is now transplanted to many other countries of the globe especially the tropical and subtropical parts of the world. It has become the second most commonly consumed farmed fish after carps [1]. It is commercially exploited in the Yamuna and Ganga River India [2-4]. Natural fisheries resources are dense by its stock in central India [5,6]. Natural fisheries are worked on a catch and return basis [7-9]. It is one of the most popular fish species for human consumption and profitable purposes by majority of poor community and fishermen [10]. *O. niloticus* is a deep-bodied fish with cycloid scales [11]. Culture of *O. niloticus* is increasing significantly in African and several Southeast Asian countries due to its fast growth rate under high stocking rates and seed availability in culture ponds [12,13]. It grows to a maximum length of 62 cm with weight 3.65 kg (at an estimated 9 years of age) [14]. Its survival and growth are superior in polluted water [15,16]. Heavy metal pollution is harmful for gonadal development [17]. Gonad condition (development) of fishes are total responsible for the propagation of the stock.

Breeding is synonymous to fish broadcast which simply means multiplication. Most riverine stocks are composed of multiple distinct breeding populations. Breeding is important for wild sock of fishes in natural water bodies. The sex ratio is very important to the reproduction of a population [18]. Information on the breeding and fecundity of *O. niloticus* can provide basic knowledge for the proper management of the resource. However, such knowledge is not recently available for this species in the Yamuna and this has hindered proper management of the fishery. Knowledge of sex ratio is considered essential in the management of the fisheries as it enables to follow the movement of the sexes in relation to the season [19]. The sex structure is very important to the sustenance of a population, and consequently there are mechanisms for adjusting it to changes in the food supply. The last is itself dependent on the population density, so that the sex ratio naturally reflects the density [20].

Studies on the various aspects of reproductive biology of *O. niloticus* have been carried out in the different parts of world. Considerable literature is available on the fecundity [21-26] spawning [24,27-29]. Sex ratio has been studied [22,24,29,30-34]. But nothing is known about *O. niloticus* with respect of reproductive biology from the Yamuna River, India. A large number of studies assess the main biological parameters and population dynamics of the *O. niloticus* for fisheries but lock in case of reproductive parameters. The present study was carried out to investigate sex ratio, sex structure, breeding season and fecundity of *O. niloticus* from the Yamuna River at Allahabad, India. Record and assessment of the present research work is necessary to formulate informed decisions about restoration and management of the fishery and rivers.

Materials and Method

Climate

The climate of the Gangetic plain is characterised by dry and wet periods. The dry period is longer than the wet period. The maximum air temperature is about 45°C to 46°C at Allahabad during May and June. The major wet period (monsoon) extends from mid-June to September. Though rainfall occurs in winter, it is negligible to be categorised as a wet period. The dry period therefore extends from October to mid-June, for nearly about 8 months. Occasional showers of local rainfall may occur in dry period following disturbances.

Methodology

During the course of study 516 specimens of *O. niloticus* (290 males and 226 females) were considered for the estimation of sex ratio and sex structure but in case of fecundity we 23 samples were collected. The female sex (fish) was determined by microscopic examination of the ovary as they show sexual dimorphism only in the breeding season. The numbers of fish samples were segregated on the basis of their sex (male and female) to determine the percentage composition of each sex in different age groups. This helped to understand the distribution of sexes in different age groups. Their ratio (M:F) was computed for each age group. The significant deviation from the hypothetical 1:1 sex ratio was tested by Chi-square [35] at 5% significance level.

Twenty three ripe female fishes were used for fecundity estimations in present study. To obtain representative samples of the whole gonads, 3 g eggs were taken from the posterior, middle and anterior of both lobes of the ovary. The numbers of ripe eggs were counted. The total number of ripe eggs in the ovary was estimated by multiplying the number of ripe eggs in the sample by the ratio of the ovary weight to the sample weight.

Sokl and Rohlf [35] have given the following formula especially for two classes calculation of chi-square.

$$Chi - Square(\chi^2) = \sum \frac{O_i^2}{E_i} - n$$

Where

O_i=Observed frequency,

E_i=Expected frequency and

n=Number of total sample

Result

Breeding seasons

The environment condition (especially temperature) of the Yamuna River at Allahabad is slightly warm which is very favourable for *O. niloticus*. The water current velocity of the Yamuna River is very poor. Both parameters are very helpful for the stability of *O. niloticus* in the Yamuna River at Allahabad. The frequency of temporal variation between ripe males and females was similar. The smallest spent female fish was recorded with 17.8 cm total length. The fishes breed in months of March to June and September to November. A lot of spent fishes were recorded in this period. Current study indicated that the *O. niloticus* breeds two times in per year. The first breeding season was reported long with 4 months and second was short with 3 months. *O. niloticus* were caught at various stages of gonad development and reproduction in almost all months. However, their frequency varied with the month of capture. The seasonal pattern of gonad development for both sexes was almost similar.

Fecundity

A total of 23 ripe female were used for fecundity estimation. Their total length ranged from 14.6 to 40.5 cm. In the current findings, *O. niloticus* were found to be mature starting below 14.6 cm total length, taking individual fish. The number of eggs per individual ranged from 410 to 4008 (Table 1). The number of ripe eggs increased with ovarian weight. Fecundity was linearly related to total length (Figure 1). Fecundity was also linearly related to weight of gonad (Figure 2). The fecundity of *O. niloticus* indicated that the climate condition of the Yamuna river most suitable for *O. niloticus*. The number of eggs closely related to size of fishes compared to the gonad weight.

SN	Total length (cm)	Gonad weight (g)	No. of eggs
1	14.6	3.41	410
2	16.8	7.89	768
3	16.9	8.73	790
4	17.8	11.65	1286
5	17.6	10.49	1016
6	18.5	10.46	987
7	20.0	12.46	1310
8	21.1	14.21	1613
9	21.9	14.00	1706
10	23.0	13.19	1920
11	25.5	16.41	1985
12	25.6	12.20	2165
13	28.2	16.49	2065
14	28.6	19.58	2428
15	30.0	16.89	2760
16	30.6	20.49	2562
17	32.5	21.68	2941
18	33.5	22.01	2946
19	35.6	26.45	3462
20	36.0	29.65	3865
21	38.0	29.46	3659
22	39.0	27.49	3669
23	40.5	31.62	4008

Table 1: Fecundity of *Oreochromis niloticus* from the Yamuna River, India.

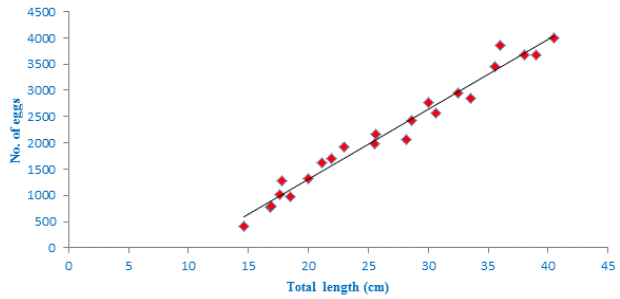

Figure 1: Relationship between fecundity and total length of *O. niloticus* in the Yamuna River.

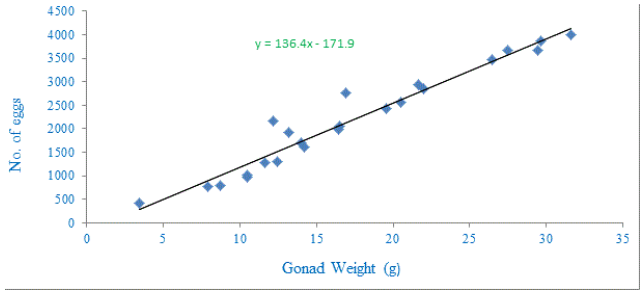

Figure 2: Relationship between fecundity and gonad weight of *O. niloticus* in the Yamuna River.

According to size, sex ratio of male and female fishes was equal in 43.1-46.0 cm size group. Male ratio was higher in all size groups except 43.1-46.0 cm size group (Table 2). The oral incubation behaviour (female, eggs and larvae) is responsible for the higher male proportion of *O. niloticus* in the Yamuna River. After spawning in a nest made by a male, the young fry or eggs are carried in the mouth of the mother for a period of 12 days. During oral incubation behaviour period female fish's movement are limited. In 10.1-13.0 cm, 25.1-28.0 cm and 28.1-31.0 cm size groups' female proportion was half as compared to male fishes. Observed difference was not significant in all size groups, except 19.1-22.0 cm size group. Chi-square values were recorded maximum in 19.1-22.0 cm size group with 4.56 and minimum in 31.1-34.0 cm size group with 0.02. Higher proportion of male was observed in the stock, sex ratio of male and female was 1:0.78 and Chi-square value was 7.94 and the difference was significant.

Size Classes (cm)	Male	Female	Sex ratio	Chi-square	Significance
10.1-13.0	10	5	01:00.5	0.72	NS
13.1-16.0	33	23	01:00.8	0.98	NS
16.1-19.0	39	35	01:00.8	1.76	NS
19.1-22.0	43	39	01:00.7	4.56	S
22.1-25.0	34	31	01:00.8	0.38	NS
25.1-28.0	39	25	01:00.5	1	NS
28.1-31.0	42	33	01:00.5	0.34	NS
31.1-34.0	15	14	01:00.9	0.02	NS
34.1-37.0	23	13	01:00.6	2.78	NS
37.1-40.0	7	5	01:00.7	0.34	NS
40.1-43.0	4	2	01:00.5	0.66	NS
43.1-46.0	1	1	01:01.0	-	-
Total	290	226	01:00.8	7.94	S

Table 2: Sex ratio of *Oreochromis niloticus* from the Yamuna River at Allahabad.

Sex structure of male and female was equal in 43.1-46.0 cm size group. Male proportion was higher than the female in all size groups. Sex structure of male was observed maximum in 10.1-13.0 cm size group (66.67%) while female was observed in 43.1-46.0 cm size group with 50% (Figure 3).

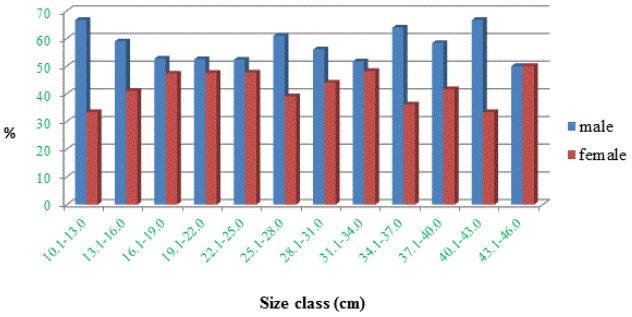

Figure 3: Sex structure of *O. niloticus* from the Yamuna River (Size).

Discussion

The fecundity of *O. niloticus* varied from 410 to 4008 eggs/fish from the Yamuna river, India. The high fecundity of *O. niloticus* in the Yamuna River at Allahabad could probably be a result of combination of different causes such as climatic condition, habitat structure, food abundance, water quality and quality of food. [28] Was observed fecundity between 241 to 709 eggs/fish in 125-209 mm size of fishes. Shalloof and Salama [36] reported more or less similar fecundity in same fish from the Abu-zabal Lake, Egypt. Lower fecundity was recorded from the lake Beseka, Ethiopia [24].

The largest size of *O. niloticus* indicated that the well stable in the Yamuna river. The size composition is good indicator for estimation of stock health in water bodies [37,38]. Male fishes of *O. niloticus* were

dominated in the lower stretch of the Yamuna River at Allahabad, India. Theoretically, the expected ratio of males to females should be 1:1 [39]. The sex ratio of most fish species in the wild tends to be 1:1, but deviations can occur and seasonal variations are common [7,40]. The sex ratio is influenced by several factors, including mortality, longevity and growth rate, these in turn lead to differences in the catch rate [41]. Generally, Tilapia species in temperate areas have very short breeding season and limited to some months only, but in tropical countries their breeding seasons are extended, and in most cases throughout the year [28]. Fecundity of *O. niloticus* depends mainly on the body condition of the fish [42].

Novaes [31] was recorded male *O. niloticus* comprised 56.1% and females 43.9% of the catches, with a sex ratio (M:F) of 1.3:1 from Barra Bontia reservoir, Brazil. Gomez-Marquez et al. [43] stated that the female *O. niloticus* (51.8%) was more than male (48.2%) from a tropical shallow lake in Mexico. Pena-Mendoza [44] reported that the 624 fishes of *O. niloticus* caught with 272 females (43.59%) and 352 males (56.41%) and sex ratio was 1:1.29 (females: males) in Emiliano Zapata dam Morelos, Mexico. Sex ratio is helpful in understanding the recruitment of fishes in population. The sex ratio in the spawning population and in the various age and size groups varies with the species, reflecting the relationship of that species to its environment. The sex structure is also adaptive to the food supply, which thereby influences the reproductive rate and the variability of the offspring [2,4].

Garcia-Lizarraga [45] stated that, in the Aguamilapa reservoir (Mexico), dominance of males *Cichlasoma beani* over females in most months. Ramos-Cruz [46] found that male *O. aureus* accounted for 72% of the population in the Benito Juarez reservoir while Biotecs [47] reported that males of *O. aureus* shared for 67% of the population in the Temazcal reservoir. Inuwa [25] reported that the sex ratio of *O. niloticus* was 1:1 in Jakara dam, Kano, Nigeria. Sex ratio differs from one population to another of the same species, and may vary from year to year in the same population [20]. The unequal sex ratio for mature fish reflects different survival rates for males and females [48]. Fecundity of fishes is associated to the growth and climatic condition [49].

Conclusion

It may be concluded that the fecundity and breeding frequency of *O. niloticus* indicated that the climatic condition of the Yamuna River is most suitable. The fecundity of *O. niloticus* in the Yamuna River is higher compared to other places of world. O. *niloticus* is powerfully invaded in the Yamuna River, India.

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