

Assessing to invasion potential of two exotic fish species, *Cyprinus carpio* (Linnaeus, 1758) and *Oreochromis niloticus* (Linnaeus, 1758) with special reference to ecological changes in the Tons river, Ganga basin, India

Abstract

Fishery resource uses/operation is the leading and economic activities for human being globally. Fishes are the top consumers in aquatic ecosystems and their size, age and growth can be concerned as an indicator of resource use efficiency and invasive potential of fishes in the ecosystems. The sample of *Cyprinus carpio* and *Oreochromis niloticus* was collected between months March 2019 to February 2021 from Sirsa fish landing centre at Prayagraj, Uttar Pradesh, India. A total of 851 (male 410 and female 441) and 935 (male 452 and female 483) fishes of *C. carpio* and *O. niloticus*, respectively individuals were examined during the study period. Size composition of *C. carpio* and *O. niloticus* fishes was fluctuated between 93 to 728 mm and 74 to 476 mm (total length), respectively. In case of pooled sample, 271-310 mm size group of *O. niloticus* fish highest fished while 241-290 mm size group of *C. carpio* fish maximum fished. In the stock, female fishes contributed greater proportion compared to male in both species. In case of pooled sample, 2+ age class of both fishes contributed maximum proportion with 25.99% in *O. niloticus* and 22.91% in *C. carpio*. All these information indicated that the both species powerfully invaded and generate problem for India major carp (IMC) in the Tons river, India.

Keywords

Cyprinus carpio, *Oreochromis niloticus*, size structure, sex structure, age pyramid.

Introduction

The *Cyprinus carpio* (Common carp) and *Oreochromis niloticus* (Nile Tilapia) has of great socio-economic importance for the Prayagraj region and keeps active a population of about 1000 to 1300 fishers family at Prayagraj, India. Both species are exotic or non-native fish species

Research Article

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Received: 26 Oct, 2025; **Accepted:** 17 Nov, 2025;

Published: 27 Nov, 2025.

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for India. Exotic or non-native species continue to be altering the function and structure of the ecosystem globally [1-4]. Invaded non-native fish species can cause significant adverse impacts on ecosystems as like food web and ecosystem functioning and ecological damage [5,6]. These fishes play important role for food security and livelihood for fishers of the Ganga basin, India [7]. The basin have many undeveloped areas and low income community especially Vindhyan region (Central India) [8]. Due to world globalization, an increase in biological invasions especially fish species (example fishes namely *Oreochromis niloticus*, *Cyprinus carpio* and few ornamental fishes) has proliferated in the few decades.

Cyprinus carpio (Common carp) is the only fish which has perhaps a worldwide distribution with dominant species in many countries since the present century [9-11]. The original natural distribution of the species was rest to a narrow belt in Central Asia within latitudes 350 to 500 North and longitudes 300 to 450 East [8,12,13]. In its original habitat common carp is a river fish (Example warm, deep, slow-flowing and still waters such as lowland riv-

ers and large) in the region of the earth with soft bottom sediments which is characterized by a hot summer and a cold winter, scarcity of rain, light seasonal, with the altitude generally over 300 m above sea level [14-16]. Its growth, fecundity and survival rate are superior in the polluted water compared to other carps except *Oreochromis niloticus* [11, 17-19]. It is one of only eight fish on the IUCN list of the world's worst 100 invaders [20]. Their invasive potential arises in new area or water due to fast growth, early maturity and high fecundity [13, 21-23]. It is the most common cyprinid fish species that generates a significant part of inland freshwater fish production in Indian sub-continent and worldwide [9, 24-26]. Although *C. carpio* is became one of the most abundant carp in inland water and most important food and game fish species.

O. niloticus (Nile Tilapia) is commonly known as Tilapia in the India. They have been transplanted in various aquatic water bodies into a huge number of tropical and sub-tropical countries in over 100 countries in the globe [27]. It is commercially exploited in the rivers Ganga with 14.56% in 2015-2016 [28] and Yamuna with 24.36% in 2011-2012 at Allahabad [13]. The tilapia species create one of the most productive and internationally traded food fish in the globe [16-31]. They are a chief source of protein in large number of the poor and developing countries. The commodity is not only the second most vital cultured fish globally (next to carp) but also labeled as the most productive aquaculture species of the 21st century [13, 16, 32]. *Oreochromis niloticus* is among leading cultured species around the world as well as impressively invader in many countries globally. It is a commercially and economical important fish species globally and play important function in the tropical and subtropical aquatic ecosystems in respect of fish productivity and fishers employment. It is form commercial catch fishery from the Ganga, Yamuna, Tons, Ken and Paisuni rivers with *Cyprinus carpio* in central India [8, 13, 16, 28]. In information, *O. niloticus* is well-known for their plasticity in feeding nature, fast growth, tolerance, high resistance to diseases, survival (Example tolerate a wide range of environmental conditions and ability to feed at different trophic levels, lowest dissolved oxygen need), size at first maturity and easily breeds. Many researchers have reported that the invasive cichlids (Example *Oreochromis niloticus*) reducing growth and reproduction especially fecundity and survival of spawn of native species [33-37]. In Indian subcontinent especially riverine ecosystem, *O.*

niloticus niche overlap mainly to *Labeo calbasu*, *Cirrhinus mrigala* and *Cyprinus carpio* fishes. It tends to quickly gain the competitive advantage because of its hardy nature and feeding plasticity due to these features.

Size composition and structure of fishes are used as a referral point for estimating nature of stock, life span, suitability of habitat, growth pattern and fishing pressure in riverine ecosystem [38-41]. Decline in ecological conditions and water quality is a typical cause for decreasing of fish size (Example wild stock) from the rivers globally [42-46]. The Sex ratio varies considerably from species to species, but in the majority of species it is close to one. (1.0:1.0). Sex ratio naturally reflects the population density. Knowledge of fish sex structure and sex ratio is essential for fisheries management and conservation, and for fulfilling the information gap in fundamental fisheries research [47-50]. Habitat change and loss of biodiversity is one of the most important drivers for the decreasing of age composition of fishes. Note that altered age composition is reported by invasion of non-native fish species [37, 51-53]. Therefore, the present study aimed to update the information on the sex structure and sex ratio of *C. carpio* and *O. niloticus* in respect of climate from the Tons river, India. The present study would help the fishery managers and planners in management of the riverine fisheries in the Ganga basin, India. Record and assessment of the present research work is also necessary to formulate informed decisions about restoration and management of the fishery especially Indian Major Carp (*Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*) and rivers.

Material and Methods

The Tons river is essentially a hilly stream water body arising in the Kaimur hills of the Vindhyan range, India. It banks are lined by deep ravines and the bed is rocky. The Tons river lies between latitude 24° 0' to 25° 16' 54" North and longitude 80° 26' 45" to 82° 04' 57" East. It is tributary of the Ganga river (Map I). The sample was collected during March 2019 to February 2021 from Sirsa fish landing centre at Prayagraj, Uttar Pradesh, India. Fishes were collected using a variety of methods including gill nets, drag nets, cast nets and hook and lines.

A total of 851 (male 410 and female 441) and 935 (male 452 and female 483) of *C. carpio* and *O. niloticus*, respectively individuals were examined during the study period.

Size composition of *C. carpio* and *O. niloticus* fishes was fluctuated between 93 to 728 mm and 74 to 476 mm (total length), respectively. The size of fishes was measured by measuring scale to nearest mm. The total length (TL) of fishes was measured from tip of the snout to the largest fin rays of caudal fin. The collected data were classified at 50 mm in *C. carpio* and 40 mm in *O. niloticus* intervals for formation of groups. The number of samples calculated according to size group then converted into percentage. Age pyramid is prepared by Odum method (1971) [54] and adopted by Nautiyal et al (2024) [51]. The number of each age group was recorded separately for *C. carpio* and *O. niloticus*. The number of fish of each age group was recorded and converted into a percentage to obtain a pyramid. This pyramid represents the status of the fish stock. The sex was determined by microscopic observation of gonads. The female fishes were identified by microscopic examination of the gonads 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 size groups. This helped to understand the distribution of sexes in different size groups.



Map 1: Tons river map with Allahabad district now Prayagraj district. The sampling site Sirsa is confluence of Tons river from the Ganga river at Prayagraj, Uttar Pradesh

Result and discussion

A total of 851 (male 410 and female 441) and 935 (male 452 and female 483) fishes of *C. carpio* and *O. niloticus*, respectively individuals were examined during the study period in the Tons river at Prayagraj, India. The size composition of *C. carpio* and *O. niloticus* fishes was fluctuated between 93 to 728 mm and 74 to 476 mm (total length), respectively.

Size composition and structure of *Cyprinus carpio*

The maximum total length 728 mm of *C. carpio* was showed that the ecological condition of the Tones river most suitable for this species. Present fishing pattern is systematic and stock healthy condition with environmentally friendly sourcing of food. Fish exploitation is an economic and livelihood activities governed by social needs and demands. The size composition of *C. carpio* was varied from 93 to 728 mm of total length of fishes with greater part between 241 to 290 mm in case of pooled fish samples in the lower stretch of the Tons river at Prayagraj, Uttar Pradesh, India (Figure 1). In case of male and female fishes, size group 251 to 290 mm was also contributed highest proportion with 18.54% and 17.91%, respectively (Figure 1). Minimum exploitation was reported with 0.24% and 0.12% in 691-740 mm size group for male and pooled samples, respectively. While lowest exploitation was recorded for female fishes in 641 to 690 size group mm with 0.91%. The size groups 91-140 mm, 141-190 mm, 191-240 mm, 291-340 mm and 341-390 mm were contributed in exploited stock with 7.56%, 11.46%, 17.56%, 12.93% and 9.27%, respectively in case of male fishes. In case of female fishes, the size groups 91-140 mm, 141-190 mm, 191-240 mm and 291-340 mm were shared slightly proportion in fished stock with 6.12%, 10.43%, 17.01% and 12.70%, respectively.

The lower size group (LSG) 93 to 290 mm was contributed 55.12%, 51.47% and 53.22% for male, female and pooled fishes, respectively (Figure 2) while middle size group (MSG) 291 to 490 mm shared 34.39%, 36.28% and 35.37%, in case of male, female and pooled samples, Higher size group (HSG) 491 to 740 mm contributed small proportion with 10.48%, 12.24% and 11.40% for male, female and pooled stocked, respectively (Figure 2). Overall,

lower size group was maximum fished compared to middle and higher size groups from the lower stretch of the Tons river at Prayagraj, India.

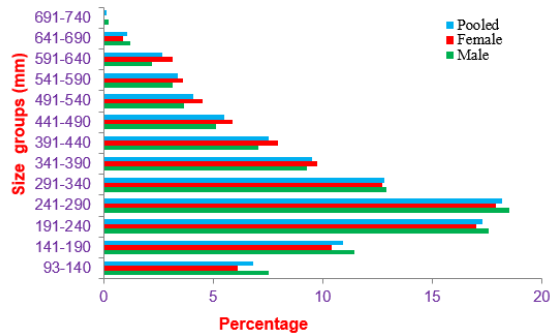


Figure 1: Size composition and structure of *Cyprinus carpio* from the Tons river, India

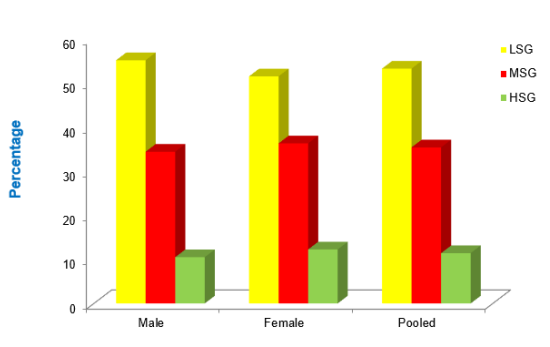


Figure 2: Contribution of different size groups of *Cyprinus carpio* in Tons river, India

Size composition and structure of Oreochromis niloticus

The maximum total length of *O. niloticus* (476 mm) was indicated that the ecological condition of the Tones river also most suited. Current exploitation pattern is systematic and healthy form. The size composition of *O. niloticus* was fluctuated between from 74 to 476 mm of total length in the lower stretch of the Tons river at Prayagraj, Uttar Pradesh, India. The large size of fishes also recorded in the Tons river in respect of river length. The maximum exploitation was noted in 271 to 310 mm size group with 20.57%, 20.08% and 20.32% for male, female and pooled fishes while lowest exploitation was observed with 0.66% in male, 0.20% in female and 0.43% in pooled fishes in 471-510 mm size group (Figure 3).

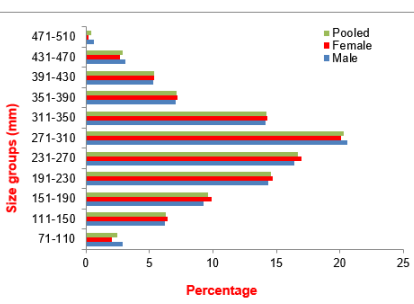


Figure 3: Size composition and structure of *Oreochromis niloticus* from the Tons river, India

The lower size group (LSG) 71 to 230 mm of *O. niloticus* was shared about 32.73%, 33.11% and 32.92% for male, female and pooled fishes, respectively in the Tons river, India. The middle size group (MSG) 231 to 390 mm contributed 55.16% in male, 58.57% in female and 58.38% in pooled fishes while higher size group (HSG) 391 to 510 mm formed small proportion with 9.05%, 8.27% and 8.65% for male, female and pooled stocked, respectively (Figure 4). Overall, middle size group was maximum fished compared to lower and higher size groups from the lower stretch of the Tons river at Prayagraj, India.

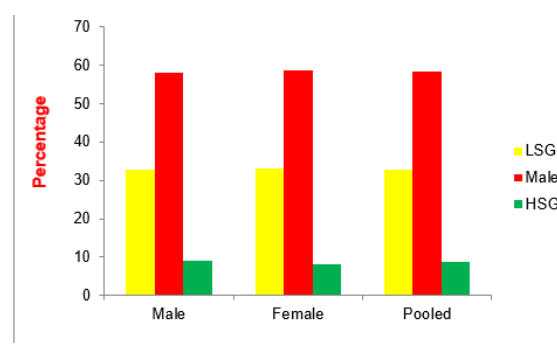


Figure 4: Contribution of different size groups of *Oreochromis niloticus* in Tons river, India

Size structure of fish varied from place to place and habitat to habitat due to fishing pressure and abundance of stock in freshwater ecosystems. It has been generally estimated that the middle-sized groups are most exploited in riverine or natural water bodies [41, 55-58]. [59] stated that the middle-size group of *Labeo calbasu* at Allahabad is being exploited more than other size groups. [60] observed that the middle-sized group of *Wallago attu* was most exploited (58.79%) compared to the small-size group (32.12%) and higher-size group (9.09%) from the Rapti River, India. The size compositions of fishes in riverine ecosystem have been declined especially for commercially important fishes.

Age Pyramid of Cyprinus Carpio

During the course of age pyramid study, 935 fish specimens of *C. carpio* (452 male and 483 female) were studied in lower stretch of the Tons River at Prayagraj, India. The age groups varied from 0+ to 7+. A urn shaped age pyramid was observed in *C. carpio* for male, female and pooled fishes (Figs 5, 6, 7) The age group 2+ dominated 25.88% in male, 26.09% in female and 25.99% in pooled samples by virtue of numbers. The present studies speci-

fied that age class 2+ is more vulnerable to the gear and is dominant in the total catches of *C. carpio*. Hence, in case of male, the proportion of the 0+ age group (12.61%) was much less than 1+ age group (20.57%) while in case of female, 0+ age group shared 11.76% proportion and 20.96% in 1+ age group (Figure 5). The higher age groups contributed 5.97% (5+), 3.54% (6+), and 1.11% (7+) in case of male fishes while age groups 5+, 6+ and 7+ shared 6.42%, 3.93% and 0.62%, respectively (Table 1). In pooled samples, the higher age groups contributed 6.20% (5+), 3.74% (6+), and 0.55% (7+). The higher age groups were contributed minute proportion in the total stock in male, female and pooled fishes. The shared distribution of *C. carpio* fishes was systematic in all age groups and formed healthy stocks in the Tons river, India (Figure 5, 6, 7).

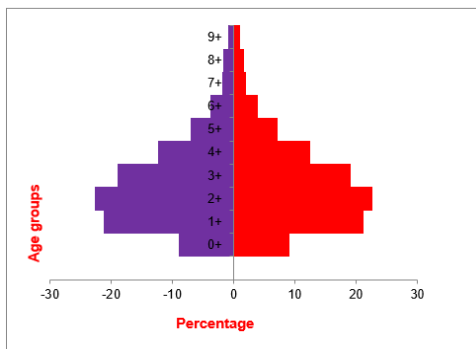


Figure 5: Age pyramid of male *Cyprinus carpio* in the Tons river, India (Male)

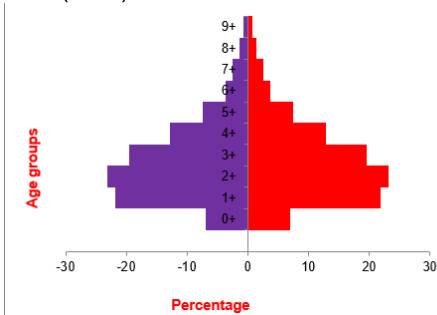


Figure 6: Age pyramid of male *Cyprinus carpio* in the Tons river, India (Female)

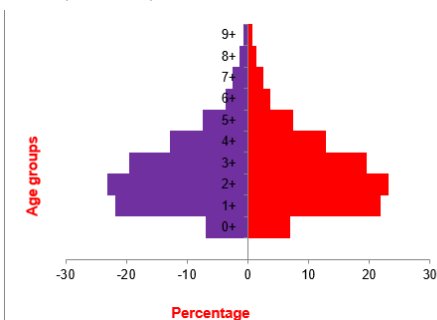


Figure 7: Age pyramid of male *Cyprinus carpio* in the Tons river, India (Pooled)

Age groups	No of male	%	No of female	%	No of pooled fishes	%
0+	37	9.02	31	7.03	68	7.99
1+	87	21.22	96	21.77	183	21.50
2+	93	22.68	102	23.13	195	22.91
3+	78	19.02	86	19.50	164	19.27
4+	51	12.44	57	12.92	108	12.69
5+	29	7.07	33	7.48	62	7.28
6+	16	3.90	16	3.63	32	3.76
7+	8	1.95	11	2.49	19	2.23
8+	7	1.71	6	1.36	13	1.53
9+	4	0.97	3	0.68	7	0.82

Table 1: Age composition and contribution of different ages in *C. carpio* in the Tons river, India

Age pyramid of *Oreochromis niloticus*

During the research work, 851 fish specimens (410 male and 441 female) of *O. niloticus* were examined for the estimation of the age pyramid. The age groups of fishes varied from 0+ to 9+. Urn-shaped age pyramid was estimated for male, female and pooled fishes (Figure 8-10). The age group 2+ was also dominated by virtue of numbers with 22.68%, 23.13% and 22.91% in case of male, female and pooled fish samples, respectively in the Tons river, India (Figure 8-10). The proportion of the 0+ age group shared in male (9.02%), in female (7.03%) and pooled (7.99%). The 1+ age group contributed slightly lower in case of male, female and pooled samples with 21.22%, 21.77% and 21.50%, respectively. The age groups 1+ and 2+ demonstrated that the small-sized fish dominate the catch of *O. niloticus* in the stock. The higher age groups contributed 2.23% (7+), 1.53% (8+) and 0.82% (9+) in case of pooled fishes (Table 2). The distribution was uneven between 0+ to 1+ age groups as the difference was 12.20%, 14.74% and 13.51% in male, female and pooled samples, respectively.

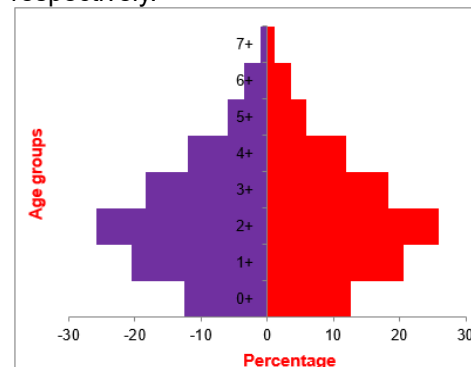


Figure 8: Age pyramid of male *Oreochromis niloticus* in the Tons river, India

Tons river, India (Male)

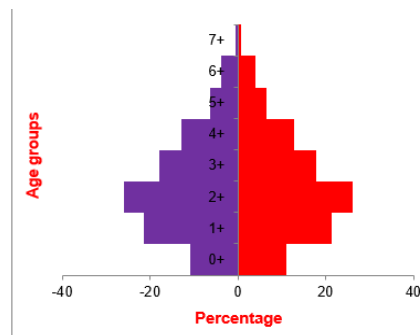


Figure 9: Age pyramid of male *Oreochromis niloticus* in the Tons river, India (Female)

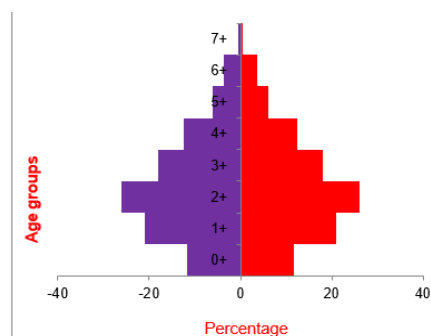


Figure 10: Age pyramid of male *Oreochromis niloticus* in the Tons river, India (Pooled)

Age groups	No of male	%	No of female	%	No of pooled fishes	%
0+	57	12.61	53	10.97	110	11.76
1+	93	20.57	103	21.32	196	20.96
2+	117	25.88	126	26.09	243	25.99
3+	83	18.36	86	17.80	169	18.07
4+	54	11.95	62	12.84	116	12.41
5+	27	5.97	31	6.42	58	6.20
6+	16	3.54	19	3.93	35	3.74
7+	5	1.11	3	0.62	8	0.55

Table 2: Age composition and contribution of different ages in *O. niloticus* in the Tons river, India

The urn shaped age pyramid was recorded in *O. niloticus* in the Yamuna river, India while the age group 2+ dominated by virtue of numbers in the species of stock [37]. The urn-shaped age pyramid indicates a low percentage of young individuals in the total stock [54, 60]. The urn-shaped age pyramid was recorded in *Cyprinus carpio* from the Ganga River at Prayagraj, India [61]. The urn-shaped

pyramid indicates a low percentage of young individuals [62]. The rate of fishing is a powerful factor that affects the age composition (for example, age pyramid shape) of the stock [51,63]. Tendency for bell-shaped age pyramid in the Ken River and bell-shaped age pyramid in the Paisuni River and the Tons River were obtained in the case of Tor tor [51]. The age pyramid of *C. carpio* showed a tendency for urn shape as mature age groups occurred in higher proportion from the Tons river [52].

Sex structure of *C. carpio*

Sex structure of male and female fishes of *C. carpio* was estimated observed with 48.18% and 51.82%, respectively in the stock in Tons river, India (Figure 13). The male proportion was recorded maximum with 53.45%, 50.54% and 55.56% in 93-140 mm, 141-190 mm and 641-690 mm size groups, respectively (Figure 12). Although the female amount was recorded highest among in 191-240 mm, 241-290 mm, 291-340 mm, 341-390 mm, 391-440 mm, 441-490 mm, 491-540 mm, 591-640 mm and 591-640 mm size groups with 51.02%, 50.97%, 51.38%, 53.09%, 54.69%, 55.32%, 57.14%, 55.17% and 60.87%, respectively (Figure 12). The female was not reported in 691 to 740 mm size group.

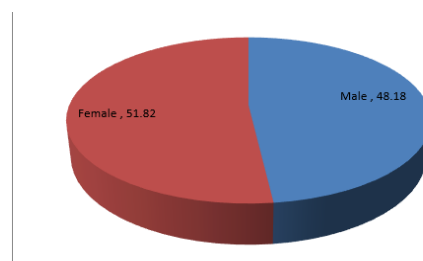


Figure 11: Contribution of male and female of *C. carpio* in the total stock in the Tons river, India

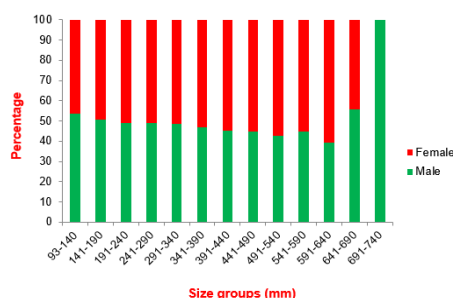


Figure 12: Sex structure of male and female of *C. carpio* in the Tons river, India

Sex structure of *O. niloticus*

The male proportion was reported highest with 56.52%, 51.85% and 75.00% in 71-110 mm, 431-470 mm and 471-510 mm size groups, respectively (Figure 13). Although the male proportion was recorded minimum with 45.16%

in 381-410 mm size group and highest with 62.50% in 441-470 mm size group of fishes (Figure 13). Sex structure of male and female fishes of *O. niloticus* was estimated with 48.34% and 51.66%, respectively in the Tons river, India (Figure 14).

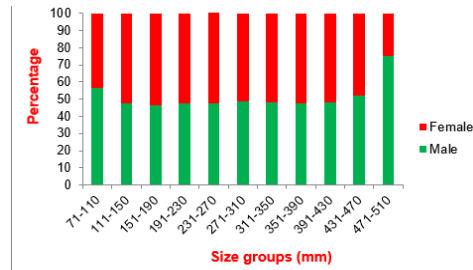


Figure 13: Sex structure of male and female of *O. niloticus* in the Tons river, India

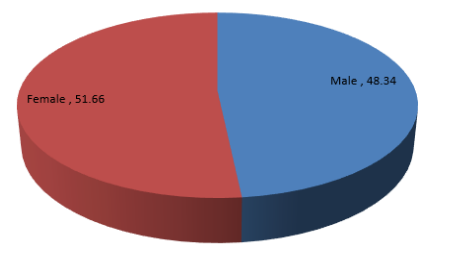


Figure 14: Contribution of male and female of *O. niloticus* in the total stock in the Tons river, India

The experienced mature female fish stock was healthy in the river in monsoon season but very high fishing pressure we observed in this season. The sex structure is also adaptive to the food supply, which thereby influences the reproductive rate and the variability of the offspring [49, 64]. The sex structure is very important to the reproduction of a population, and consequently there are mechanisms for adjusting this structure to any changes, and especially to changes in food supply, nutrient composition, water quality, concentration of heavy metals and invasion of exotic fish species [66-75]. The sex ratio emerged as a central concept in modern evolutionary ecology. Not only did it provide key links between sexual assortment, population parameters and evolutionary trajectories, but it could also be the center of adaptive allocation strategies where individuals adjusted their relative investment in male and female to match recent and expected fitness [22, 76-77].

Conclusion

It may be concluded that the species, *C. carpio* and *O. niloticus* powerfully invaded and generate problem for India major carp (IMC) in the Tons river, India. The maximum size of both species also indicated that the stock is stable condition and ecological condition fully suited to species.

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Citation: Amitabh Chandra Dwivedi. "Assessing to invasion potential of two exotic fish species, *Cyprinus carpio* (Linnaeus, 1758) and *Oreochromis niloticus* (Linnaeus, 1758) with special reference to ecological changes in the Tons river, Ganga basin, India." *J Environ Toxicol Res* (2025):116. DOI:10.59462/3068-3505.2.2.116