Journal of the Kalash Science, Volume -2, Number-3 (Special Volume), 2014 : 41-46

Food security, livelihood and non-native fish species: status, trends and future perspectives

Amitabh Chandra Dwivedi, Dharm Nath Jha and Priyanka Mayank
Regional Centre, Central Inland Fisheries Research Institute (ICAR), 24 Panna Lal Road Allahabad, India

Abstract

Demand for fish has been recently increased rapidly in the world due to changes feeding and life style of human being. Non-native fishes provide food security, nutrition, welfare and livelihood to its consumer and fishers. Study was undertaken during the period August 2011 to July 2012 from the Yamuna river, India. Fish farming and aquaculture are growing progressively throughout country with help of *C. carpio* and *O. niloticus*. Currently, non-native fish species have almost half share in total landing and are playing major role in livelihood and food security of fishers and consumers, respectively at Allahabad region. Analysis of annual data on fish landing showed that *Oreochromis niloticus* and *Cyprinus carpio* have aggressively invaded the lower stretch of the Yamuna river at Allahabad. The estimated annual catch was dominated by *O. niloticus* (147.81 kg day-1) followed by *C. carpio* (132.04 kg day-1) and miscellaneous group (92.34 kg day-1) and they accounted for 24.36%, 21.76% and 15.22%, respectively. The stock of *C. carpio* has well established itself in riverine and pond ecosystems, while stock of *O. niloticus* is well stable in riverine ecosystem but very poor in pond ecosystem in Allahabad region.

Keywords: Food security, inland fisheries, nutrition, ecosystem, *Cyprinus carpio, Oreochromis niloticus*

Introduction

Human behaviors are the main factor for promoting the movement of aquatic organisms (especially fishes) globally (Cambray 2003, Gozlan 2008, Dwivedi & Nautiyal 2010). Time to time these organisms increase the biodiversity at a certain stratum. Aquaculture and ornamental fishery are the gateway for movement of exotic species (Naylor *et al.* 2001, Mayank *et al.* 2011). These exotic species or non-native fish species are very destructive in nature for native fishes and inland fish assemblages (Dwivedi *et al.* 2004, Vörösmarty *et al.* 2010, Pathak *et al.* 2011a, Kumar *et al.* 2013, Mayank & Tyagi 2013). But, due to their high growth rate and reproduction they provide food security, nutritional security and support livelihoods. India has also recorded a huge number of non-native fish species introduced from different zoogeographic regions (e.g. *Cyprinus carpio, Oreochromis niloticus*) are among them. Diverse inland fish assemblages are very essential to maintain ecosystem integrity, productivity, plasticity and flexibility (Dwivedi *et al.* 2006, Schindler *et al.* 2010, Rizvi *et al.* 2010). In recent years, non-native fishes have made inadvertent access to the many natural water bodies of India including rivers, reservoirs and lakes (Kumar *et al.* 2013, Dwivedi *et al.* 2009, Pathak *et al.* 2011b, Mayank *et al.* 2011, Dwivedi & Jha 2013). At present, the fishes (e.g. *Cyprinus carpio* and *Oreochromis niloticus*) are abundantly distributed from the river Yamuna, a major tributary of the mighty Ganga river system. These fishes are fully established in the river (Dwivedi 2009) as evidenced from availability of different age classes and regular auto stocking of the fish in the river. It is also well stable in the Ghaghara river (Dwivedi *et al.* 2007). The culture fishery in Indian sub-continent is found dense by non-native fish species especially *C. carpio* (Dwivedi *et al.* 2004). *C. carpio* and *O. niloticus* are well stable in polluted ecosystem (e.g. riverine ecosystem) globally (Tiwari *et al.* 2013, 2014).

Food security and non-native fish species are two attributes of prime importance in fish stock, status and trends to Indian sub-continent. There is complete dearth of published information on food security and non-native fish species from the Indian rivers and ponds

particularly from the Ganga river system. The study would help the fishery managers and planners in management of the riverine and pond fisheries.

Material and methods

Lower stretch of the Yamuna river was selected for study purpose at Allahabad, India during August 2011 to July 2012. Fish landing data were collection from Sadiapur wholesale fish market. Sadiapur fish market is just by the left side of river Yamuna and major part of fish catch from the lower stretch of the river is brought to this market for disposal. Experimental fishing was conducted by local fishermen with the help of using drag net, gill net, cast net, scoop net and hook and line.

For collection of data, Sadiapur fish market was visited early in the morning. Earlier studies have shown that bulk of the night catches from the lower stretch of river Yamuna is brought to this wholesale fish market for disposal. The data were collected species-wise. For the purpose of collection of data a stratified sampling design was adopted (Tyagi and Mandal 2008). A month was divided in four strata of seven or eight consecutive days, depending upon the month and from each stratum data were collected for two randomly selected days.

Different neighboring districts of Allahabad viz. Allahabad, Pratapgarh, Kaushambi and Fatehpur were surveyed to assess the culture status of these fishes on different agro-climatic regions. The survey programmes were performed at village levels. Culture techniques and methods were noted separately for all districts.

Results and discussion

The fish landing data were recorded from Sadiapur wholesale fish market on sampling day and estimates were derived. Analysis of annual data on fish landing showed that *O. niloticus* and *C. carpio* have invaded the lower stretch of the Yamuna river at Allahabad in a big way. The estimated total annual catch was 222085 kg, by *O. niloticus* (147.81 kg day-1) followed by *C. carpio* (132.04 kg day-1) and miscellaneous group (92.34 kg day-1) and they accounted for 24.36%, 21.76% and 15.22%, respectively. 46.12% share of non-native fishes indicated that these species have potential to provide the main food security and livelihood provided. The estimated annual catch was higher for *O. niloticus* (54100 kg) than *C. carpio* (48326 Kg) and miscellaneous (33798 kg). Total landing decline of the Yamuna river has resulted in unemployment among fishers and a good population has shifted to other occupations. By increasing the fishing effort, the yield can be increased to a certain level, but further increase in exploitation levels leads to reduction in the yield and if the effort is still further increased regardless of the reduction in total catch and catch rates, the stock under exploitation may collapse and the fishing community may have to face the problem of rehabilitation. Under fishing (overexploitation) not only reduces the population but also alters its intraspecific and interspecific relations (Rizvi *et al*. 2010, Dwivedi & Nautiyal 2012).

The estimated fish landing at Sadiapur centre without exotic species from the Yamuna river was 164.22 tones (miscellaneous 28.73 tones) during 1966 (Anon 1967) while during April 1990 to February 1991, the total fish landing at Sadiapur was estimated as 70.94 tones (miscellaneous 37.11 tones) (Anon 1991). Slightly decline in total catch was recorded during 2002-2003 at Sadiapur (Allahabad) and estimated as 68.37 tonnes (exotic carps-17.8%, others-62.7%) (Anon 2002-03). Non-native species were contributed 17.8% in 2002-2003 which had upto 46.12% in present study. First time measurable amount of non-native fishes were recorded in 2002-03 while earlier it had included in miscellaneous group. The *O. niloticus*

dominated among exotics. Presently, non-native species are playing main role in livelihood and food security of fishers/fish farmers and consumers at Allahabad region. The water qualities of the Yamuna and Ganga rivers at Allahabad are most suitable for *C. carpio* and *O. niloticus* (Dwivedi & Jha 2011, Mayank *et al.* 2011, Dwivedi & Mayank 2013,). *C. carpio* and *O. niloticus* have been struggling for space and food to *C. mrigala* and *L. calbasu* in riverine ecosystems. In other words, *C. carpio* and *O. niloticus* were dominated over to *C. mrigala* and *L. calbasu* for space, breeding ground and food due to enduring nature in riverine ecosystems (Mayank *et al.* 2009).

In recent years, fishes have taken industrial resources with culture in India. The aim of the fish culture is mainly the production of fish for human food. There are mainly three types of culture techniques (e.g. 3 species, 4 species and 6 species) available in Allahabad region and country for fresh water fish culture, but six species culture technique is the most popular. India has taken a great leap in evolving and popularizing a technique termed as composite fish culture (Polyculture) in which compatible and high yielding combination of carps, consisting of three indigenous Indian major carps and three exotic carps are cultured in ponds (Dwivedi et al. 2004). This technology is applicable to the ponds and other water bodies throughout the country without any zonal restriction except hilly region. At Allahabad region, *L. rohita* (Rohu), *C. catla* (Bhakur/Catla) and, *C. mrigala* (Nain/Mrigal) are major species of Indian major carps and *Hypophthalmichthys molitrix* (Silver carp), *Ctenopharyngodon idella* (Grass carp) and *C. carpio* (Common carp) are major species of exotic carp suitable for composite fish culture. *C. carpio* is also use as ornamental organism by some person. *O. niloticus*, with a known ability to adjust to various environmental conditions, have high potential for aquaculture (Dwivedi & Jha 2013).

In culture system, *L. rohita* is dominated followed by *C. carpio, C. catla, C. mrigala, H. molitrix* and *C. idellus* at Allahabad region. *L. rohita* is preferred in culture system due to its taste and production bu *C. carpio* is second rank for only production at Allahabad region. Quality fish seed is a basic input for the success of a fish culture programme. There are two sources for obtaining fish seed; one is the spawn from natural breeding of fish (e.g. rivers) and the other is the spawn from artificial breeding of fish (e.g. hatchery). The hatcheries mainly produce seeds of Indian major carps (*Catla catla, Labeo rohita, Cirrhinus mrigala*) and *C. carpio* because of great demand of such seeds by fish farmers. However, some vendors from other states come in the districts and provide seeds of both Indian and exotic carps to the fish farmers. In addition to above mentioned seed sources some seeds of Indian major carps, exotic major carp and *O. niloticus* are also collected by fishermen from rivers and made available to fish farmers for stocking. Stocking of *O. niloticus* is also performed by few farmers at Allahabad region. Seed availability of *O. niloticus* totally depends on the riverine stock.

Fishery trends in present time of both species are dramatically changed in Allahabad region and Indian sub-continents. In case of *C. carpio,* its fishery trend is modifying from pond ecosystem to riverine ecosystem while in case of *O. niloticus* it is transforming riverine ecosystem to pond ecosystem. Many Indian riverine ecosystems are dense by *C. carpio* and *O. niloticus* (Mayank *et al.* 2011, Pathak *et al.* 2011b, Dwivedi and Nautiyal 2013, Anon 2011-2012). *C. carpio* and *O. niloticus* will be scattered other river ecosystem in near future. Growth increment and production of both species are greater in rivers compared to pond ecosystems in Indian climate. *O. niloticus*

originate from the tropical and subtropical parts of Africa (Fryer & Iles 1972) but are now cultured throughout the world (Mayank *et al.* 2011). Water quality is not determining factor for distribution, production and culture of *C. carpio* and *O. niloticus* (Tiwari *et al.* 2013, 2014). 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 (Sukadi 2001). Artificial feeding systems for *C. carpio* and *O. niloticus* are not properly managed in pond systems. But natural feeding (e.g. planktons) in riverine ecosystems is the most suitable feed for *C. carpio* and *O. niloticus.*

These fishes breed two/three times (throughout year) in the Yamuna river (Dwivedi & Mayank 2013). Fingerlings of these fishes are available 6 months in a year in the riverine ecosystems at Allahabad region. Fish farmers stock *C. carpio* two or three times in their ponds. *O. niloticus* is a low economic value and low consumer preference fish. The main problem faced by *O. niloticus* is early reproduction before reaching marketable size (Mayank *et al.* 2011). In future, both species will be contribute a huge production in the culture and capture system in India. Both species are well showed for aquaculture potential because these are extremely hardy, have a wide range of tropic and ecological adaptations and possess adaptive life history features such as fast growth, high fecundity and multiple breeding. These adaptive qualities predispose of *C. carpio* and *O. niloticus* to be a highly successful invader. Natural or feral populations are now well established in most river catchments in the Ganga basin. Owing to these tough nature and wide range of ecological adaptations, *C. carpio* and *O. niloticus* are presently among the most widely distributed non-native fish species globally, having established feral populations in most tropical and sub-tropical environments to which they provide food security and livelihood (Welcomme 1988, Smith *et al.* 2005, Canonico *et al.* 2005, Zambrano *et al.* 2006, Welcomme *et al.* 2010, Zengeya *et al.* 2011). In pond ecosystem, low water level (e.g. summer season) is also helpful for culture of these species because of their feeding habits (bottom feeder).

It may be concluded that the status of *C. carpio* is well stable in riverine and pond ecosystems, while status of *O. niloticus* is well stable in riverine ecosystem but very poor in pond ecosystem. Overall, both species are providing very good food security and livelihood in this region. In future, contribution of these species will increase in fisheries sector (e.g. culture and capture) of Allahabad region.

References

Anon, 1967. (Annual Report), Central Inland Fisheries Research Institute (ICAR), Barrackpore, Calcatta, West Bengal.

Anon, 1991. (Ann ual Report), Central Inland Fisheries Research Institute (ICAR), Barrackpore, Calcatta, West Bengal.

Anon, 2002-03. (Annual Report), Central Inland Fisheries Research Institute (ICAR), Barrackpore, Calcatta, West Bengal.

Anon, 2011-2012. (Annual Report), Central Inland Fisheries Research Institute (ICAR), Barrackpore, Calcatta, West Bengal.

Cambray, J.A. 2003. Impact on indigenous species biodiversity caused by the globalization of alien recreational freshwater fisheries. *Hydrobiologia*, **500:** 217-230.

Canonico, G.C., A. Arthington, J.K. McCrary & M.L. Thieme 2005. The effects of introduced tilapias on native biodiversity. *Aquat. Conserv.: Mar. Freshwat. Ecosyst.,* **15:** 463–483.

Dwivedi, A.C. & D.N. Jha 2013. Population structure of alien fish species, *Oreochromis niloticus* (Linnaeus, 1757) from the middle stretch of the Ganga river, India. *J. Kalash Sci.*, **1(1):** 157-161**.**

Dwivedi, A.C. **&** P. Mayank 2013. Studies on the age, growth pattern and sex ratio of *Cyprinus carpio* var. *communis* from

the largest tributary of the Ganga river, India. *J. Kalash Sci.,* **Special Volume:** 21-27.

Dwivedi, A.C. & P. Nautiyal 2010. Population dynamics of important fishes in the Vindhyan region, India. LAP LAMBERT Academic Publishing GmbH & Co. KG, Dudweiler Landstr. 99, 66123 Saarbrucken, Germany, Pp. 220.

Dwivedi, A.C. & P. Nautiyal 2012. Stock assessment of fish species, *Labeo rohita, Tor tor* and *Labeo calbasu* in the rivers of Vindhyan region, India. *J. Environ. Biol.,* **33(2):** 261-264.

Dwivedi, A.C. & P. Nautiyal 2013. Alien fish species, *Cyprinus carpio* (common carp) as a invader in the Vindhyan region (Ken, Paisuni, Tons rivers), India. *J. Kalash Sci.,* **1(2):** 133-139.

Dwivedi, A.C. 2009. Ecological assessment of fishes and population dynamics of *Labeo rohita* (Hamilton), *Tor tor* (Hamilton) and *Labeo calbasu* (Hamilton) in the Paisuni river. *Aquacult,* **10(2):** 249-259.

Dwivedi, A.C., A. S. Mishra, S. Khan, K.R. Singh, P. Mayank & P. Mishra 2006. Studies on the sex ratio, sex structure and exploitation pattern of *Labeo calbasu* (Hamilton) in the Ghaghara river. *J. Nat. Res. Develop.,* **1(2):** 124-128.

Dwivedi, A.C., N.P. Tewari & K.R. Singh 2004. Present structure of capture and culture fishery of the Faizabad District (U.P.). *Bioved,* **15(1, 2):** 95-98.

Dwivedi, A.C., N.P. Tewari & P. Mayank 2007. Biodiversity of fishes of Faizabad district (U.P.). *Flora Fauna*, **13(2):** 379-383.

Dwivedi, A.C., P. Mayank, S. Masud & S. Khan 2009. An investigation of the population status and age pyramid of *Cyprinus carpio* var. *communis* from the Yamuna river at Allahabad. *The Asian J. Animal Sci.,* **4(1):** 98-101.

Fryer, G. & T.D. Iles 1972. The Cichlid Fishes of the Great Lakes of Africa, their biology and distribution, Oliver and Boyd; Edinburg, Scotland: 641.

Gozlan, R.E. 2008. Introduction of non-native freshwater fish: is it all bad? *Fish and Fisheries*, **9:** 106-115.

Kumar, J., A.K. Pandey, A.C. Dwivedi, A.S.K. Naik, V. Mahesh & S. Benakappa 2013. Ichthyofaunal diversity of Faizabad district (Uttar Pradesh), India. *J. Exp. Zool. India,* **16(1):** 149-154.

Mayank, P. & R. K. Tyagi 2013. Studies on fish biodiversity and their conservation of the Yamuna river at Allahabad, Uttar Pradesh, India. *J. Kalash Sci.,* **1(2):** 105-110.

Mayank, P. A. Kumar & A.C. Dwivedi 2011. Alien fish species *Oreochromis niloticus* (Linnaeus, 1757) as a powerful invader in the lower stretch of the Yamuna River. *Bioved,* **22 (1):** 65-71.

Mayank, P., D. Srivastava, A.C. Dwivedi & K.R. Singh 2009. Assessment of sex ratio and sex structure of *Labeo calbasu* (Hamilton) from the Gomti river at Sultanpur. *Aquacult,* **10(1):** 113-117.

Naylor, K.R., S.L. Williams & D.R. Strong 2001. Aquaculture-a gateway for exotic species. *Science,* **294:** 1655-1656.

Pathak, R.K., A. Gopesh & A. C. Dwivedi 2011a. Age composition, growth rate and age pyramid of an exotic fish species, *Cyprinus carpio* var. *communis* from the Ganga river at Allahabad, India. *Natl. Acad. Sci. Lett.,* **34 (5 & 6):** 223-228.

Pathak, R.K., A. Gopesh & A. C. Dwivedi 2011b. Alien fish species, *Cyprinus carpio* var. *communis* (common carp) as a powerful invader in the Yamuna river at Allahabad. *Natl. Acad. Sci. Lett.,* **34(9 & 10):** 367-373.

Rizvi, A.F., A.C. Dwivedi & K.P. Singh 2010. Study on population dynamics of *Labeo calbasu* (Ham.), suggesting conservational methods for optimum yield. *Natl. Acad. Sci. Lett.,* **33(7 & 8):** 247-253.

Schindler, D.E., R. Hilborn, B. Chasco, C.P. Boatright, T.P. Quiinn, L.A. Rogers & M.S. Webster 2010. Population diversity and the portfolio effect in an exploited species. *Nature,* **465:** 609-612. Doi: 10.1038/nature09060.

Smith, L.E.D., S. Nguyen Khoa & K. Lorenzen 2005. Livelihood functions of inland fisheries: policy implications in developing countries. *Water Policy,* **7:** 359-383.

Sukadi, F. 2001. Tilapia culture in Indonesia. *INFOFISH Int.,* **4:** 37-39.

Tiwari, A. A.C. Dwivedi, D.N. Shukla & P. Mayank 2014. Assessment of heavy metals in different organ of *Oreochromis niloticus* from the Gomti river at Sultanpur, India. *J. Kalash Sci.,* **2(1):** 47-52.

Tiwari, A., A.C. Dwivedi & D.N. Shukla 2013. Accumulation of heavy metals in liver, muscle and gill of *Cyprinus carpio* from the Gomti river at Jaunpur, Uttar Pradesh. *J. Kalash Sci.,* **1(2):** 127-132.

Tyagi, R.K. & S.K. Mandal 2008. Sampling methodologies for estimation of inland fish catch in India. CIFRI, Barrackpore, W.B. Pp. 71.

Vörösmarty, C.J., P.B. McIntyre, M.O. Gessner, D. Dudgeon, A. Prusevich, P. Green, P.S. Glidden *et al.* 2010. Global threats to human water security and river biodiversity. *Nature*, **467:** 555-561. Doi: 10.1038/nature09440.

Welcomme, R.L. 1988. International introductions of inland aquatic species. FAO Fisheries Technical Paper, FAO, Rome, p. 294.

Welcomme, R.L., I.G. Cowx, D. Coates, C. Be´ne´, S. Funge-Smith, A.S. Halls & K. Lorenzen (2010) Inland capture fisheries. *Philos. Trans. R. Soc.,* **B365:** 2881-2896.

Zambrano, L., E. Martinez-Meyer, N. Menezes & A. T. Peterson 2006. Invasive potential of common carp (*Cyprinus carpio*) and Nile tilapia *Oreochromis niloticus* in American freshwater systems. *Canadian J. Fish Aquat. Sci.,* **63:** 1903-1910.

Zengeya, T.S., A. J. Booth, A. D.S. Bastos & C. T. Chimimba 2011. Trophic interrelationships between the exotic Nile tilapia, *Oreochromis niloticus* and indigenous tilapiine cichlids in a subtropical African river system (Limpopo river, south Africa). *Environ. Biol. Fish.,* **92:** 479-489.