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A REVIEW OF INTRODUCTION OF COMMON CARP *Cyprinus carpio* IN PAKISTAN: ORIGIN, PURPOSE, IMPACT AND MANAGEMENT

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ABSTRACT

Common carp *Cyprinus carpio* was introduced from Thailand to Pakistan in 1964 for the purpose of aquaculture. Due to its high tolerance to temperature and turbidity, and prolific pond breeding habit, it was established promptly in most of natural inland waters, including rivers, lakes, streams, canals, wetlands and even village ponds of the country. Although common carp became one of the most abundant cyprinid species in inland waters and important food fish in Pakistan, its impact is not well documented. Fish farming of common carp has been carried out in Pakistan since 1970; initially it grew slowly but now it is playing an important role in the economy of the country by employing more than 400,000 people. Nowadays, farming of freshwater carps is present throughout Pakistan, especially in the provinces of Punjab and Sindh. There is a huge potential in common carp farming and it could help increase the livelihood of people and gross domestic product (GDP) of the country as well. Still, there is a need to improve the fish farming practice to meet the world-class demands that could only be possible by the keen interest of policy makers and stake holders with better management.

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INTRODUCTION

Common carp *Cyprinus carpio* (Linnaeus, 1758) is naturally distributed in its wild form from the piedmont zone of the Danube River to the Black, Caspian and Aral Sea basins, as western dispersant in central Asia and as eastern dispersant in Siberia (Kirpitchnikov, 1999). On the other hand, as a result of translocations and introductions of domesticated and wild forms since Roman times (Balon, 1995), common carp is now established in 91 out of 120 countries worldwide (Casal, 2006). So far, despite its adaptability to a very wide range of environmental conditions (Balon, 2006), common carp is currently classed as susceptible in most

of its native areas of distribution owing to a significant loss of genetic variability in domesticated races, breeds and strains mixing with the pure wild form (Khalili and Amirkolaie, 2010). At the same time, common carp has long been regarded as a highly insidious species in North America (Weber and Brown, 2009) and Australia (Koehn, 2004), with recent dispersants representing a high risk of even further spread across these and other continents (Zambrano et al., 2006). On the contrary, in other areas of introduction such as Western Europe and the Mediterranean Region, common carp had previously been regarded as naturalized, that is, having well-known self-sustaining populations in the wild, and has been present long enough to have integrated itself within the resident community of organisms (Copp et al., 2005). According to the newest FAO statistics (FAO, 2008), among the seven countries in Southeast Asia (Malaysia, Indonesia, Myanmar, Cambodia, the Philippines, Vietnam and Thailand), Cambodia ranked amongst the top 25 producers of inland fisheries in terms of aquaculture capacity. Together, the seven countries earned more than 11 billion dollars from aquaculture in 2006 (Hishamunda et al., 2009).

Originally native to temperate region of Asia, especially China, common carp is now the most cultivated and refined carp species throughout the world. Common carp, the most common cyprinid species, creates an important part of inland fish production (Cetinkaya, 2006). Polyculture carp system is an old practice in South Asia, especially in India, Bangladesh and Pakistan, and it is the main aquaculture system in this region (Miah et al., 1997, FAO, 1997 and Reddy et al., 2002). It is an omnivorous bottom dweller which managed to survive mainly on benthic fauna and decaying floral matter. It often warrens the pond bottom in search of food. This habit of burrowing the pond bottom helps in maintaining the productivity of un-drainable ponds, hence culture of common carp with other carp species is of great advantage. Furthermore, it also feeds directly on the defecated material of grass carp. Its growth mainly depends upon the underneath fauna, stocking density and the rate of added feed. In polyculture fish ponds, it grows to about 1 kg within one year. In a tropical climate, it spawns throughout the year while in the pond environment there are two peak periods: one between January and March, and the other during July and August. The eggs are minute and adhesive in nature, while in tropical conditions it achieves maturity within 12 months (Alikunhi, 1966). In a temperate climate, carp spawn once a year between May and June (Kottelat and Freyhof, 2007), and carp fingerlings, also called “yearlings”, have a total length ranging from 8 to 12 cm and a live weight varying from 10 to 40 g (FAO, 2015).

Common carp is the most commonly transplanted species of fish in the world. This fish is very much favored for cultivation in ponds in Asia, Near and Far East, alone or in combination with other fishes, because of its excellent growth rate, omnivorous habit, breeding in confined waters (unlike the Indian and Chinese major carps), hardy nature and easy adaptation to artificial feeds. Studies have shown that this bottom feeder has a much higher growth rate than *Cirrhinus mrigala*, the Indian major carp with similar feeding habits (Parameswaran et al., 1971).

Common carp has long been observed as a highly persistent and deleterious non-native species worldwide, with restricted impacts branded more recently in several other parts of its introduced range (Vilizzi et al., 2015). The organization of common carp has therefore become a major issue of concern in efforts to lessen its detrimental effects on freshwater ecosystems (Britton et al., 2010a). This is in particularly true for ecosystems already ruined by human activities (Smith et al., 2009) and those susceptible to the effects of climate change (Britton et al., 2010b). Common carp is able to colonize these ecosystems by the virtue of its versatile ecological necessities (Balon, 2004), and eventually the costs of common carp invasion are a decrease in native biodiversity and simultaneous homogenization of the fish fauna (Marr et al., 2013). Improvement of these impacts results in costly eradication and control measures at any time practicable, as well as economic losses due to deterioration in amenity value (Koehn et al., 2000).

Common carp, the most common cyprinid species that generates a significant part of inland freshwater fish production, is introduced to inland waters such as lakes, dam lakes and streams in different regions (Vilizzi and Tarkan, 2015). The economic value of common carp has been increased by the growth rate in terms of length and weight, high meat yield, non-selective habitat use, tasty meat and production availability in fish farms (Demirkalp, 1992). Consequently, common carp has been introduced into many water bodies throughout the world, including Europe, Australia and North America. The broad distribution and successful introductions of common carp are frequent due to its tolerance to changeable environmental conditions (Mills et al., 1993). Consequently, the aim of the present review was to identify the impact of common carp on the ecology and economy in Pakistan. Specific objectives were to (1) identify the purpose of introductions of common carp; (2) identify the role of common carp in the Pakistani

aquaculture industry; (3) detect reasons for low growth performance of common carp in Pakistan; (4) make recommendations for the future management of common carp in Pakistan.

HISTORY AND PURPOSE OF INTRODUCTION OF COMMON CARP

Pakistan has immense freshwater, brackish and marine water resources with a 1046 km of coastline. Being located at a drainage basin of the Himalayas, it has extensive areas of inland waters. Region between 33°N and 20°N constitutes a vast network of rivers, canals, reservoirs, lakes and waterlogged areas, etc., with an area of around 8.6 million hectares. The department of fisheries was established in 1912, initially, with a mandate to conserve local fish fauna and to enhance fish production in natural waters. Early experiments in breeding of Indian major carps in the Indian subcontinent were started in Gujranwala district at Chhenawan Headworks in 1930s. These breeding trials continued on and off but were not succeeded in those times. Fish farming in Pakistan has been carried out in the last four decades. In 1970s, there were just a few fish farms in the private sector which had very low production per unit area. At the beginning, aquaculture practices were very limited and the growth rate of aquaculture was quite slow due to inadequate supply of seed of required fish species and lack of proper culture techniques. At that time, as a common practice, fish seed of different species was collected from natural fish breeding grounds of rivers and "dhunds" after monsoon floods, sorted out and supplied to fish farmers for their small fish ponds.

To overcome this situation, some prolific pond breeder fishes were acquired by the department to sustain. The exotic fish species like Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) and common carp were hence introduced in the country. Common carp was brought from Thailand and the UK in 1964 and was introduced in both captive and inland waters of Pakistan (FAO, 1998; Directorate of Fisheries Punjab). Due to its high tolerance to temperature and turbidity, and prolific pond breeding habit, the fish was established promptly in most of natural inland waters including rivers, lakes, streams, canals, wetlands and even village ponds of the country, especially in the province of Punjab and Sindh. This fish is growing very well in all these natural and manmade water bodies.

Indigenous major carps like roho labeo *Labeo rohita* (Hamilton, 1822), mrigal carp *Cirrhinus mrigala* (Hamilton, 1822) and catla *Catla catla* (Hamilton, 1822) do not breed in stagnant waters; they only breed naturally during monsoon in running waters. Furthermore, no artificial breeding technology was available in the country in 1960s and there was acute shortage of fish seed to supply the fish farmers. Common carp being a prolific pond breeder which breeds in rivers, lakes, streams, ponds and other stagnant waters was therefore exported at that time to fill the gap to start aquaculture activities in the country.

During the year 2010, common carp contributed 52% in the average catch at Mangla Reservoir Pakistan (Mirza *et al.,* 2012). A similar study, which was also conducted in 2013, showed an increase in the catchment of common carp of up to 54.4%, with a 2.4% increase (Mirza *et al.,* 2013). In the Jhelum River, cyprinids were abundantly found with average rate of 67%, including common carp which was 10% of the total fish collected (Mirza *et al.,* 2011). Akhtar *et al.* (2014) revealed that there are 3 orders and 3 families including Cyprinidae which were dominant while exploring the fish fauna of the River Swat, Khyber Pakhtunkhwa, Pakistan. The overall catches showed the domination of common carp in the River Swat, Pakistan.

HISTORY AND CURRENT SITUATION OF FISHERIES AND AQUACULTURE IN PAKISTAN

Fisheries and aquaculture play an important role in the economy of Pakistan by employing 400,000 people directly and another 600,000 in the subsidiary industries (Ebrahim, 2014). With a coast line of 1046 km (Pernetta and Wells, 1993), marine as well as inland waters of the country hold a large variety of aquatic animals. This aquatic diversity includes various species of fish, crustacean and molluscs. It is observed that a number of different types of aquatic animals are found along the Makran coast (Gondal et al., 2012). The contribution of agricultural sector in the GDP of Pakistan was USD 17300 million in 2006, while the contribution of fisheries sub-sector in the GDP was USD 232.5 million. Among marine and inland sectors, the former is the main sector contributing nearly 60% of the total fish production. The capture of deep-water fish in Pakistan from an exclusive economic zone (EEZ) contributes 1.3% to the total marine capture (FAO, 2008).

The inland production is low even though having bright prospects. This reduced production is a result of insufficient knowledge, lack of fishing gears and lack of skillful and motivated manpower (Nazir et al., 2014). The

Indus River, along with its streams, is the main capture point of freshwater fish. Inland fish capture is mainly from rivers and reservoirs. It contributes more than 80% of the fish from inland freshwaters. To encourage fisheries sector, six large reservoirs have been created, spanning an area of 250,000 ha. All of these efforts are for the purpose of improvement in fisheries sector, thus strengthening the overall agriculture sector (FAO, 2008).

The main purpose of introducing the planktophagous Chinese carps and common carp was to increase the production through consumption of the phytoplankton and zooplankton (Cremer and Smitherman, 1980). So, the semi-intensive pond polyculture of carps is a popular practice in south Asia, especially in Pakistan, Bangladesh and India, where it is the main aquaculture production system (Reddy et al., 2002). In south Asian polyculture, a large diversity of fish species are cultured. Among those fish species, *L. rohita*, *C. catla* and *C. mrigala* are very popular (Kanak et al., 1999). Between 1980 and 1990, these three species contributed 75% of the total inland aquaculture production in Pakistan (Mahboob, 1992).

In fish ponds, the production of fish has often been considerably influenced by the quality and quantity of phytoplankton. Nutrient enrichment by the addition of fertilizers, additional feeds and other eutrophication processes are said to have caused production of algae (Padmavathi and Veeraiah, 2009). Polyculture is also favored, based on the assumption that each fish species has its own feeding niche that does not overlap much with the feeding niche of the other species. As a result, a large fraction of natural food available in the pond is used in multi-species systems. In some cases, one species boosts the food available for other species, thus further increasing the total fish yield per unit area (Miah et al., 1993). The dynamics of plankton are described in order to establish the relations between the biomass of plankton present in the pond and that in the guts of fishes, and the relative consumption of different plankton component by different fish species.

Fish production per unit from the polyculture of Indian major carps was quite low due to a relatively slow growth of these local culturable fish species. Hence, in 1980s, Chinese carps viz. silver carp *Hypophthalmichthys molitix* (Valenciennes, 1848) and grass carp *Ctenopharyngodon idella* (Valenciennes, 1844), and later on bighead carp *Hypophthalmichthys nobilis* (Richardson, 1845) were introduced into the country for composite fish culture in ponds which has increased per unit yield making fish farming more cost-effective and profitable. With the addition of these Chinese carps in the aquaculture system, common carp, however, has been discouraged to continue as part of semi-intensive pond polyculture system due to its negative effects on pond productivity as well as on pond structure.

Farming of freshwater carps is in practice a major aquaculture activity in the provinces of Punjab and Sind, while in Khyber Pakhtun-khaw (KPK) province both carp and trout are being cultured. In Balochistan province, with efforts from the provincial government, fish farming, at a small scale, has just recently been started in the private sector. Pakistan is endowed with a rich freshwater fish fauna, comprising more than 200 species, but only seven warm water and two cold water trout species are cultivated commercially in the country. However, costal or marine aquaculture still does not exist in the country. Farming of GIFT Tilapia and some local high-value carnivore species is also at the pilot stage. Nowadays, the earthen semi-intensive pond polyculture of indigenous major carps and exotic Chinese carps with a combination of 4-5 species, in various ratios, has become very popular amongst the fish farmers. Presently, the following fish species are being aquacultured in Pakistan (Table 1).

All the same, the production systems are constantly changing. Presently, farmers prefer to stock rohu because it receives a higher consumer interest and market value. Farmers also prefer to stock common carp as a bottom feeder instead of *C. mrigala* because common carp grows faster than *C. mrigala* and the overall production is higher when combined with *L. rohita* and *C. catla* in polyculture ponds (Milstein et al., 2002), but common carp has some negative impacts as well. Wahab et al. (2002) performed an experiment with *L. rohita*, *C. catla*, pool barb *Puntius sophore* (Hamilton, 1822), common carp and *C. mrigala* in semi-intensive polyculture and achieved a 60% higher yield of *L. rohita* with common carp as bottom feeder compared to *C. mrigala*. *L. rohita*, known as a water column feeder, mainly feeds on plankton (Wahab et al., 1994), and common carp is a bottom feeder mainly feeding on benthic macro-invertebrates and zooplankton (Spataru et al., 1983). When artificial feed is applied, common carp readily accepts artificial food (Milstein and Hulata, 1993). The food and feeding habits of *L. rohita* and common carp might vary according to the overall food and feed availability. Stirring effect of common carp may enhance nutrient availability, which in turn increases natural food availability in ponds (Milstein et al., 2002). Like in India, carp culture is quite successful in Pakistan as well. Pond culture is growing and fish production of today is much higher than the previous monoculture

Table 1. List of main freshwater fish species present in Pakistan aquaculture in 2015

No	Scientific Name	Local Name	English name	Level
1.	*Labeo rohita* (Hamilton, 1822)	Rohu	Roho labeo	Commercial
2.	*Cirrhinus mrigala* (Hamilton, 1822)	Mori	Mrigal carp	Commercial
3.	*Catla catla*	Thaila	Catla	Commercial
4.	*Hypophthalmichthys molitrix* (Valenciennes, 1848)	Silver carp	Silver carp	Commercial
5.	*Ctenopharyngodon idella* (Valenciennes, 1848)	Grass carp	Grass carp	Commercial
6.	*Hypophthalmichthys nobilis* (Richardson, 1845)	Bighead carp	Bighead carp	Commercial
7.	*Cyprinus carpio* Linnaeus, 1758	Common carp	Common carp	Commercial
8.	*Oncorhynchus mykiss* (Walbaum, 1792)	Rainbow trout	Rainbow trout	Commercial
9.	*Oreochromis Spp*.	Tilapia	Tilapia	Pilot
11.	*Chana marulius* (Hamilton, 1822)	Sol	Great snakehead	Pilot
12.	*Sperata seenghala* (Sykes, 1839)	Singhari	Giant river-catfish	Pilot

system (Keshavanath and Gangadhara, 2006; Sahu et al., 2007).

IMPACTS OF COMMON CARP ON FISH FARMING

Presently, common carp is normally kept away from pond polyculture due to its frequent breeding habits and *C. mrigala* is generally adopted as a bottom feeding species to complete the stocking combination ratios. Introduction of common carp in a current culture set-up is controversial. Jian (2002) opined that this fish species can bear variable climatic conditions and that it improves pond bottom by turning over bottom soils, releasing nutrients for microscopic plants and exposing debris to the sunlight (Ritvo et al., 2004). Microscopic life gets these nutrients from cow dung, poultry, pig, duck, goat and sheep excreta, biogas slurry and artificial feed, which are frequently added to fish ponds to enhance pond productivity (Sehgal and Sehgal, 2002) and are available only when they are fully dispersed and suspended in water column, which common carp can easily do if present in pond.

However, the borrowing habit of common carp makes pond water turbid and muddy which decreases the transparency and light penetration into water, which in turn not only hampers photosynthesis and primary pond productivity but also reduces visibility necessary to search for food. This ultimately negatively effects fish growth and the overall fish production. Slow growth of common carp is also attributed to genetic deterioration due to consistent breeding of existing stocks since decades. On the other hand, common carp fetches a relatively low price on the market when compared with other carps. These are the disadvantages attached to this particular fish species which have made common carp the least preferred species amongst cultured carps for semi-intensive pond polyculture system in Pakistan.

IMPACTS OF INTRODUCED COMMON CARP ON NATURAL AQUATIC ECOSYSTEMS AND BIODIVERSITY

Common carp being a popular game, food and ornamental fish, has been cultured for more than 2500 years. However, as per Global Invasive Species

Database, this fish ranks third among the 100 worst invasive alien species, most frequently introduced in the world. It has been introduced in tropical and subtropical lakes and riverine systems of the world (Lowe et al., 2000). Common carp is amongst the most widespread, disadvantageous invasive species (Lowe et al., 2004) because of its ability to be stocked in extreme densities up to 1000 kg/ha (Koehn, 2004) and to alter inland aquatic ecosystems (Weber and Brown, 2009). This fish induces copious damaging effects especially on shallow lakes, both at ecosystem as well as community level by increased nutrients availability, phytoplankton abundance and turbidity (Lougheed et al., 1998), reducing aquatic macrophytes and benthic macro-invertebrates, and altering the assemblage of zooplankton and impaired water quality (Parkos et al., 2003). Though direct pragmatic evidences are limited, these ecosystem alterations caused by the reduction or elimination of macrophytes, change in planktonic communities and disruption of substrate (Stuber et al., 1982) have enough potential to reduce the abundance of several other fish species through reductions or eliminations in fish spawning (Durocher et al., 1984) and rearing habitats (Paukert et al., 2002).

In Pakistan, not much work has been done on this peculiar issue of the impact of introduction of invasive alien fish species to freshwater bodies (Khan et al., 2008; Khan et al., 2011a; Khan et al., 2011b; Mirza et al., 2012). Mostly studies have been conducted on the aspects of common carp culture (Abbas et al., 2010; Chughtai and Mahmood, 2012), toxicology (Tayybah et al., 2012) and reproduction (Abassi et al., 2011). Khan et al. (2011b) have reported that though the alien fish species in Pakistan were introduced with good intentions on enhancing fish production, these have subjected the native species to new predators and competitors which they are inept to withstand. Common carp initially was introduced for the purpose of aquaculture; it has now been well settled into freshwater ecosystems of Pakistan as wild species. Along with other expected reasons like barrage construction, pollution and habitat destruction, the introduction of this alien species has also contributed to a significant decline in the catches of local commercial fish species.

REGULATION OF ALIEN INVASIVE SPECIES

Alien invasive fish species are introduced to increase production, higher economic values and market demand. Several alien invasive fish species have been inaugurated, including common carp, in the warm waters of Pakistan (Khan et al., 2011). The instigation of alien invasive fish species in freshwater ecosystems of Punjab and other provinces of Pakistan is a great risk in declining economic values due to their vigorous reproductive potential and feeding competitions with the native fish fauna. In Pakistan, there is still no proper law or regulation for the introduction of alien invasive fish species to maintain its fish fauna. This leads to the degradation of natural ecosystems due to the alien fish species. There is a need to establish proper regulations and legislations with the help of policymakers to sustain native biota.

GENETIC DEGRADATION OF COMMON CARP

In Pakistan, however, no such work on genetic improvement of common carp has been done so far, due to which stocks of common carp have deteriorated genetically over the years. Further prolific and self-breeding habits of this species, even of small-sized fish, in ponds and other stagnant waters have added more to the genetic degradation of common carp. So the growth performance of common carp has slowed down significantly even under culture conditions due to which fish farmers do not prefer to stock common carp in their ponds under pond polyculture system.

CONCLUSION AND RECOMMENDATIONS

Introduction of common carp in Pakistan has both positive and negative consequences. It is a cheap food and it became an important food fish for the poor, which contributes to the increasing of Pakistan's economy. However, due to prolific breeding, overcrowding in ponds and slow growth attributed to consistent inbreeding of stocks and early maturation, it has almost been delisted from the producers' preference in Pakistan. Pakistan has a great aquaculture potential not only in ponds but also in lakes and man-made dams for cage culture. There is a dire need to work on genetic improvement and single sex production of this auspicious fish species in the country. Introduction of new fast growing strains and production of mono-sex seed of common carp may restore producers' confidence in growing this species under various culture systems and help to develop sustainable aquaculture in the country. Also, common carp is well adapted to inland waters of Pakistan, and to prevent its future negative impact on the environment and native

aquatic species, a solution can be found by encouraging commercial fishermen to increase fishing pressure on this fish species.

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Sažetak

PREGLED INTRODUKCIJE ŠARANA (*Cyprinus carpio*) U PAKISTANU: PORIJEKLO, SVRHA, UTJECAJ I UPRAVLJANJE

Šaran je unesen u Pakistan iz Tajlanda 1964. godine u svrhu akvakulture. Zbog njegove prilagodljivosti na temperaturne promjene i mutnoću vode, te zbog lakoće mriješćenja u ribnjacima, brzo se udomaćio u većini prirodnih kopnenih voda uključujući rijeke, jezera, potoke, kanale, močvare, kao i seoske ribnjake. Iako je šaran postao jedna od najbrojnijih ciprinidnih vrsta u kopnenim vodama i važna hrana u Pakistanu, njegov utjecaj nije posebno dokumentiran. Komercijalni uzgoj u Pakistanu je započeo 1970. godine. U samim počecima rast proizvodnje bio je spor, ali danas igra važnu ulogu u ekonomiji zemlje zapošljavajući više od 400.000 stanovnika. Danas se uzgoj šarana prakticira u cijeloj zemlji, a posebno u pokrajinama Punjab i Sindh. Postoji ogroman potencijal ciprinidnog uzgoja što bi moglo pomoći povećanju boljitka stanovništva, kao i BDP-a zemlje. Ipak, postoji potreba da se osuvremeni tehnologija uzgoja prema standardima razvijenog svijeta koji bi bili uspješni samo u slučaju posebnog interesa kreatora politike i boljeg upravljanja dionika.

Ključne riječi: šaran, kopnene vode, akvakultura, Pakistan, alohtone ribe

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