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Feeding Overlap Investigations between Hypophthalmichthys Molitrix and Cyprinus Carpio from Punjab, Pakistan

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FEEDING OVERLAP INVESTIGATIONS BETWEEN HYPOPHTHALMICHTHYS MOLITRIX AND CYPRINUS CARPIO FROM PUNJAB, PAKISTAN

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ABSTRACT

Freshwater ichthyofauna is facing intensive stress as a result of urbanization and growing industries in Pakistan. The alien fish species are considered one of the major challenges due to their deleterious effects. Feeding habit analysis is a basic tool to evaluate the ecological stress on fish species residing in different habitats. The present study was designed to disclose the feeding overlap between *Cyprinus carpio* (Common Carp) and *Hypophthalmichthys molitrix* (Silver Carp) from Head Marala (river Chenab) and Mangla Dam (river Jhelum). For this purpose, 20 samples i-e 10 from each site of each fish species out of total 40 were captured from March to May 2022 and analyzed at the Department of Zoology, University of Sialkot through gut content analyses. Results indicated that there was a significant feeding overlap with Schoener index values of 0.65 and 0.89 at Head Marala and Mangla Dam respectively between two exotic fish species. It is observed that the aquatic ecosystem of Pakistan is being depleted, where highly generalist feeder invasive fishes have interspecific feeding overlap. It is recommended that the management of the freshwater ecosystem and resident ichthyofauna should be treated as a top priority; otherwise, these may embrace an inevitable and incalculable loss. This functional baseline data will help the land managers and aquaculturists to conserve the freshwater ecosystem of Pakistan.

Keywords: Alien invasive fish species, ecological stress, freshwater ecosystem, gut content analysis, schoener index.

INTRODUCTION

The largest canal system with an area of 0.78 million hectares is found in Pakistan (Altaf et al., 2014). The irrigation system of the Punjab province consists of five main rivers that are interconnected through different dams, barrages, canals and other waterways. Head Khanki, Sukhar barrage, head Qadirabad, Rasul barrage, Mangla dam, Taunsa barrage, head Marala and Chashma barrage act as the dominant aquatic biodiversity sources (Iqbal et al., 2017; Imran et al., 2021).

Freshwater is among the most threatened ecosystem on the planet earth due to its delicacy (Nicacio and Juen, 2015) having large proportions of endangered organisms and their fatalities. Increased water pollution, invasion of non-native species, and agriculture practices are the great challenges for aquaculturists and land managers (Ribeiro and Leunda, 2012).

There are approximately 25000 different fish species known to date worldwide including 15000 marine and nearly 10000 being freshwater (Bollerslev et al., 1994). Fish does not only indicate the pollution status of an aquatic ecosystem but is also one of the main components of the food web (IUCN, 2011). Fish is an important major source of protein for humans all around the world (Tacon and Metian, 2013).

The freshwater fishes of Pakistan belong to class Actinopterygii, sub-class Teleostei with 13 orders, 3cohorts, 30 families, 6 super-orders, and 86 genera (Rafique and Mian, 2012). Among the total fish species, 8 are exotic while 78 are reported as indigenous to Pakistan (Rafique, 2007), 43 indigenous fish species of special concern have been declared endemic to Pakistan and Kashmir.

Silver carp are surface-feeding Chinese fish that consume plant material with size less than 0.025 mm. Its digestive tract is extensively large for the extraction of necessary material from a meal. Fish health quality is determined by proximate age, food composition, feeding rate and genetic strain (Meyllianawaty et al., 2022). Changed water flow and habitat may enhance the chances of invasive species establishment and a large number of tributaries may increase their chance to spread in nearby drainages (Gido and Brown, 1999). *Hypophthalmichthys molitrix* has expanded into the center of the United States via the Mississippi River waters, which is a good example. In North America, it is responsible for significant yearly damage (Pimentel et al., 2005).

Eastern Asia's native silver carp is being introduced worldwide (Kolar et al., 2007; Garvey, 2012). Currently, its population is increasing in the Mississippi river, Illinois river, and lake Michigan tributaries (Chick and Pegg, 2001). *H. molitrix* is one of the most important Phyto-planktivorous fish in China and has been introduced for aquaculture promotion in other parts of the world (FAO, 1991). It is the most cultured in Central and Eastern Europe with more than 80 % of total fish production (Woynarovich et al., 2010, Adámek et al., 2012). An adult is considered to be an omnivorous species and utilizes a relatively high proportion of animals in its food (Michel, 1995).

Fish feeding is an example of the integration of numerous significant ecological factors, such as behavior, health, habitat utilization, energy intake, and interactions between and within species. Understanding trophic interactions in the aquatic ecosystem also depends on accurate descriptions of fish food and feeding practices. Analysis of diet composition can be used to assess the ontogenetic impacts of alien invasive fish species (Chipps and Garvey, 2007; Gelwick and Mcylntare, 2017; Khaing and Khaing, 2020).

Understanding different eco-ichthyologic aspects (at ecosystem, community, population and individual levels) is possible with gut content analysis. It also aids in the fixation of many particular problems such as invasions, speciation, evolution, and fishery management. The stomach content studied can be used to fill the variety of research objectives (Kohler and Ney, 1982; David et al., 2017).

The numerical approach provides more useful information about the feeding behavior of animals (Macdonald and Green, 1983). The relative importance of a dietary item for a predator is calculated through the multiplication of frequency of occurrence and percentage of number and volume (Pinkas, 1971; Hyslop, 1980**)**. With the help of such investigations, three major goals can be attained, most notably the relative diet composition, prey selection, and food intake ratio. The majority of aqua-culturist working on fish feeding mostly evaluates its relative composition (Hyslop, 1980; Manko, 2016).

Gut content analysis (feeding behavior) of fishes plays a crucial role in fisheries management and aquaculture promotion because the actual scenario in the invisible medium of aquatic ecosystem is only possible with the evaluation of their feeding habits. The current study is designed to disclose the feeding overlap between two exotic fish species named *H. molitrix* and *C. Carpio.*

METHODOLOGY

Sampling Area

The mature fish samples were collected from two distinct localities named as head Marla (E 74.467216 & N 32.713671) and Mangle dam (E 73.655494 & N 33.1434406) of the Province of Punjab, Pakistan. The Punjab province has an area of 79284 square miles (205344 kilometers). Selected sampling sites were mapped through Global Positioning System (GPS) mentioned in Figure 1.

Sample Collection and Preservation

With the help of local fishermen and appropriate net size (Khan et al., 2011; Said et al., 2022) 20 mature fish samples (10 from each site) of each fish species (40 in total) were collected from March to May 2022. Samples were identified (Mirza and Sharif, 1996), photographed, weighed (0.1 g), measured (0.1 mm), and preserved in 10 % formalin. The preserved fish specimens were transported to the Department of Zoology, University of Sialkot for further processing.

Quantitative Analysis of Observed Food

i. Frequency of Occurrence

This technique identifies the organism that is used as a source of food by using the underlying formula (Ahlbeck et al., 2012; Baker et al., 2014).

Frequency of occurrence, % Oi = $\frac{Ni}{N} \times 100$

ii. Numerical Method

This approach helps to enumerate the discovered food item from the stomach. The number of each food group was calculated and reported as a percentage of all food categories to ascertain the composition of the overall percentage (Hynes, 1950).

Number of percentage % *N*i, = $\frac{Ni}{Nt} \times 100$

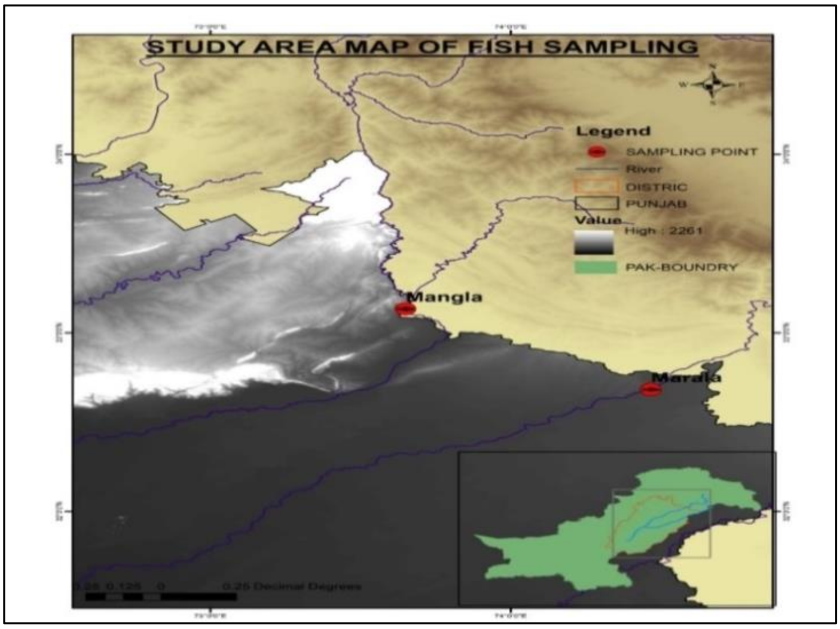

Figure 1: Pictographic presentation of sampling sites

iii. *Relative Importance Index (IRI)*

It is a measurement of the integration of frequency and number. By reducing the skews of individual food category percentages, this index helps to find an accurate portrayal of feeding behavior (Schoener, 1974).

$$\text{IRI} = \%Ni \times \%Oi$$

iv. *Importance of % Relative of Index*

It is difficult to compare the feeding habit of two different fish species by using IRI, so % IRI is calculated by using the following formula

$$\% \text{ IRI}i = 100 \times \frac{IRIi}{\sum IRI}$$

v. *Feeding Overlap*

Diet overlap between two different species is calculated through the underlying formula (Schoener, 1974).

$$D = 1 - 0.5(\Sigma_{i=1}^{s}|Xi - Yi|)$$

The Schoener index values range from 0 to 1 (0 means no while 1 represents total feeding overlap). A 0.6-0.99 value indicates significant feeding overlap (Schoener, 1974).

RESULTS

There is a lack of knowledge regarding gut content analysis of freshwater fishes in Pakistan, except few studies made by Sandhu and Lone, (2017) and Imran et al. (2021). During the present study, a total of 40 fish individuals of *C. carpio* and *H. molitrix* (20 of each) were selected for gut content analysis (GCA). Among harvested fish specimens no one was deprived of food so all countered samples were processed. Both of these selected species are exotic to Pakistan.

The mean body weight of *H. molitrix and C. carpio* was recorded as (640.23 ± 250.23) and (538.30 ± 92.85) whereas similarly mean standard body lengths were (345.23 ± 35.79) and (253.30 ± 14.56). In parallel fashion mean fork lengths were recorded as (70.89 ± 11.03) and (52.50 ± 3.46) respectively. The mean gut length of *H. molitrix* and *C. carpio* was recorded as (3050.78 ± 89.28) and (572.90 ± 95.47) respectively while mean gut weight (containing food) in a parallel way were as (21.18 ± 7.25) and (10.30 ± 2.58) respectively (Table 2). In the present study observed food was categorized as plant matter (lower plants/phytoplankton and higher plants/macrophytes), animal matter (fish parts, higher invertebrates, and zooplankton), and detritus (detritus, mud/sand and unidentified matter).

Head Marla

Silver and Common carp have significantly overlapped feeding strategies at sampling site head Marala. Results indicated that C. *carpio* at head Marala selected all food categories (macrophytes, phytoplanktons, fish, zooplanktons, mud/sand, higher invertebrates, unidentified matter, and detritus) where fish was selected as the least component (50 %) while others showed 100 % frequency. Detritus was the preferred food followed by plant matter (macrophytes 5.50 % and phytoplanktons 21.00 %). 49.50 % of food was comprised of mud and sand, unidentified material and detritus comprised 39 and 4.50 % respectively while 24 % of food was animal matter (zooplanktons, higher invertebrates, and fish were 19.00, 4.50, and 0.50 % respectively) (Table 3, Figure 2). Detritus (% IRI 39.09 & IRI 3900) > phytoplanktons (% IRI 21.05 & IRI 2100) > zooplanktons (% IRI 19.05 & IRI 1900) > mud/sand (% IRI 6.02 & IRI 600) > macrophytes (% IRI 5.52 & IRI 550) > unidentified matter (% IRI 4.51 & IRI 450) > higher invertebrates (% IRI 4.51 &

IRI 450) > fish (% IRI 0.25 & IRI 25) was observed food selection criteria (Table 4).

H. molitrix fed at animal contents upto 50.67 % (higher invertebrates, zooplanktons, and fish as 0.67 %, 50 % 0 % respectively) after that plant matter as 46.67 % (higher plants/macrophytes and phytoplanktons as 3.67 % and 43.00 % respectively) then detritus as minimum as 2.67 % (1.67, 0.67, and 0.33 % of unidentified matter, detritus and sand/mud respectively) (Table 3, Figure 2). IRI values for macrophytes, phytoplanktons, zooplanktons, fish, undifferentiated matter, detritus, and mud/sand were 367, 4300, 44.67, 5000, 00, 167, 66, and 22 while % IRI with similar fashion was observed as 3.68, 43.15, 0.45, 50.17, 0.00, 1.67, 0.66 and 0.22 % respectively (Table 4). Fish/fish parts < mud/sand < higher invertebrates < detritus < undifferentiated matter < macrophytes < phytoplankton and zooplankton was the pattern of food preference.

Table 2: Morphometric variables of selected fish species from sampling site head Marla and Mangla Dam

Fish	MFW(g)± S.D	MSL(mm)± S.D	MFL(mm)± SD	MGL(mm)± S.D	MGW(g)± S.D	MCW(g)± S.D
H. molitrix	640.23±250.23	345.23±35.79	70.89±11.03	3050.78±89.28	21.18±7.25	8.30±3.17
C. carpio	538.30±92.85	253.30 ±14.56	52.50±3.46	572.90±95.47	10.30±2.58	4.65±1.45

Note: Mean Weight of Fish (MFW), Mean Standard Length of fish (MSL), (Mean fork length of fish (MFL), Mean Gut Length of fish (MGL), (Mean Gut Weight of fish (MGW), Mean Content Weight of fishes (MCW).

Mangla Dam

Zooplankton and phytoplankton were present in 100 % followed by unidentified matter and macrophytes in 75 % while detritus and higher invertebrates in 25 % and 25 % examined guts of *H. molitrix.* Present investigations declare that *H. molitrix* mainly fed (83 %) on animal material (higher invertebrates 2 %, fish 0 % planktons 81 %) followed by plant matter (13 %) as (macrophytes 2 %, phytoplanktons 11 %) whereas 4 % encountered food was based on detritus as (mud/sand 0.25 %, unidentified matter 3 % and detritus 0.75 %,) (Table 3, Figure 3). IRI values for macrophytes, phytoplanktons, fish, undifferentiated matter, mud/sand, detritus, higher invertebrates, and zooplanktons were 150, 1100, 00, 225,6.25, 50, 37.50, 8100, whereas % IRI values with similar fashion were recorded as 1.55,11.37, 0.52, 0.00, 2.33, 0.07 0.38 % 0.52 %, and 83.78 % respectively (Table 4).

Fish/fish parts < mud/sand < higher invertebrates < detritus < undifferentiated matter < macrophytes < phytoplankton and zooplankton was the food preference strategy in *H. molitrix* (Table 4). Its food significantly overlapped with *C. carpio* at Mangla Dam.

C. carpio chose all food items with different occurrences of frequency (mud/sand, higher invertebrates and fish at 50 %, macrophytes, phytoplanktons, unidentified matter, zooplanktons, and detritus as 100 %). It fed on debris as 50 % (detritus 39.50, mud/sand 5.50, and unidentified matter as 5.00 %) (Table 3) whereas, 26.75 % on plant material followed by macrophytes (5.25 %), phytoplankton (21.50 %) and 23.25 % on animal material (higher invertebrates 4 %), fish 0.50 % and zooplanktons 18.75 %. Detritus (% IRI 41.58 and IRI 3900) < phytoplanktons (% IRI 22.63 and IRI 2100) < zooplanktons (% IRI 19.74 and IRI 1900) < macrophytes (% IRI 5.53 and IRI 550) < unidentified matter (% IRI 5.26 and IRI 450) < mud/sand (% IRI 2.89 and IRI 600) < higher invertebrates (% IRI 2.11and IRI 450) < fish (and % IRI 0.26 and IRI 25) was the feeding preference strategy at Mangla dam (Table 4, Figure 3).

Table 3: Percentage of food consumption in *H. molitrix* and *C. carpio* at both sampling sites

Food items		Number of percentages		
Minor category	**Main Category**	Samples sites	*C. carpio*	*H. molitrix*
P	Plant material	HM	21.00	43.00
		MD	21.50	11.00
M		HM	5.50	3.67
		MD	5.25	2.00
Z	Animal material	HM	19.00	50.00
		MD	18.75	81.00
H		HM	4.50	0.67
		MD	4.00	2.00
F		HM	0.50	0.00
		MD	0.50	00
U	Detritus	HM	4.50	1.67
		MD	5.00	3.00
MS		HM	6.00	0.33
		MD	5.50	0.25
D		HM	39.00	0.66
		MD	39.50	0.75

Note: M=macrophytes, H= higher invertebrates, D=detritus, Z=zooplanktons, P=phytoplankton, F= fish, U= unidentified mater and MS= mud/sand

Table 4: Percent relative index importance of food items for *C. carpio* & *H. molitrix*

Samples Sites	**Food contents**	**Species**	
		H. molitrix	***C. carpio***
HM	P	43.15	21.05
	M	3.68	5.52
	Z	50.17	19.05
	H	0.45	4.51
	F	0.00	0.25
	U	1.67	4.51
	MS	0.22	6.02
	D	0.66	39.09
MD	P	11.37	22.63
	M	1.55	5.53
	Z	83.78	19.74
	H	0.52	2.11
	F	0.00	0.26
	U	2.33	5.26
	MS	0.07	2.89
	D	0.38	41.58

Note: M = macrophytes, D= detritus, Z= zooplanktons, P= phytoplankton, H= higher invertebrates, F= fish, U= unidentified mater and MS= mud/sand

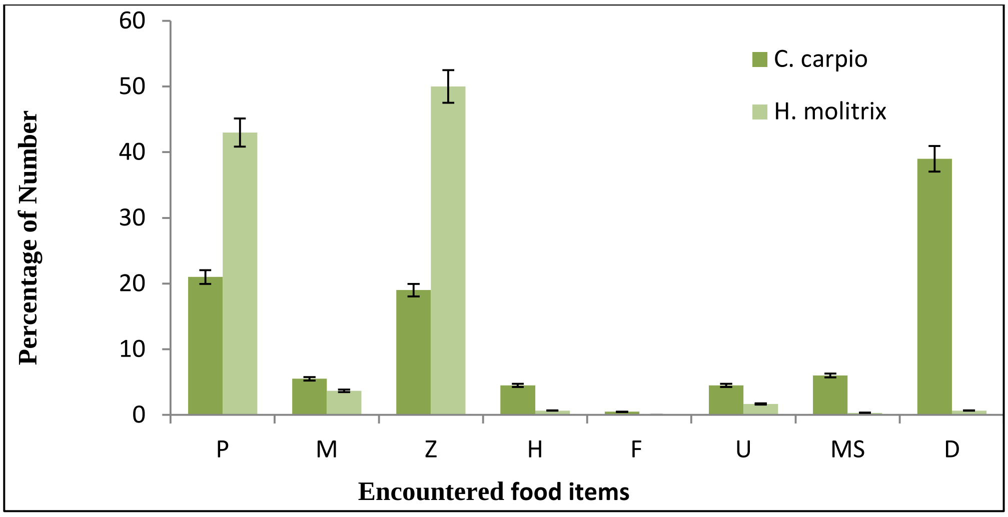

Figure 2: Feeding preference strategy of *C. carpio* and *H. molitrix* at the head Marala site.

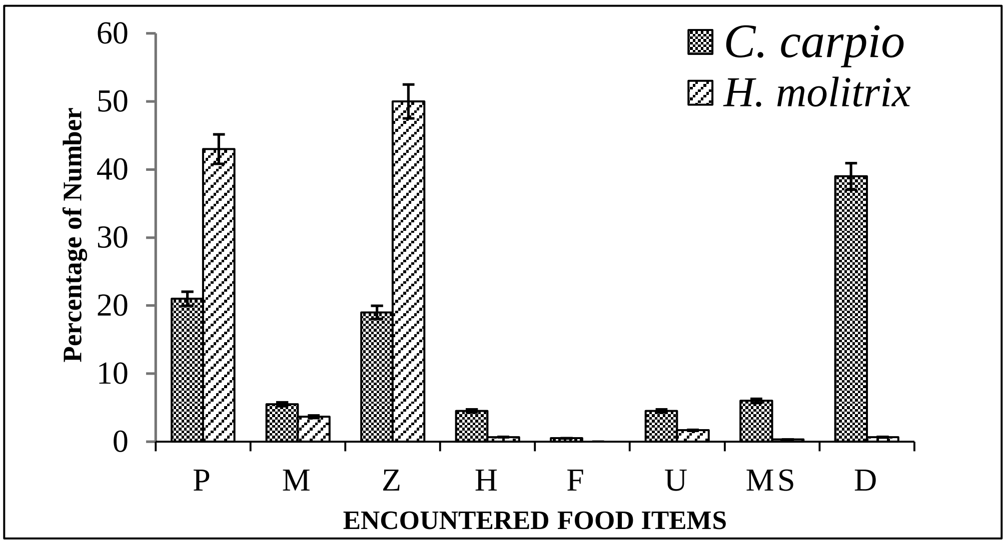

Figure 3: Feeding preference strategy of *C. carpio* and *H. molitrix* at Mangle Dam site

DISCUSSION

Gut content analysis is a tool to access the alien's success in a newly invaded habitat (Imran et al., 2021) while physical examination of gut length gives the clues about feeding nature of fish species (detritus and omnivorous have longer GIT which is necessary for the extraction of nutrients) (Hofer, 1982; Hofer and Newrkla, 1983; Sandhu and Lone, 2017). *C. carpio* is considered a pest because it uproots the vegetation which leads to an increase in turbidity (FAO, 1984; Koehn et al., 2000). It has culminated that the impact of exotic fish fauna is changeable in time and space because their addition may expire huge native species diversity worldwide (Cambray, 2003).

During current *H. molitrix* and *C. carpio* showed different morphological variations as (total length 143.74 mm, fork length 124.18 mm, and final weight 867.55 g) and (total length 101.43 mm, final weight 905.94 g and fork length 81.32 mm) respectively. Examine *C. carpio* specimens from Dal Lake, Kashmir ranging in length from 144 to 414 mm and weight 40 to 4450 g. that show regional synchronization. Morphometric relationships in ichthyologic studies are of major concern because growth patterns, species distribution, and health depend upon changing environmental conditions (Pandey, 2017).

At Head Marala *H. molitrix* took most of its plankton-based diet while at Head Marla fed at both zooplanktons and phytoplanktons (nearly in equal amounts). The current study declared the *C. carpio* as a generalist feeder from both sites based on availability (opportunistic feeder). The results of the present investigation are synchronous with Haseeb et al., 2016 who published supportive findings that *C. carpio* primarily fed on dead benthic fauna and flora matter. Because of high tolerance against turbidity and temperature, common carp have extensive growth rate also has persistent deleterious effects on co-existing indigenous fish species such as *C. mrigala* also a bottom feeder (Parameswaran et al., 2011). Mahboob culminated in 2011 that *C. carpio* mainly feeds on Pupa/larvae, oligochetes, insects, and a minor quantity of zooplanktons whereas sometimes detritus makes its 35 % of gut contents which is in line with the present study. Said et al., (2022) reported that *C. carpio* is a bottom feeder and mainly feeds on the animal matter (particularly benthic macroinvertebrate fauna) but their findings strongly disagree with current investigations where zooplanktons were consumed about 5.7 % of the total food that might be due to its opportunistic feeding habit. Imran et al., (2021) culminated that the major food component of common carp is plant and animal-based matter (protozoans, insect larvae, rotifers, fish, oligochetes, and crustaceans) along with detritus which strongly supports the present observations.

Kloskowski, (2011); Naik et al., (2015); Soni and Ujjania (2018); and Sahtout et al. (2018) inveterate its detri-omnivorous behavior because an enormous number of animals based food were observed in its gut. Its omnivorous feeding nature was confirmed by (Haseeb et al., 2016) from Anchar Lake which is also coherent with current findings.

CONCLUSION

The global fish community is under severe threat due to human activities like urbanization, species introduction, climate change, habitat destruction, and pollution (Abilhoa et al., 2011). There is a close relationship between population dynamics and feeding ecology. The opportunistic feeding habit of alien fish (ranging from herbs and detritus) based on resource availability is alarming for native fish species. A recent study (Motta and Wilga, 2001; Abilhoa et al., 2011) shows how the aquatic environment of Punjab, Pakistan, must be managed because it is changing so quickly. A huge sample size and prolonged time scale is required to generate a detailed picture of the diet overlap between native and invasive fish species in different aspects. It is concluded that the high fecundity, generalist feeding behavior, and tolerance range (temperature and turbidity) of the exotic make them successful invaders at the cost of natives. Although both exotic species have feeding overlap that is might be due to ecosystem instability. It is suggested that law and enforcement agencies in collaboration with aqua culturists and land managers must take strict actions against the unlawful invasion of alien fishes and water-polluting units.

AUTHOR'S CONTRIBUTION

Afzala Munawar, contributed in the investigation and write up the original draft. Dr. Muhammad Imran, helped out in sampling, and enumeration gut contents. Dr. Muhammad Ameen, contributed in conceptualization and supervision of the manuscript. Dr. Abdul Majid Khan, contributed in provision of Lab facilities and guided about manuscript design. Ayesha Sania, is credited to evaluate the feeding competition. Muhammad Shahbaz, edited and reviewed the manuscript.

CONFLICT OF INTEREST

It is being declared from all authors that, there is no conflict of interest in any aspect of this article

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