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DIETARY OVERLAP BETWEEN NATIVE AND EXOTIC FISHES REVEALED THROUGH GUT CONTENT ANALYSIS AT HEAD BALOKI, PUNJAB, PAKISTAN

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ABSTARCT

An imminent threat to indigenous freshwater ichthyofauna is the introduction of alien fishes that can alter the behavior, population dynamics and native community structure. Thus, it is necessary to understand their feeding behaviour to avoid any unwanted incalculable loss. At sampling site, Head Baloki feeding habits both of native (*L. calbasu*, *C. catla*, *L. rohita* and *C. mrigala*) and alien (*H. nobilis*, *H. molitrix*, *C. carpio*, *C. idella*, *C. auratus*, *O. aureus*, *O. niloticus* and *O. mozambicus*) species were analyzed through frequency of occurrence and percentage by number from January 2017-December 2019. Results indicated that *L. rohita* remained herbivorous while *L. calbasu*, *C. catla*, *C. idella* and both *C. carpio* and *C. mrigala* were detritivore, planktivore, phytoplanktivore and generalist feeders, respectively. *H. molitrix* and *C. auratus* showed planktivorus and generalist feeding behaviour, respectively. Tilapia species enlisted as detritivores Whereas, *H. nobilis* was generalist feeder. Complex dietary overlap has been observed between different co-existing species. Current study has uncovered some surprising results where diet of *O. niloticus* was altered as detritus feeder. Change in feeding habit of alien fishes is the strategy to make them successful that is in line with current findings from freshwater ecosystem of Punjab, Pakistan.

Keywords: Alien, freshwater fishes, feeding habits, community dynamics.

INTRODUCTION

The alien species may cause a drastic impact on already stable native fish faun of freshwater ecosystems however succession predictor characteristics of species which promote invasion success are few in number and are different from one system to the other (Ribeiro et al., 2008). It is therefore suggested that investigation of system and species is required to answer the question in particular way (Van-Kleunen et al., 2010). The trophic cascade of alien species in invaded habitats can predict and evaluate their success in new habitats. According to Marchetti et al., (2004), ecological generalist with strong physiological tolerance can be the powerfully established aliens in any new population.

Biological invasion induces economic and ecological consequences worldwide (Gozlan et al., 2010). Fishes are introduced more because it has a strong interaction with human being. Some alien fish species cannot establish in self-sustained ecosystem while few established communities are not impacted by aliens (Gozlan, 2008). A strong literature body indicates that invader species have a strong effect on native populations which range from gene to an ecosystem level (Cambray, 2003; Cucherousset & Olden, 2011) but various impacts still have not been culminated. A fish in a new ecosystem may be added due mainly to four basic reasons including angling/sport, aquaculture, fisheries and ornamental purposes (Gozlan, 2008).

Alien fishes are generally lager than the native ones which is a biological trait leading to the invasive success (Miller et al., 2002; Blanchet et al., 2010). Trophic position of an organism in an ecosystem is also determined by the size of animal's body (Hildrew et al., 2007). Introduction of a large body alien animal in an ecosystem can develop an interaction with prey, predator and competitor. The new competition between alien and native fish may develop indirectly (trophic cascade) or directly (predation and competition) which may affect the native food web and community dynamics (Lockwood et al., 2007). It is required to investigate the ecological impact induced by alien fish on aquatic ecosystem that already has disturbed by the challenging human activities (Cucherousset & Olden, 2011).

Competition between two co existing species for resource acts as a limiting factor for shaping the community as in the case of geography and climate which are abiotic factors of the environment. Interspecific competition impacts both the species, negatively. Resources get exploited by the alien population (Molles, 2002). Each population has a dietary and fundamental niche. Members of the population mostly use possible diet as a subset which depends upon the dietary niche of the concerned population (Stephens et al., 2007). Both intraspecific and interspecific competition helps to find out the resources which belong to respective dietary niche (Stephens et al., 2007; Araujo et al., 2011).

In new habitats the trophic dynamics are important to predict the potential impact of invader species. Kolar and Lodge, (2002) demonstrated that alien species having broad dietary niche are more successful in establishing the new population.

Reservoirs face various anthropogenic disturbances than natural water bodies especially lakes which are ranging from public assessment to the water level fluctuations and face higher variability in its nature (Leira and Cantonati, 2008). It is also found that reservoirs are less resistant to the alien species and lakes are more susceptible to invasiveness (Johnson et al., 2008).

Exotic fishes such as *O. niloticus*, *O. mozambicus*, *C. idella*, *H. nobilis* and *C. carpio* were imported in 1985 (De Silva, 2004), 1954 (Naik 1973), 1964 (FAO, 1970), 1975 (Mahboob and Sheri, 1997) and 1964 (FISHBASE, 2003) from Egypt, Thyland/Egypt & Indonesia, China, China & Nepal and United Kingdom & Thailand respectively while H. molitrix (FAO, 1970) and C. auratus (Mirza, 2003) were imported with unknown source. The alien fishes were introduced to promote Aquaculture practices, to control aquatic weeds, to promote ornamental culture and enhancement of sport fishing in Pakistan (khan *et al*. 2011). Alien fishes Compete with native fishes because they breed in shallow water, mother is mouth breeder, modify food and stabilize in changing food resources De Silva, (2004). Current study is designed to report actual mission of alien fishes in disturbed aquatic ecosystem of Pakistan. Invisibility of alien fishes is almost higher in disturbed ecosystem (Davis *et al*. 2017) that is driven by two basic phenomenon such as vacant and empty niches(Turetsky et al., 2017; Fridley and Sax, 2014; Lekevičius, 2009).

MATERIALS AND METHODS

The sampling was conducted from the year 2017 to 2019 in the territory of Punjab Province, Pakistan from Head Baloki, River Ravi (31°23'23 N; 73°86'90 E) (Figure 1).

The sampling was made twice in the month of January, April, August and December throughout the whole study period to collect maximum number of samples. Data based on Global Positioning System (GPS) was collected from selected sampling site and recorded in Table 1. Targeted fish species were captured through cast nets, drag nets and hand nets. Gill nets with same length of (10 m) and height of (1.6 m), but with meshes varying from 15 to 110 millimeter, knot-knot

(Khan et al., 2011) Appropriate identification keys were used to identify the samples up to the species level (Mirza and Sharif, 1996; Talwar and Jhingran, 1991).

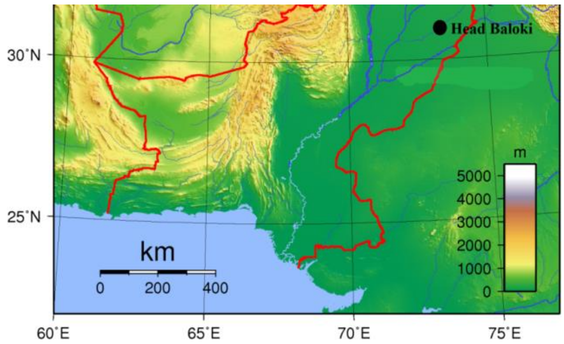

Figure 1: Map of sampling sites Head Baloki (HB)

Quantitative analysis of fish food was carried out by using three parameters proposed by Hyslop in 1980 was used to evaluate the importance of particular food items for fish species with the help of Metallurgical Microscope with Polarizing Darkfield & Dual Lights + 5.0 MP Digital Camera 40X-1600X - EQ-MM500T-USB.

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

% O = Occurrence frequency of a given food i

Ni = Number of stomachs which contain food item i

N = all stomachs which contain food

$$\textbf{Percentage number (\%Ni)} = \%\textbf{Ni} = \frac{\textbf{Ni}}{\textbf{Nt}} \times \textbf{100}$$

%Ni = percentage number of given food i

Ni = number of particular food i

Nt = total number of food items (gut contents)

Index of relative importance (IRI) = %Ni × %Oi

%Ni= percent of percentage number

Oi= percent percentage of frequency

Percent Index of Relative Importance (%IRI) = $\textbf{\%IRIi} = \textbf{100} \times \frac{\textbf{IRIi}}{\boldsymbol{\Sigma}\textbf{IRI}}$

%IRI*i*= *percent index of relative importance of food item i.*

IRIi= index of relative importance of food i.

Σ*IRI = sum of index of relative importance.*

Dietary overlap was found by using underlying formula proposed by Schoener, (1968) as:

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

S= number of food classes

Xi= %IRI of food category i in one species

Yi=%IRI of food category i in other species.

Values of Schoener index ranges from 0 (overlap is absent) to 1(complete overlap between two species). 0.6 values indicated a significant overlap of diet item between two species (Schoener, 1974).

RESULTS

There is a clear cut absence of knowledge regarding the function, structure and stomach analysis for encountered food in freshwater fishes of Pakistan except few history tasks made on some catfishes (Ahmad and Ali, 2000; Sandhu and Lone, 2017). During current study total 39 fish samples including 2 *L. rohita* (1 male + 1 female), 2 *L. calbasu* (2 male + 0 female), 1 *C. catla* (1 male + 0 female), 1 *C. mrigala* (0 male + 2 female), 3 *H. molitrix* (2 male+1female), 8 *H. nobilis* (5 male + 3 female), 2 *C. idella* (1 male + 1 female), 2 *C. carpio* (1 male + 1 female), 8 *C. auratus* (5 male + 3 female), 2 *O. niloticus* (1male + 1 female), 6 *O. aureus* (3 male + 3 female) and 2 *O. mozambicus* (1 male + 1 female) mature fish individuals (from targeted species) out of 616 collected samples were selected for gut content analysis. All the reported fish specimens from Head Baloki were identified as belonging to 41 species. Among selected fishes none of the sample was deprived of food so remained for further proceedings (Table 1).

Table 1: Selected mature (native& alien) fishes contained food in gut.

S. No	Fish Species	*S.T	**I.S	***T.S.S
1	*Labeo rohita*	1	M	2
		1	F	
2	*Labeo calbasu*	2	M	2
		0	F	
3	*Catla catla*	1	M	1
		0	F	
4	*Cirrhinus mrigala*	0	M	1
		1	F	
5	*Hypopthalmicthys molitrix*	2	M	3
		1	F	
6	*Hypophthalmichthys nobilis*	5	M	8
		3	F	
7	*Ctenopharyngdon idella*	1	M	2
		1	F	
8	*Cyprinus carpio*	1	M	2
		1	F	
9	*Carassius auratus*	5	M	8
		3	F	
10	O. niloticus	1	M	2
		1	F	
11	*Oreochromis aureus*	3	M	6
		3	F	
12	*Oreochromis mozambicus*	1	M	2
		1	F	

**S.T (Sample strength), **I. S (Individual Sex), ***T. S. S (Total Sample Strength)*

Phytoplanktons, macrophytes and zooplanktons were present in 100% and unidentified matter in 50% whereas higher invertebrates, fish/fish parts, mud/sand and detritus were the least preferred food as reported in 0% of the examined guts of *L. rohita*. Its food comprised of phytoplanktons, macrophytes, zooplanktons and unidentified matter as 50.50%, 45.50%, 3.50% and 0.50%, respectively whereas other food categories (H, F, MS and D) remained absent in the examined gut of *L. rohita*. IRI & %IRI indicated that Phytoplankton>Macrophytes>zooplankton >undifferentiated matter>higher invertebrates, fish/fish parts, mud/sand and detritus was the food selection pattern of *L. rohita*. *L.rohita* did not show any significant dietary competition with other reported fish species (Table 2).

The occurrence frequency of phytoplanktons, macrophytes, zooplanktons, unidentified matter, mud/sand and detritus was 100% in *L. calbasu* while higher invertebrates and fish/fish parts remained absent in same fish. Major food of *L. calbasu* was based on detritus which comprised about 91.80% (undifferentiated matter, mud/sand and detritus as 0.50, 1.50 and 89.80%, respectively). Plant based diet was 5.70% (phytoplankton 4.40 and macrophytes 1.30%) of the total consumed food. The least consumed food 2.50% by *L. calbasu* was animal based (zooplankton as 2.50% while higher invertebrates and fish/fish parts remained 0%). According to %IRI *L. calbasu* preferred food as Detritus>Phytoplanktons>zooplanktons>mud/sand>macrophytes> undifferentiated matter. Higher invertebrates and fish/fish parts were not found from any one of the examined gut (Table 3). *L. calbasu* showed a significant dietary competition with three tilapia species (*O. niloticus*, *O. aureus* and *O. mozambicus*) (Table 2).

Phytoplanktons, macrophytes, zooplanktons, unidentified matter, mud/sand and detritus were found in all (100%) examined guts of *C. catla* whereas occurrence frequency of higher invertebrates and fish/fish part remained 0%. According to percentage analysis plants (phytoplanktons 40.00% and macrophytes 4.00%) and animals based (zooplanktons 53.00%, higher invertebrates and fish/fish parts as 0.00%) whereas detritus based diet comprised only 3.00% (undifferentiated matter, mud/sand and detritus as 2.00%, 0.50% and 0.50% respectively) of total consumed food. zooplankton>phytoplankton>macrophytes >undifferentiated matter>mud/sand and detritus was the food preference strategy of *C. catla* in wild habitat at Head Baloki. Higher invertebrates and fish/fish parts were not observed form the analyzed fish guts (Table 3). *C. catla* diet significantly overlapped with an alien fish *H. molitrix* (Table 2).

Current study demonstrated that phytoplankton, macrophytes, zooplankton, higher invertebrates, fish/fish parts, mud/sand and detritus were observes in all (100%) processed guts of *C. mrigala*. Results indicated that it takes detritus based diet that is about 49.50% (detritus, mud/sand and undifferentiated matter as 39.50%, 5.50% and 4.50% respectively) while plant based diet was 26.80% of the consumed diet (Phytoplanktons 21.50% and macrophytes 5.30%). animals based diet was consumed about 23.70% (zooplanktons, higher invertebrates and fish/fish parts as 19.20%, 4.30% and 0.20% respectively). Detritus>phytoplankton>zooplankton>mud/sand>macrophytes>undifferentiated matter>higher invertebrates>fish/fish parts is the food preference strategy of the *C. mrigala* as mentioned in table 2. Table 3 showed that *C. mrigala* competed with *H. nobilis* and *H. molitrix*. O occurrence frequency of planktons (phytoplankton & zooplanktons), macrophytes, unidentified matter and detritus was reported as 100% whereas higher invertebrates and mud/sand in 66.67% examined guts of *H.*

Table 2: %O, %N, IRI and %IRI values of dietary items in gut contents of alien and native fish fauna at Head Baloki.

Food Type			Fish Type											
Major category	**Minor category**	Q.V	*L. rohita*	*L. calbasu*	*C. catla*	*C. mrigala*	*H. molitrix*	*H. nobilis*	*C. idella*	*C. carpio*	*C. auratus*	*O. niloticus*	*O. aureaus*	*O. mozambicus*
Plant material	P	%*O*	100	100	100	100	100	100	100	100	100	100	100	100
		%N	5.50	4.40	40.00	21.50	43.00	20.90	80.00	21.00	20.25	4.00	4.25	5.00
		IRI	5050	440	4000	2150	4300	2090	8000	2100	2025	400	425	500
		%IRI	50.63	4.34	40.00	21.50	43.15	21.08	80.20	21.05	20.51	4.03	4.30	5.03
	M	%*O*	100	100	100	100	100	100	100	100	100	100	100	100
		%N	45.50	1.30	4.00	5.30	3.67	5.54	0.00	5.50	6.00	1.00	1.50	1.75
		IRI	4550	130	400	530	367	554	00	550	600	100	150	175
		%IRI	45.62	1.28	4.00	5.30	3.68	5.59	0.00	5.52	6.08	1.00	1.52	1.77
Animal material	Z	%*O*	100	100	100	100	100	100	100	100	100	100	88.34	100
		%N	3.50	2.50	53.00	19.20	50.00	18.88	13.50	19.00	19.00	2.00	2.70	3.50
		IRI	350	400	5300	1920	5000	1888	1350	1900	1900	200	238.52	350
		%IRI	3.50	3.94	53.00	19.20	50.17	19.04	13.54	19.05	19.24	2.02	2.41	3.53
	H	%*O*	0	0	0	100	66.67	87.50	0	100	100	50	50	50
		%N	0.00	0.00	0.00	4.30	0.67	4.44	0.00	4.50	5.00	0.50	0.50	1.00
		IRI	00	00	00	430	44.67	388.50	00	450	500	25	25	50
		%IRI	0.00	0.00	0.00	4.30	0.45	3.91	0.00	4.51	5.06	0.25	0.25	0.50
	F	%*O*	0	0	0	100	0	12.50	0	50	62.50	0	66.67	50
		%N	0.00	0.00	0.00	0.20	0.00	0.37	0.00	0.50	0.50	0.00	0.50	0.50
		IRI	00	00	00	20	00	4.63	00	25	31.25	00	33.34	25
		%IRI	0.00	0.00	0.00	0.20	0.00	0.04	0.00	0.25	0.31	0.00	0.34	0.25
detritus	U	%*O*	50	100	100	100	100	100	50	100	75	100	66.67	100
		%N	0.50	0.50	2.00	4.50	1.67	4.75	0.50	4.50	4.19	0.50	0.75	1.00
		IRI	25	50	200	450	167	475	25	450	314.25	50	50	100
		%IRI	0.25	0.49	2.00	4.50	1.67	4.79	0.25	4.51	3.18	0.51	0.50	1.00
	MS	%*O*	0	100	100	100	66.67	100	0	100	100	100	88.34	100
		%N	0.00	1.50	0.50	5.50	0.33	6.22	0.00	6.00	5.68	1.50	1.00	1.00
		IRI	0	150	50	550	22	622	00	600	568	150	88.34	150
		%IRI	0.00	1.48	0.50	5.50	0.22	6.28	0.00	6.02	5.75	1.51	0.89	1.52
	D	%*O*	0	100	100	100	100	100	100	100	100	100	100	100
		%N	0.00	89.80	0.50	39.50	0.66	38.90	6.00	39.00	39.38	90.00	88.80	85.75
		IRI	0.00	8980	50	3950	66	3890	600	3900	3938	9000	8880	8575
		%IRI	0.00	88.47	0.50	39.50	0.66	39.25	6.01	39.09	39.87	90.68	89.79	86.40

Note: P (Phytoplankton), M (Macrophytes), Z (zooplanktons), H (Higher invertebrates), F (Fish / fish parts), U (Unidentified mater), MS (Mud/sand), D (detritus) and QV (quantitative values).

Table 3: Dietary overlap between native-native, native-alien and alien-alien fishes at Head Baloki.

L.rohita		*L. calbasu*		*C. catla*		*C. mrigala*		*H. molitrix*		*H. nobilis*	
L. calbasu	0.09	L. rohita	0.09	L. rohita	0.48	L. rohita	0.30	L. rohita	0.50	L. rohita	0.30
C. catla	0.48	C. catla	0.11	L. calbasu	0.11	L. calbasu	0.51	L. calbasu	0.10	L. calbasu	0.50
C. mrigala	0.30	C. mrigala	0.51	C. mrigala	0.48	C. catla	0.47	C. catla	0.96	C. catla	0.47
H. molitrix	0.50	H. molitrix	0.10	H. molitrix	0.96	H. molitrix	0.47	C. mrigala	0.47	C. mrigala	0.98
H. nobilis	0.30	H. nobilis	0.50	H. nobilis	0.47	H. nobilis	0.98	H. nobilis	0.46	H. molitrix	0.46
C. idella	0.54	C. idella	0.15	C. idella	0.54	C. idella	0.41	C. idella	0.57	C. idella	0.40
C. carpio	0.30	C. carpio	0.50	C. carpio	0.47	C. carpio	0.99	C. carpio	0.46	C. carpio	0.99
C. auratus	0.30	C. auratus	0.51	C. auratus	0.46	C. auratus	0.98	C. auratus	0.47	C. auratus	0.97
O. niloticus	0.07	O. niloticus	0.97	O. niloticus	0.08	O. niloticus	0.49	O. niloticus	0.08	O. niloticus	0.48
O. aureus	0.08	O. aureus	0.98	O. aureus	0.09	O. aureus	0.50	O. aureus	0.09	O. aureus	0.49
O .mozambicus	0.10	O. mozambicus	0.98	O.mozambicus	0.12	O. mozambicus	0.53	O. mozambicus	0.12	O. mozambicus	0.52
C. idella		*C. carpio*		*C. auratus*		*O. niloticus*		*O. aureus*		*O. mozambicus*	
L. rohita	0.54	*L. rohita*	0.30	*L. rohita*	0.30	*L. rohita*	0.07	*L. rohita*	0.08	*L. rohita*	0.10
L. calbasu	0.14	*L. calbasu*	0.50	*L. calbasu*	0.51	*L. calbasu*	0.97	*L. calbasu*	0.97	*L. calbasu*	0.97
C. catla	0.54	*C. catla*	0.47	*C. catla*	0.46	*C. catla*	0.08	*C. catla*	0.10	*C. catla*	0.12
C. mrigala	0.41	*C. mrigala*	0.98	*C. mrigala*	0.97	*C. mrigala*	0.48	*C. mrigala*	0.51	*C. mrigala*	0.54
H. molitrix	0.57	*H. molitrix*	0.46	*H. molitrix*	0.46	*H. molitrix*	0.08	*H. molitrix*	0.10	*H. molitrix*	0.12

H. nobilis	0.40	*H. nobilis*	0.99	*H. nobilis*	0.97	*H. nobilis*	0.48	*H. nobilis*	0.51	*H. nobilis*	0.54
C. carpio	0.40	*C. idella*	0.40	*C. idella*	0.40	*C. idella*	0.12	*C. idella*	0.13	*C. idella*	0.15
C. auratus	0.40	*C. auratus*	0.97	*C. carpio*	0.97	*C. carpio*	0.48	*C. carpio*	0.51	*C. carpio*	0.54
O. niloticus	0.12	*O. niloticus*	0.48	*O. niloticus*	0.49	*C. auratus*	0.49	*C. auratus*	0.51	*C. auratus*	0.54
O. aureus	0.12	*O. aureus*	0.49	*O. aureus*	0.50	*O. aureus*	0.98	*O. niloticus*	0.98	*O. niloticus*	0.95
O.mozambicus	0.14	*O.mozambicus*	0.52	*O .mozambicus*	0.53	*O. mozambicus*	0.95	*O. mozambicus*	0.96	*O. aureus*	0.96

★ *Value above 0.60 (Bold) is indication of significant diet overlap* *molitrix*. Results of current study indicated that *H. molitrix* mainly feeds on animal based diet as 50.67% (zooplanktons 50.00%, higher invertebrates 0.67% and fish/fish parts 0.00%) followed by plant material as 46.67% (phytoplanktons 43.00 and macrophytes 3.67%) then based on detritus as 2.67 % (detritus, unidentified matter and mud/sand formed 0.67%, 1.67% and 0.33% respectively). Values of IRI for phytoplanktons, macrophytes, zooplanktons, higher invertebrates, fish/fish parts, undifferentiated matter, mud/ sand and detritus were 4300, 367, 5000, 44.67, 00, 167, 22, 66 whereas %IRI values in same manner were recorded as 43.15, 3.68, 50.17, 0.45, 0.00, 1.67, 0.22 and 0.66% respectively. Zooplankton>phytoplankton>macrophytes >undifferentiated matter>detritus>higher invertebrates>mud/sand>fish/fish parts is the food preference pattern of *H. molitrix* (Table 3). *H. molitrix* overpaled its diet with *C. catla* significantly (Table 3).

Macrophytes, zooplanktons, phytoplanktons, detritus, mud/sand and unidentified matter were present in 100% whereas higher invertebrates and fish/fish parts showed their presence in 87.50 and 12.50% respectively in examined guts of *H. nobilis*. In current study it was investigated that *H. nobilis* used each food category with preference of detritus based diet as 49.87% (detritus 38.90%, mud/sand 6.22% and unidentified matter as 4.75%) followed by 23.69% of the food contents composed of animal based diet (zooplanktons, higher invertebrates and fish/fish parts as 18.88, 4.44 and 0.37% respectively). Plant based diet is of least importance for *H. nobilis* that was about 26.44% (Phytoplanktons 20.90% and macrophytes 5.54%). preference of *H. nobilis* (table 3) showed the sequence as of consumed food as detritus (IRI=3890 & %IRI=39.25)>Phytoplanktons (IRI=2090 & %IRI=21.08)>zooplankton (IRI=1888 & %IRI=19.04)>mud/sand (IRI=622 & %IRI=6.28)>macrophytes (IRI=554 & %IRI=5.59)>unidentified matter (IRI=475 & %IRI=4.79)> higher invertebrates (IRI=388.50 & %IRI=3.91)>fish/fish parts (IRI=4.63 & %IRI=0.04). At Head Baloki *H. nobilis* showed significant diet overlap with two other species named as *C. mrigala* and *C. auratus* (table 3).

Detritus, zooplankton, macrophytes and Phytoplanktons showed 100% whereas unidentified matter showed 50% frequency of occurrence in the feeding behavior of grass carp (*C. idella*). Higher invertebrates, fish/fish parts and mud/sand remained absent at Head Baloki. *C. idella* preferred to consume food as phytoplankton 80% (IRI=8000 & %IRI=80.20)>zooplankton 13.50% (IRI=1350 & %IRI=13.50)>detritus 6% (IRI=600 & %IRI=6.01)>unidentified matter 0.50% (IRI=25 & %IRI=0.25) while other food categories remained absent (Table 2). *C. idella* did not show significant diet overlap with any other selected specie at Head Baloki (Table 3).

Results of gut content analysis indicated that at Head Baloki *C. carpio* fed at all defined food types (phytoplanktons, macrophytes, zooplanktons, higher invertebrates, fish/fish parts, unidentified matter, mud/sand, detritus) where fish/fish parts showed minimum frequency of occurrence as 50% unlike others those showed their presence in 100% of the examined guts. Table 2D showed that *C. carpio* feeds on detritus matter as 49.50% (detritus, mud/sand and unidentified matter as 39.00, 6.00 and 4.50% respectively) followed by plant based matter 26.50% (phytoplanktons=21.00% and macrophytes=5.50%) and animal based diet 24.00% (higher invertebrates=4.50%, zooplanktons=19.00% and fish/fish parts=0.50%). *C. carpio* showed the food preference strategy as detritus (IRI=3900 & %IRI=39.09)>phytoplanktons (IRI=2100 & %IRI=21.05)>zooplanktons (IRI=1900 & %IRI=19.05)>mud/sand (IRI=600 & %IRI=6.02)>macrophytes (IRI=550 & %IRI=5.52)>unidentified matter (IRI=450 & %IRI=4.51) & higher invertebrates (IRI=450 &

%IRI=4.51)>fish/fish parts (IRI=25 & %IRI=0.25) (Table 2).Table (3) indicated that *C. carpio* showed a significant diet overlap with *C. mrigala*, *H. nobilis* and *C. auratus.*

Phytoplankton, macrophytes, zooplanktons, higher invertebrates, mud/sand and detritus were observed in all the examined guts of *C. auratus* whereas unidentified matter and fish/fish parts showed their presence in 75 and 62.50% of the guts respectively. The observed values of IRI & %IRI (food preference) were 1900 & 19.24 for zooplanktons, 3938 & 39.87 for detritus, 600 & 6.80 for macrophytes, 2025 & 20.51 for phytoplanktons, 500 & 5.06 for higher invertebrates, 568 & 5.75 for mud/sand, 31.25 & 0.31 for fish/fish parts and 314.25 & 3.18 for unidentified matter in symmetric pattern. Food of *C. auratus* comprised of 39.38% of detritus, 20.25% of phytoplanktons, 19.00% of zooplanktons, 6.00% of macrophytes, 5.68% of mud/sand, 5.00% of higher invertebrates, 4.19% of unidentified matter and 0.50% of fish/fish parts. Overall animal, detritus and plant based diet was composed of 42.2, 32.4 and 25.4% respectively (Table 2). *C. auratus* significantly overlapped its food with *C. mrigala*, *H. nobilis* and *C. carpio* (Table 3).

Phytoplanktons, macrophytes, zooplanktons unidentified matter, mud/sand and detritus food contents showed the 100 whereas higher invertebrates and fish/fish parts as 50 and 0% frequency of occurrence in processed guts of *O. niloticus*. Present study investigated that *O. niloticus*’s major portion of diet is based on detritus 92.00% (detritus, mud/sand and unidentified matter as 90.00, 1.50 and 0.50% respectively) followed by plant matter 5.00 % (4.00% phytoplanktons and 1.00% of macrophytes) and animal based 2.50% (zooplanktons, higher invertebrates and fish/fish parts and as 2.00%, 0.50% and 0.00% respectively) consisted of diet based on animals. Table 3 narrated that most preferred food for *O. niloticus* is detritus (IRI=9000 & %IRI=90.68) whereas other types including phytoplankton (IRI=400 & %IRI=4.03), zooplanktons (IRI=200 & %IRI=2.02), mud/sand (IRI=150 & %IRI=1.51), macrophytes (IRI=100 & %IRI=1.00), unidentified matter (IRI=50 & %IRI=0.51), and higher invertebrates (IRI=25 & %IRI=0.25) and fish/fish parts (IRI=00 & %IRI=0.00) was given minor impotence. According to data in table 3 diet of alien fish *O. niloticus* was overlapped with one indigenous (*L. calbasu*) and two alien fish species (*O. aureus* and *O. mozambicus*) significantly.

Detritus, phytoplanktons and Macrophytes were found in each whereas both mud/sand and zooplanktons were reported in 88.34% of the examined guts of *O. aureus*. Unidentified matter and fish/fish parts showed 66.67% frequency of occurrence while higher invertebrates showed least concern for this where only 50% of the processed guts contained it. Results of present investigations reported the food preference i.e. Detritus (%Ni=88.80, IRI=8880 & %IRI=89.79)>Phytoplanktons (%Ni=4.25, IRI=425 & %IRI=4.30)>zooplanktons (%Ni=2.70, IRI=238.52 & %IRI=2.41)>macrophytes (%Ni=1.50, IRI=150 & %IRI=1.52>mud/sand (% Ni=1.00, IRI=88.34 & %IRI=0.89)>unidentified matter (%Ni=0.75, IRI=50 & %IRI=0.50)>fish/fish parts (%Ni=0.50 , IRI=33.34 & %IRI=0.34)>higher invertebrates (%Ni=0.50 , IRI=25 & %IR=0.25) (table 3). Results in table 3 showed that *O. aureus* took significantly overlapped diet with *L. calbasu, O. niloticus* and *O. mozambicus*

100% guts of *O. mozambicus* showed the presence of phytoplanktons, macrophytes, zooplanktons, unidentified matter, mud/sand and detritus while higher invertebrates and fish/fish parts were reported in 50% of the processed guts for food analysis. *O. mozambicus* mainly focus on Detritus based diet as 87.75% (detritus, both unidentified matter and mud/sand as 85.75, 1.00% respectively) followed by plant based diet as 6.75% (phytoplanktons=5.00% and macrophytes=1.75%). Animal based 5.00% (zooplanktons, higher invertebrates and fish/fish parts as 3.50, 1.00 and 0.50% respectively) diet is least concern for *O. mozambicus*. Calculated values indicated the food preference strategy of *O. mozambicus* is as detritus (IRI=8575 & %IRI=86.40)>phytoplankton (IRI=500 & %IRI=5.03)>zooplankton (IRI=350 & %IRI=3.53)>macrophytes (IRI=175 & %IRI=1.77)>mud/sand (IRI=150 & %IRI=1.52)>unidentified matter (IRI=100 & %IRI=1.00)>higher invertebrates (IRI=50 & %IRI=0.50)>fish/fish parts (IRI=25 & %IRI=0.25)(Table 3). *O. mozambicus* significantly overlapped its diet with three species including two aliens (*O. niloticus* and *O. aureus*) and one native (*L. calbasu*) of the Punjab, Pakistan (Table 3).

DISCUSSION

Mahboob, (2011) investigated the major food component of *L. rohita* is composed of Phytoplanktons (70-80%) followed by zooplanktons (25-30%) which supports current investigations as *L. rohita* comparatively have large openings in filtering apparatus thus it takes large sized food particles (Khaing and Khaing, 2020). Imran *et al*. (2014) corroborated the current investigation by nominating the *L. calbasu* as bottom dwelling fish that mainly feeds on detritus whereas macrophytes, zooplanktons and Phytoplanktons were also found from processed guts. Khabade, (2015) investigated that *C. catla* is an omnivore surface feeder whose adult members feed on algae, higher invertebrates and vegetable debris. Mahboob, (2011) is in line with the current study reporting that the *C. mrigala* is a generalist feeder. Soni and Ujjania, (2018) reported that major food *C. mrigala* consists of detritus while small portion was unicellular algae, filamentous algae and plant matter endorsing the current picture. *H. molitrix* took plankton based diet while *H. nobilis* was found to be a general feeder. Cremer and Smitherman, (1980) reported that both silver and bighead carps (Asian carps) mainly feed on zoo and Phytoplanktons based on the structure of their gill rakers (Bighead carp 20-60 µm and silver carp 20-25 µm) and compete with native filter feeding fishes. *C. idella* is phytoplanktivore specie that preferably eed on plant matter. Milstein and Svirsky (1996) narrated that major food component of *C. idella* is plant based matter while zooplanktons remained in the recessive food category probably due to feeding habit. It was further explained that *C. idella* intake variable food based on its availability (available prey organism), interaction and combination of species. Khan et al. (2016) reported supporting results that *C. carpio* feeds primarily on decaying floral matter and benthic fauna at the bottom of water body. Due to high tolerance against temperature and turbidity *C. carpio* have more growth rate than native *C. mrigala* also feeding at bottom (Parameswaran et al., 1971). Current study indicates that *C. auratus* is a generalist feeder. Saoud, (2006) empowered the current findings by stating that *C. auratus* is omnivore that feeds on crustaceans, mosquito larvae, zooplanktons, plant matter and detritus. *O. niloticus* was observed as detritus feeder. Teferi et al. (2000) reported the same results as of current investigations that *O. niloticus* feed mainly on Phytoplanktons followed by detritus while zooplanktons formed inconsiderable category in natural food. *O. aureus* is an opportunistic detriti-omnivore alien fish that fed mostly at detritus based diet. Michael & Mallin, (2009) reported kindred results with current study where he found that major gut contents of *O. aureus* were dominated by organic detritus whereas 18.8, 4.0 and 0.5% algae, zooplanktons and benthos were investigated respectively. Feeding behaviour of *O. mozambicus* was detritus feeder. Roshni et al. (2016) conducted a study in Chalakudy river of Kerala (India) to investigate the feeding habit of *O. mozambicus*. Quantitative observations revealed that it as omnivorous fish that feeds on detritus, Phytoplanktons (chlorophycae, bacillariophycae and cyanophycae), zooplanktons, macrophytes, sand particles, fish/ fish parts, insects and miscellaneous items.

Fishes have wide range of feeding habits ranging from herbivore- detritus feeder based on resource availability which is reflection of fish behavior (morphology and physiology) along with the consumed food. Alien fishes (surprising concern *O. niloticus*) have wide range of feeding habits than indigenous fish fauna that tells the story of their successful survival in fatly changing aquatic ecosystem of Punjab, Pakistan. Dietary overlap between alien and native fishes is due to high fecundity, feeding on general food categories and tolerance (temperature and turbidity) of alien fishes to survive in invasive environment.

CONCLUSION

The human activities like urbanization, species introduction, change in climate, destruction of habitat and pollution are causing the jeoparadism of fish community worldwide (Abilhoa et al., 2011). Study of feeding ecology is necessary because there is a strong link between population dynamics and understanding the subject such as prey selection strategy (Motta and Wilga, 2001). Alien fishes have wide range of feeding habits ranging from herbivore-detritus feeder based on resource availability than indigenous fish fauna that tells the story of their successful survival in fastly changing aquatic ecosystem of Punjab, Pakistan. Diet overlap between indigenous and alien fish fauna has ecological perspectives and needs different aspects to produce a clear picture. Dietary overlap between alien and native fishes may be due to high fecundity, feeding on general food categories and tolerance (temperature and turbidity) of alien fishes. Further, it is recommended that by using analysis of Stable Isotope and Gut Content from large number of fish samples can provide a vibrant picture on feeding competition among native and alien fishes.

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