Bulletin of Pure and Applied Sciences
Zoology (Animal Science), Vol.42A, No.1,
January-June 2023: P.190-213

Print version ISSN 0970 0765
Online version ISSN 2320 3188
DOI: 10.48165/bpas.2023.42A.1.17

Review Article *Content Available online at: https://www.bpasjournals.com/zoology*

Feeding Ecology of Fishes – A Mini Review

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Article Info:
Received on 22.02.2023
Revised on 23.03.2023
Approved on 19.05.2023
Accepted on 25.04.2023
Published on 16.06.2023

ABSTRACT:
Fishes constitute more than half of the vertebrates, inhabiting almost every aquatic habitat of the world and form an inexpensive source of vital nutrients. The depletion of fishery stocks as a result of anthropogenic interferences is evident worldwide and mandates an urgent need to address the cause before rate of loss exceeds the limit. This makes the assessment of various aspects of fish, especially their feeding ecology quite imperative for developing conservation and management strategies. Food forms a vital factor for fishes required chiefly for growth and reproduction in fishes and its qualitative or quantitative variation is influenced by various biotic and abiotic factors. Amongst the various attributes influencing fishes, food and feeding constitute a vital aspect that impacts the growth and general wellbeing of the fish. Feeding ecology of a fish is directly linked to its population dynamics and helps in understanding of various aspects of fish like habitat preference, competition, prey selectivity, energy transfer etc. Under this backdrop the current review was drafted to acquire knowledge about the three major aspects of feeding ecology of fish i.e., analysis of the gut contents, feeding biology and prey selectivity. The analysis of gut contents helps to identify the prey diversity and abundance consumed by a fish. Feeding biology helps to evaluate the acceptability of the prey by depicting the correlation between biology of the fish and its food preferences. Prey selectivity deals with the evaluation of prey choice depicting the reason behind choice of one prey over the other.

Keywords: Conservation, Gut content analysis, Prey selectivity, Abiotic factors

How to cite this article: Bakhtiyar Y., Nissar S., Arafat M.Y., and Mushtaq R. (2023). Feeding Ecology of Fishes – A Mini Review. *Bulletin of Pure and Applied Sciences-Zoology*, 42A (1), 190-213.

INTRODUCTION

With approximately 35,100 species, fishes form more than half of the vertebrates, inhabiting almost every aquatic habitat of the world (Froese and Pauly, 2023). Fish acts as an inexpensive source of vital nutrients, especially proteins, lipids, minerals, and vitamins (A and D), as such termed as the rich food for the impoverished (Sujatha *et al*., 2013; Mohanty *et al*., 2019; Ali *et al*., 2020). Overfishing, alongside other anthropogenic interferences (climate change, pollution, introduction of new species and encroachments) has led toa decrease in the fish stocks (Jackson *et al*., 2001),eventually leading to the extinction of many fish species (e.g., Pauly *et al*., 2002; Scheffer *et al*., 2005; Heithaus *et al*., 2008). Such a scenario mandates critical action to prevent biodiversity loss, before the loss exceeds the limits (Rockstrom *et al*., 2009). The biodiversity loss also mandates extensive research in various fields (feeding, population dynamics, invasive species, etc.) to form baseline data for various species to facilitate their better conservation.

A wide variety exists in the body forms of the fish, ranging from the small *Paedocypris progenetica* (8 mm total length) to the large *Rhincodon typus* (12 m total length), with the latter reaching around 15000 kg (Helfman *et al*., 2009; Froese and Pauly, 2011). The vast difference in size is accompanied by variety of feeding habits, as fishes are found practically at every trophic level, from decomposers to herbivores to tertiary predators (Gerking, 1994; Wootton, 1998).Variation is further found with the generalists having a wider food preference range in comparison to the others that rely on specific food items like fins or scales (Nelson, 2006; Winemiller *et al*., 2008). Besides the feeding mode in fishes depends on various morphological features, especially the shape of the body, length of the gut, gill rakers, size of the mouth, etc. (Cailliet *et al*., 1996; Wootton, 1998). The type of food consumed by a fish also impacts its behavioural traits (Jobling, 1995).

Of all the attributes influencing the physiology, ecology, and general biology of the fishes, food and feeding constitute an extremely cardinal aspect influencing the survival and general health of the fish. Since almost all the fishes are characterized by typical type II survivorship curves with heavy mortality in the larval stages (Begon *et al*., 1990), therefore, the availability of the right type of food at right time and that too in the right concentration needs to be deliberated upon with assertion, as fishes are diverse with quite different feeding habits. Feeding ecology primarily helps to explore the strategy an animal opts for the optimum foraging of its preferred food and how a fish selectively ingests some organisms preferred over others, besides analyzing the multiple modes of feeding adaptations that comply with their morphological, sensoneural, and physiological responses to the type and abundance of food in the habitat (Wotton, 1998). Food and trophic level preferences play a critical role in the growth and development of fishes, due to their complex life history and often shift during the course of their life. Feed also forms the main input of aquaculture, as such the genre of feeding ecology has gained quite an impetus in recent years. Various workers (Helawell and Abel, 1971; Hyslop, 1980) have proposed that studies on the diet composition play a useful role in fishery science to comprehend trophic interactions, whereas the studies on the food and feeding habits of fishes help in determining their niche in the aquatic ecosystem, the preferred food items by the same further facilitate to determine the food spectrum overlapping with that of coexisting fishes (Yeon *et al*., 1999). Further knowledge of an animal's dietary habits is a prerequisite to study its nutritional requirements, interactions with other organisms, and successful culture (Santos and Borges, 2001). The behaviour and population dynamics of a species are intricately linked with its feeding ecology (Braga *et al*., 2012) which helpsin understanding the subjects of habitat preference (Alimohammadi *et al*., 2022; Adamczuk, 2022), resource partitioning (Ross, 1986; Guedes and Arau´jo, 2008; Alimohammadi *et al*., 2022), predation (Martin *et al*., 2005; Frid and Marliave, 2010), prey selection (Motta and Wilga, 2001), and energy transfer(Nakano and Murakami, 2001; Baxter *et al*., 2004, 2005;

Rezende *et al*., 2008). These ecological subjects are of great importance while developing conservation strategies for species and their ecosystems (Simpfendorfer *et al*., 2011). The genre of feeding ecology is not a novel (e.g., Northcote, 1954), but emerged as a concept probably in the early 1980s (Cummis & Klug, 1979). This concept was refined in case of fishes by Gerking (1994) under the backdrop of optimal foraging theory in the context of physiological adaptation of fish.

FEEDING ECOLOGY OF FISHES IN NATURE

Fishes are either herbivorous, carnivorous, or omnivorous and their body adapts morphologically, physiologically, and anatomically with their feeding (Wainwright, 1988, 1996; Yashpal, 2009). Alteration in several morphometric parameters has a direct relationship with feeding and body form is conventionally considered a strong attribute to successful feeding in fish (Bohórquez-Herrera *et al*., 2015). Studies also reveal a functional relationship between gut microbes in a fish and the feeding habits (Bolnick *et al*., 2014), sensory organs, and digestive functions, that adjust to optimize the feeding process (Wilkens *et al*., 2001; Scharnweber *et al*., 2013). Environment invariably plays an important role in governing the food and feeding habits of different fish stocks and fish populations. The food and feeding in fishes is greatly influenced by many factors including temperature, light, salinity, fish size, activity and behaviour, appetite, feeding regime, starvation, stress, and type of food (Webb, 1978; Assan *et al*., 2021). Nikolsky (1961) stressed that food supply is not only governed by the conditions for obtaining and utilizing food but also depends on many ecological conditions experienced during the feeding period such as temperature, illumination, winds, fluctuations in the water level, and changes in the feeding area. Many fishes exhibit great flexibility in their trophic ecology, for example, ontogenetic and seasonal changes in diet composition (Wooton, 1998; Costalago *et al*., 2012; Fanelli *et al*., 2022). The genre of the feeding ecology of fish could be studied under three main headings, gut content analysis, feeding biology, and prey selectivity as depicted in figure 1.

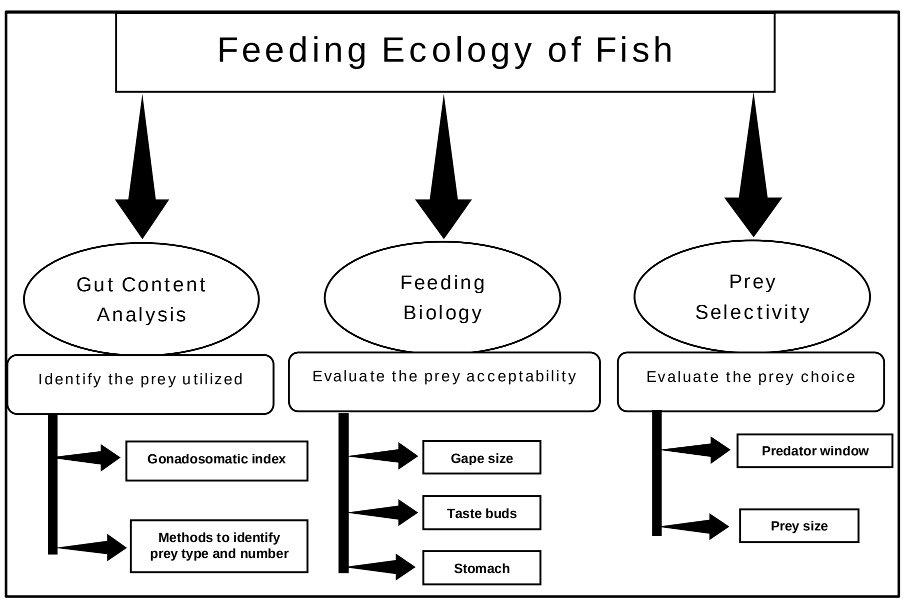

Figure 1: The various aspects studied under the genre of the feeding ecology of fish

GUT CONTENT ANALYSIS

The knowledge about the diet of animals based on the analysis of gut contents is fundamental to the understanding of nutritional requirements and their interactions with other organisms (Windell and Bowen, 1978). Therefore, studies to evaluate the gut content try to identify and quantify the resources utilized by the species, providing information on those selected from the choices available in the environment (Williams, 1981; Tararam *et al*., 1993). The process of gut content analysis requires the measurement of the length and weight of the fish specimen followed by dissecting its gut and preserving it in 5% formalin. This content is further analyzed using a binocular microscope. The gastrosomatic index of the fish is calculated using the formula given below:

$$Gastrosomatic Index (GSI) = \frac{Weight of Stomach X 100}{Weight of Fish}$$

The contents in the fish gut are analyzed qualitatively and quantitatively as well (Hynes, 1950). There are three main approaches for the analysis of the fish gut i.e., bulk, numerical, and presence or absence, with the former comprising mass reconstruction, gravimetric, volumetric, point, and relative-fullness methods (Hyslop, 1980). The presence or absence method has the simplest approaches whereas the others are quite laborious. Many workers are of the view that stomach contents are based on prey consumed shortly before capture, but often it is observed that high percentage of stomachs are empty (Divita *et al*., 1983; Brewer *et al*., 1991; Bakhtiyar *et al*., 2017) and therefore, these kinds of analysis represent the limited view of the diet in time and space (Pinnegar *et al*., 2002; de la Mormiere *et al*., 2003). A variety of indices, particularly the index of preponderance (IOP) (Natarajan and Jhingran, 1961), the index of relative importance (IRI) (Hyslop, 1980), the feeding index (FI) (Kawakami and Vazzoler, 1980) and the proposed and derived indices by Mohan and Sankaran (1988), Costello (1990) and Amundsen *et al*., (1996). have been used for sampling of either undigested / poorly digested gut contents to obtain information on the prey consumption (Pinkas, 1971; Manko, 2016; Mahesh *et al*., 2018). Despite the statistical loopholes, these measures are frequently used due to easy computation and homogeneity, minimizing the error by enhancing the sample size (Carss, 1995). The studies have further been carried out by various workers to overcome the constraints met in gut analysis by improving and refining the methodology time by time. According to Windell and Bowen (1978), the selection of an appropriate technique will ultimately be determined by the investigation type, the presented hypothesis, or the nature of the food to be analyzed, though at times, equipment, time scale, or site restriction may take precedence. Several scientists have expressed their concern about the choice of analytic methods to observe the stomach contents of fish. Hyslop (1980) and Bowen (1983) proposed four main methods to study the gut content of fish, these are - numerical, weight, occurrence, and volumetric frequencies. The studies of the stomach contents of fishes suggest that one of the three methods becomes necessary to evaluate the abundance of the food items in the sample. Many types of conjugated data have been used to get the maximum possible information initiated from an inspection of the contents of the fish stomach. Amundsen and Sánchez-Hernández (2019) have provided a critical review of the various methods of analyzing stomach contents, suggesting the combination of the presence or absence method and relative fullness method for reliable results. Recent approaches in fish dietary studies involve the use of DNA barcoding of prey items (Kress *et al*., 2015; Jakubaviciutė *et al*., 2017), however, it being a novel approach has some constraints yet to overcome. The principle involved for all of the mentioned methods is that food items should be counted or at least weighed or measured by their volume. Dietary descriptions of fish and other aquatic invertebrates are greatly influenced by the choice of method to quantify the relative importance of each prey to the diet. However, Braga (1999) and Lima-Junior (2000) proposed that the separation of food items for counting, weighing, or volumetric quantifying in an individual way is impossible. Thus, recently a new method of analysis of fish stomach contents has been given by Lima-Junior and Goitein (2001).The most commonly used measures (numerical abundance, frequency of occurrence, and volume or weight measures) convey different types of information on feeding habits (Mac Donald and Green, 1983; Cortes, 1997, 1998; Amundsen and Sánchez-Hernández, 2019).

FEEDING BIOLOGY

After acquiring information regarding the preferred food of a fish, one needs to look into the functional correlation between the biology and food preferences of the fish. The integration of biological evidence (based on food selectivity) with the mathematical indices could provide a better ecological hypothesis based on more scientific terms. Feeding ecology particularly shares its most interactive part with three aspects of fish biology i.e., physiological, morphological, and anatomical (Boglione *et al*., 2003; Yúfera & Darias, 2007a, b). The procedure starts with the analysis of the morpho-ecology of mouth (Wainwright & Richard, 1995; Wainwright, 1996), which significantly defines the fish feeding habits during its ontogeny (Luczkovich *et al*., 1995). Besides the feeding habits of fish changes with alterations in the surrounding environment and life stages. For instance, *Cyprinus carpio* exhibits peri-phytophagous feeding habit in rice fields but turns planktivorous in ponds (Saikia & Das, 2009). Similarly, *Labeo rohita* shows a carnivorous feeding habit in the fry stage and shifts to herbivorous diet upon reaching adulthood (Kamal, 1967). Similar reports on dietary shifts in response to prey availability and environmental variables have been demonstrated by Matsumoto and Kohda (2002) and Wang *et al*. (2019). Such flexibility in the diet breadth of a fish is facilitated by the plasticity of the mouth morphometry. Mouth gape acts as an entry point that limits the level of ingestion in a fish and has a strong correlation with the size of the prey a fish consumes at different stages of life (Knutsen & Tilseth, 1985; Mittelbach & Persson, 1998; Lukoschek & McCormick, 2001; Keppler *et al*., 2015). Blaxter (1965) found gape size of the larvae of Atlantic herring as an important morphological constraint in the early life of fish, also, according to Hyat (1979) and Dabrowski (1984), the gape size of the fish larvae is probably the most important morphological attribute that determines the behaviour and ecology of feeding. Being gape-limited predators, the larval fishes are initially constrained to small zooplankton prey, therefore, till the time they are gape-limited, the availability of small vulnerable zooplankton greatly influences the larval success (Zaret, 1980; Hansen and Wahl, 1981). Similarly, Dabrowski and Bardega (1984) studied the mouth size in the larvae of three cyprinid species to predict the size of food preferred by the fish at the initiation of exogenous feeding. They found a linear relationship between mouth size and the total length of fish, from the initial exogenous feeding stage up to 20-30mm. Ponton and Muller (1990) also found a linear relationship between gape size and the length of coregonous larvae. Unlike the adult planktivorous, larval fish are ‘gape-limited’ and as the larvae mature the gape size also starts increasing which thus allows them to take progressively larger prey (Lazzaro, 1987; Schael *et al*., 1991; Bremigan and Stein, 1994). Hasan & Mcintosh (1992) suggested the optimum particle food size for the carp fry, whereas Mookerji and Rao (1993) have reported a direct and linear increase in the mean size of the particle taken by the larvae of rohu (*Labeo rohita*) and singhi (*Heteropneustes fossilis*) as the age and the gape size increases.The feeding pattern (ram or suction) is an understated feature that can be inferred by the gape size of the fish (Wainwright& Richard, 1995). Two indices viz., Mouth area (MA) (Erzini *et al*. (1997) and Gape size (GS 90°) (Ponton & Müller, 1990) give us an estimation of the fish gape size. Morphologically, the vertical and horizontal width of the mouth and the head shape can be considered to explain the prey selectivity of various fishes.

Taste buds, a chemoreceptor or gustatory mechanoreceptor localized in the mouth, tongue, gills, and branchial cavity (Whitear, 1971; Finger, 1997) play a vital role in the feeding mechanism of fish. These receptors are quite responsive to a wide array of substrates, especially the amino acids having a wellcoordinated system for diet selection (Oike*et al*., 2007).

Immunohistochemical analysis (fluorescent dye assisted ligand specific induction followed by histomicrography) of taste buds could establish their role in food selectivity of fishes (Døving *et al.*, 2009). There are instances of food rejection in fishes even after ingestion into the mouth cavity (Bardach *et al*., 1959; Gerhart *et al*., 1991; Schulte and Bakus, 1992), indicating the involvement of receptors within the mouth cavity of the fish in the evaluation of food items (Kasumyan and Doving, 2003). The involvement of the gustatory sensory system as the final evaluator of feeding process is well-known scientifically and complemented by the anecdotes from fishermen, depicting the importance of taste properties of baits and feeds on food consumption, fishing success, and growth rate of fish (Jones, 1984; Takeda and Takii, 1992; Kasumyan, 1997). Fish possess more taste buds than other animals, with external as well as internal taste buds found in the former whereas only internal ones are found in the latter. In fish the taste buds are located on gill rakers, lips, oral cavity, oesophagus, pharynx, as well as on the body surfaces like barbels and fins (Ishimaru *et al*., 2005). The external taste buds help in the detection and food selection of materials found in close proximity tothe headbut the oral taste buds play a vital role to determine the final food consumption (Kasumyan and Døving, 2003; Hansen and Reutter, 2004). The stomach forms the next major feature of the gut and accommodates recently ingested food items, as such could be used to characterize the food habits of a fish species. The first two coils of the guts are utilized for the same purpose in case of stomachless fish. The presence of the stomach and the length of the gut in relation to the body size (relative length of gut i.e., RLG) has been conventionally used as rough indicator of the feeding habit of a fish. Moreover, the analysis of gut microsections followed by enzymatic and bacterial assay analysis could provide more reliable information on the feeding habits of the fish (Bolnick *et al*., 2014). Stomach content analysis of *Pterengraulis atherinoides* revealed the fish to be a specialized predator of Teleostei and juvenile Nanantia, with the diet varying with a change in month and size (Krumme *et al*., 2005).The gut contents analysis of *Argyrosomus japonicus* revealed mysid shrimps to be its most common prey item (for < 250mm total length fish), prawns were common in larger fish (301-450mm) and smaller fish were most common in the diet of fish larger than 500mm (Taylor *et al*., 2006). The feeding ecology of *Delphinus delphis* revealed the diet to be dominated by smaller fish (especially *Notoscopelus kroyeri*), cephalopods, and crustaceans (Pusineri *et al*., 2007).

PREY SELECTIVITY

Prey selectivity pertains to the preference given by a fish species to prey over the other prey items, depending on several factors. It is quite a common feature of feeding in fish and has been the subject of a large number of studies. Selective foraging could be studied by comparing predator diets with the range of prey sizes available in the environment. Many workers have tried to explain selective foraging by designing theoretical, mechanistic models such as optimal foraging models (Stephens and Krebs, 1986) in manipulative experiments. It is observed that selective prey choice could arise either through passive processes (Scharf *et al*., 1998) or through active choice by a predator (Sih and Christensen, 2001). It is further suggested that in aquatic environments, size is one of the major determinants of encounter rate or capture success because most populations of predators and prey are size-structured (Turesson *et al*., 2002). Several reviews on the mechanism of prey selection by planktivorous fish (Eggers, 1977; Confer *et al*., 1978; O'Brien *et al*., 1979) have identified that differential visibility due to prey size, shape, color and motion, differential evasive ability among prey, and behavioral preference on the part of predator for certain prey, collectively contribute to prey selection. In case of piscivorous fishes, it is observed that when given a choice, piscivores feed upon the prey smaller than the maximum ingestible size (Webb, 1986; Wahl and Stein, 1988; Nilsson *et al*., 1995 and Nilsson and Bronmark, 2000). Selectivity for a specific prey type at a given age must be an adaptative feature in larval fish to optimize energy intake (Greene, 1986).

Ontogenetic changes in prey selection patterns of larval fishes reveal that in nature larvae initiate feeding by engulfing small prey items and progressively go on selecting larger prey as they grow.

Fishes may be classified as stenophagous and euryphagous based on their diverse range of prey items (Oscoz *et al*., 2005). Such classification is based on the concept of diet breadth, which explains the proportionality between ingested prey items and their availability in the environment. Despite the shortcomings of the gut analysis techniques, various diet breadth indices like, Levin's index (Hurlbert, 1978), and Manly's α (Manly *et al*., 1972; Chesson, 1978), etc are frequently used. Several other diet-based indices are associated with diet overlap and selectivity like, Ivlev's selectivity index (Ivlev, 1961) and Schoener's index (Schoener, 1968, 1970).Growth is one of the most important processes that determine the recruitment success during the early life history of fish (Crowder *et al*., 1987). It is observed that growth in fish is strongly influenced by the availability of appropriate food items (Welker *et al*., 1994). Most of the larval fish rely on small zooplankton as prey due to limited gape width (Bremigan and Stein, 1994; Devries *et al.,* 1998) and reduced visual acuity (Wahl *et al*., 1993). Therefore, to understand processes at higher levels of organization, it becomes mandatory to understand the behavioural decisions made by individual predators and prey and the subsequent constraints that are imposed upon their behavioural strategies (Lima, 1998).Predators are usually selective foragers with respect to species and size of prey, where selectivity is defined as any difference in prey type composition and the predator diet compared to the composition of the available prey in the environment (Ivlev, 1961; Chesson, 1978).

While analyzing the ecology of 27 species of piscivorous freshwater fishes, Mittelbach and Persson (1998) showed that both the maximum and mean size of the prey eaten, increased with the predator size. During the culture of larvae also, it has been observed that prey size sequencing ensures optimal survival and growth rates (Tucker, 1998).Since size selectivity is often interpreted as optimal foraging, in which, the predator encounters small prey but ignores it due to its low energetic content (Charnov *et al*., 1976), however, it is further reported that differential encounter rate may be due to lower detectability of small prey (Sih and Christensen, 2001). Many workers have supported that minimum prey size has been referred to as predator's ability to detect its prey (Parma and Deriso, 1990; Lundvall *et al*., 1999). Further, apart from prey size alone, Nilsson (2001) suggests that predator behaviour may seriously affect its prey, and size and density-dependent interactions between predators may be a major key to the understanding of predator-prey dynamics and community composition of aquatic habitat. Mechanisms, such as morphological constraints (Werner, 1974; Nilsson and Bronmark, 2000) or differences in spatial scales in combination with the swimming abilities of predator and prey (Christensen, 1996), may explain the maximum realized prey size a predator can take. A prey can be captured and eaten if the prey length: predator length ratio is within a specific range. This range has been referred to as the 'predation window' by Claessen *et al*. (2002). Earlier studies conducted byAlikunhi *et al*. (1955) suggested that the availability of live food organisms (zooplankton) of appropriate size and appropriate densities is probably one of the most critical factors affecting fry survival. Lubzens *et al*. (1984) have supported that during the first few days following yolk exhaustion, larvae of many carp species appear to feed either exclusively on zooplankton or feed very poorly when reared on other feeds, which are non-living and thus to overcome such problems an understanding of prey-predator interaction stands notable (Khadka and Rao, 1986). Gardner (1981) carried out experimental studies on the mechanisms of size selectivity in planktivorous fishes and indicated that the size selectivity results from the decisions made by the fish to ignore the small size class of *Daphnia*. Similar studies were carried out by Checkley Jr. (1982) in Atlantic Herring (*Clupea harengus*) larvae where it was observed that particles smaller than the largest acceptable size were consistently preferred by the predatory larvae. Rehage *et al*. (2005) conducted field and laboratory examinations to study the relationship between specie's foraging behaviour and its impact by comparing the feeding behaviour of two non-invasive *Gambusia* species. Invasive *Gambusia* preferred *Daphnia*, avoided *Lirceus*, and consumed *Drosophila* in proportion to their availability. Larger fish consumed more prey items in their diets thus increasing diet breadth. Experimental studies by Colgan *et al*. (1986) on the feeding behaviour of largemouth bass (*Micropterus salmoides*) suggest that the natural diet of fry had significantly better net efficiency than the artificial diet of fry. The work of Khadka and Rao (1986) on the prey size selection by common carp larvae indicates that with increasing prey density the larvae selectively capture larger (more profitable) prey. Diet composition and prey preference of tench, perch, and roach were investigated by Giles *et al*. (1990). Experimental analysis of prey selection in the feeding of Largemouth Bass was carried out by Hambright (1991) who observed piscivorous fish to be the size-selective predators. Similar experimental studies were carried out by Gulbrandsen (1991) on Atlantic halibut larvae whereas Malhotra and Langer (1993) reported that fish larvae show preferential selection, which is determined by several factors viz. larval age, gape size, visibility, prey density, and prey digestibility. The works conducted by various other workers also confirm the factors influencing prey selectivity (Meng, 1993; Welker *et al*., 1994; Wanzenbock, 1995; Mookerji and Rao, 1995; Liu and Uiblein, 1996; Bremigan and Stein, 1997; Limburg *et al*., 1997 and Devries, *et al*., 1998). Sirois and Dodson (2000) observed the critical period and growth-dependent survival of an estuarine fish, rainbow smelt (*Osmerusmordax*). Experimental studies by Turesson *et al*. (2002) on the prey size selection in piscivorous pikeperch (*Stizostedion lucioperca*) indicate that pikeperch actively selects small-sized prey. Similar prey selectivity patterns were observed by Deuderoand Morales-Nin (2001) in some planktivorous juvenile fishes. Predator-prey interactions with respect to prey size were investigated by Gill (2003) and Dorner and Wagner (2003). Fish size and prey availability and foraging behaviour in larval yellow perch (*Percaflavescens*) was investigated by Graeb *et al*. (2004). Similarly, Holzmann and Genin (2005) studied the mechanisms of selectivity in a nocturnal zooplanktivorous fish, *Apogonannularis* and Cruz-Escalona *et al*. (2005) carried out observations on the feeding habits and trophic morphology of inshore lizardfish (*Synodusfoetens*). Islam and Tanaka (2006) studied the changes in the diet of Japanese sea bass larvae with increasing size and changing ontogeny. Similar work on the ontogenetic shifts vis-à-vis interspecific diet similarity was undertaken by Nunn *et al*. (2007) whereas; selectivity patterns and food requirement of planktivorous alewife for two invasive predatory cladocerans were recorded by Pothoven *et al*. (2007). Prey selection patterns of common minke were recorded by Murase *et al*. (2007) while Lehtiniemi *et al*. (2007) studied the prey selectivity in three species of littoral fishes on nocturnal zooplankton assemblages. The feeding preferences of various commercially important fishes are compiled in table 1.

Table 1: Depicts the feeding preferences of some economically important fish species

Species	Feeding	Habitat	Reference
Cyprinus carpio	Omnivorous Main feed item: Crustaceans (Copepods) Alternatively feeds on algae	Freshwater (benthopelagic)	Sahtout *et al*., 2018
	Feeds upon: Detritus, ostracods, macrophytes, zooplankton, insects, phytoplankton, and gastropods		Dadebo *et al*., 2015
	Main prey item: Benthic insects, crustacea and detritus		Crivelli, 1981
	60 food items (22 Chlorophyceae, 12 Cyanobacteria, 10 Bacillariophyceae, and 16 Zooplankton) items found in gut content analysis		Saikia and Das, 2009

	Omnivorous Gut content analysis: 48.47% phytoplankton (mainly Bacillariophyceae and Chlorophyceae) and 51.53% zooplankton (mainly Rotifera)		Mondol *et al*., 2013
Ctenopharyngodon idella	2.5 cm fish eat duckweed, *Spirodela* Adults prefer rooted plants	Freshwater (benthopelagic)	Lin, 1935
	Fish of size 11-15 mm TL may feed on Rotatoria, crustaceans, and sometimes chironomids and algae Fish of size 17-18 mm TL feed heavily on chironomids; reduced feeding on Rotatoria. Fish of size 30 mm feed exclusively on the microflora		Opuszynski, 1972
	Fish of size 17- 31 mm primarily consume benthic invertebrates Fish of size 32-86 mm chiefly consume periphyton and hydrilla and bank vegetation		Watkins *et al*., 1981
Hypophthalmichthys molitrix	Silver carp diet was dominated by diatom (*Cyclotella* spp.) followed by Chlorophyceae, Cyanophyceae, Crustacea, Dianophyceae, and Rotifera	Freshwater (benthopelagic)	Esmaeili and Johal, 2015
	Consumed zooplankton (Cladocera and Copepoda) and phytoplankton (Pyrrophyta, Chlorophyta, and Cyanophyta)		Spataru and Gophen, 1985
Labeo rohita	Fingerlings, preferred zooplankton (*Arcella* and *Difflugia*, *Keratella* and *Brachionus*, *Daphnia,* and *Cyclops*), and smaller algae (*Cosmarium*, *Closterium*, *Euglena*, *Volvox*, algal spores and zygotes) while phytoplankton (green algae, diatoms, and blue-green algae) were avoided Adults showed a negative selection for zooplankton and a positive selection for green algae and diatoms (*Ankistrodesmus, Spirogyra, Selenastrum, Scenedesmus, Tetraspora, Stephanodiscus, Diatoma, Synedra,* and *Nitzchia*). Blue green algae were avoided	Freshwater (benthopelagic)	Khan and Siddiqui, 1973
	A herbi-omnivore in adult stages and an omnivore-planktophage in the early stages of life Early stage of life: algae, protozoans, rotifers, and Cladocerans were the most preferred food items Advanced stages: macrophytes, detritus, and sand / mud formed the major share of food.		Bakhtiyar *et al*., 2017
Catla catla	Planktivorous (zooplankton feeder) Gut content analysis: Crustaceans (cladocerans and copepods) formed the main food item, followed by rotifers,	Freshwater	Lalit *et al*., 2015

	Bacillariophyceae (diatoms), aquatic insects, Chlorophyceae, Myxophyceae, microvegetation, decayed and semi-decayed organic matter.		
Oncorhynchus mykiss	It is an active invertebrate predator Feeds preferentially on insect adults and larvae. Leptophlebiid may flies and dipteran pupae were the two most abundant food items in Blaylock Creek Representatives of seven insect orders, an isopod and a crayfish followed by Dipterans, Ephemeropterans, Trichopterans, and Hymenopterans were retrieved from the stomachs of the fish in Long Creek	Freshwater (benthopelagic)	Metcalf *et al*., 1997
	Two most important food group: aquatic insects (89%) and fishes Intake of algae and plant material increased with size of fish Microcrustaceans (Cladocera and Copepoda) were also preferred by the smaller trout		Leonard and Leonard, 1949
Salmo truttafario	Most common food items: Brachycentridae, *Blepharocera* spp., Hydropsychidae, *Ephemerella* spp.	Freshwater (pelagic-neritic)	Khan *et al*., 2021
	Main food items: Trichoptera, Ephemeroptera, Diptera, Plecoptera, Coleoptera, Odonata, Amphipoda, Hirudinea, Megaloptera, trout egg, plant seeds and terrestrial ants		Rasool *et al*., 2012
Salvelinus fontinalis	Most common terrestrial prey: small Hymenopterans, Coleopterans, and Aphids Other frequently genera: Simuliids, Plecopterans, and water mites Low frequency of occurrence: Coleopterans (aquatic fraction), adult Trichopterans, Dipterans, and Psyllids (terrestrial fraction) Fishes and lizards were also observed from the stomach of few individuals	Freshwater (benthopelagic)	Horká *et al*., 2017
Brycinus nurse	The relative importance (RI) indices of *Ceriodaphnia sp*., *Povillaadusta* eggs, *Ceriodaphnia* eggs and detritus were found to be higher in dry season as compared to the wet season	Freshwater (pelagic)	Saliu, 2002
Oligosarcushepsetus	*Cichlamonoculus* dominating in autumn Lepidoptera and Hymenoptera dominated in winter Hemiptera dominated the diet in summer	Freshwater (benthopelagic)	Araujo *et al*., 2005
Labeo niloticus	Availability of food governed diet quality Variability of feeding attributed to breeding season and climate A bottom feeder, feeds on organic debris, soft and decaying vegetation, and small	Freshwater (benthopelagic)	El Moghraby and El Rehman, 1984

	organisms found in its habitat		
Creagrutusbrevipinnis	A seasonal variation in the feeding activity of the fish Mainly feeds from 06:00 to 18:00 hrs	Freshwater (benthopelagic)	Roman-Valencia, 1998
Chanos chanos	Gut content analysis: Mainly single cellular green algae (Chlorophyceae) and filamentous blue-green algae (Cyanophyta) Small fraction: Diatoms, crustaceans (copepods, phyllopods, and nauplii), Ciliata, Dinoflagellata, and Rotatoria	Amphidromous (benthopelagic)	Lückstädt and Reiti, 2002
	Main food (19-27 cm): Phytoplankton (Cyanophyceae and Dinophyceae groups) *Navicula* and *Fragillaria* are preferred quite less		A'yun and Takarina, 2019
Mugil cephalus	Major food: Plant matter (diatoms, algae, and dinoflagellates) Animal origin food: Annelids, fish larvae, insect parts and crustaceans	Catadromous (benthopelagic)	Jamabo and Maduako, 2015
	Omnivorous feeder Highest amount: Sand and mud Basic food: Diatoms and algal matter		Lavanya *et al*., 2018
	Bacillariophyceae as the most preferred food material Myxophyceae was given the second preference Dominant zooplankton in gut content Dinoflagellates, followed by copepods Besides parts of fish and shrimp also formed minor contents of stomach		Mondal *et al*., 2015
Etroplus suratensis	Main food: Decayed organic matter (38.61%), filamentous algae (29.15%), and miscellaneous matter (8.04%)	Brackish (benthopelagic)	Joseph and Joseph, 1988
	Main components of gut: Aquatic macrophytes (33%) and filamentous algae (31%) Other components: Detritus and digested matter (12%), diatoms (11%), zooplankton (5%) and molluscs (1%)		Emmanuel *et al*., 2019
	Major food items: Filamentous algae, detritus, aquatic plants and diatoms Other food items: Rotifers, insect larvae, Cladocerans, Copepods, and gastropods		Priya *et al*., 2020
Lates Latescalcarifer calcarifer	Major items: Crustaceans (34%) and small fishes (22.0%) Other items: Mollusca (13%) and algae (9.5%)	Catadromous (demersal)	Panchakshari *et al*., 2016
	Major components: Crustaceans (shrimps and crabs) and fish larvae Other components: Fish larvae, polychaetes and algae (Bacillariophyceae)		Krishna *et al*., 2016
Percalates colonorum	Shows temporal, spatial and size class	Catadromous	Howell *et al*.,

	variations in diet; Diet changed seasonally	demersal	2004
Onchorhynchus tshawytsha	*Engraulismordax, Sebastes* spp., *Clupea pallasii* and *Cancer magister* as main prey Seasonal and annual differences in the dominant prey items	Anadromous (benthopelagic)	Hunt *et al*., 1999
Salvelinus alpinus	Feeding habit shows a dominance of zooplankton in late autumn and of chironomid larvae in winter and chironomid pupae in summers	Anadromous	Svenning *et al*., 2007
Lutjanus fulviflamma	Dawn and dusk as peak feeding hours Opportunistic feeders 46% specimens had empty stomach Brachyurans were the main prey item (48% Index of relative importance)	Marine/brackish (reef-associated)	Kamukuru and Mgaya, 2004
Pseudaphritisurvilli	Numerical and volumetric analysis of the gut contents of 698 specimens revealed the fish was a generalized omnivore, feeding on benthic animals	Catadromous (benthopelagic)	Horte and White, 1980
Paralichthys orbignyanus	Diet comprised of polychaetes	Oceanodromous (demersal)	Prisco *et al*., 2001
Dissostichus eleginoides	Wide variations in the diet with respect to the season, size, and depth of the ocean	Oceanodromous (pelagic-oceanic)	Arkhipkin *et al*., 2003
Synodus foetens	*Loligopealei* and *Upenusparvus* being vital prey during nortes season *L. pealei* and *Engyophryssenta* were reported to be the main prey during rainy season	Marine/brackish (reef-associated)	Cruz-Escalona *et al*., 2005.
Trachurus trachurus	Majority of empty stomachs in January and February and minimum during July and August	Oceanodromous (pelagic-neritic)	Santic *et al*., 2005
Pagrus pagrus	Carnivorous feeding habit feeds primarily on decapods	Oceanodromous	Labropoulou *et al*., 1999
Oncopterus darwinii	Diet comprised of small crustaceans	Marine (benthopelagic)	Prisco *et al*., 2001.
Notolabrus fucicola	Major prey items are crabs, bivalves, and amphipods. 18 prey items from the stomach (microalgae, aquatic insects, terrestrial arthropods and plant matter)	Marine (reef-associated)	Denny and Schiel, 2001; Ortaz, 2001
Rastrelliger kanagurta	Mainly feed on pelagic crustaceans (copepods) represented 51.15% by weight. Fishes accounted 66.7% occurrence and 30.35% by weight Minor item from gut: Sand 38.8%by occurrence and scales 30.6%by occurrence	Oceanodromous (pelagic-neritic)	Nath *et al*., 2015
Sardachiliensis chiliensis	Ichthyophagous and stenophagous fish Generalist predator Fish feed more during the autumn season. Main food items: *Pleuroncodes monodon* and *Engraulis ringens*	Oceanodromous (pelagic-neritic)	Pepe-Victoriano *et al*., 2022
Sardinella longiceps	Mainly feeds on Diatoms Other food items: Dinoflagellates, copepods and fish eggs	Oceanodromous (pelagic-neritic)	Zaki *et al*., 2021

Conflict of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article

Acknowledgments

The authors are highly grateful to the Head, Department of Zoology, University of Kashmir for providing all the necessary facilities during the present study.

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