Food and feeding habits of some peninsular carps

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Carps contribute significantly to global freshwater fish production. In India, the main aquaculture species include catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*). Several indigenous carps are also in high regional demand. These include fringe-lipped carp (*Labeo fimbriatus*), calbasu (*Labeo calbasu*), kuria labeo (*Labeo gonius*), bata (*Labeo bata*), reba (*Labeo ariza*), pig-mouth carp (*Labeo kontius*), pulchellus (*Hypselobarbus pulchellus*), kolus (*Hypselobarbus kolus*), and Carnatic carp (*Barbodes carnaticus*). Studies have shown that some of these species are compatible with major carps in polyculture systems. Integrating them into polyculture with Indian major carps could enhance productivity and increase farmers' income.

Small-scale farmers manage limited resources carefully to minimise risk. Using indigenous fish species can lower input costs and reduce financial risk in aquaculture. These species grow more slowly than commercial carps, making them more suitable for household consumption rather than large-scale retail. Their use could also help conserve biodiversity. Peninsular carps have high potential due to their ability to utilise natural productivity, reducing the need for additional feed. Suitable species for small-scale water bodies include *Hypselobarbus pulchellus*, *Barbodes carnaticus*, *Labeo fimbriatus*, *Labeo calbasu*, and *Labeo kontius*. Research (DFID, 1998) has identified *Labeo* species as the best candidates for low-input culture in small water bodies.

Studies on the food and feeding habits of animals are essential for understanding growth, migration, reproduction, and seasonal changes in body condition. Assessing the diet of fish helps determine their habitat and preferred food sources. Observing feeding habits alongside species composition also provides insights into competition for food among different populations.

Basic knowledge of a species' diet and feeding behaviour is crucial for assessing its suitability for aquaculture. It helps identify compatible species for culture systems, minimising interspecies competition for natural food (Anon, 2001). This information is also useful for developing supplementary feeds. This study compiles and summarises existing literature on the feeding habits of some peninsular carps, whose breeding technology has already been standardised.

Hypselobarbus pulchellus (Day, 1870)

Hypselobarbus pulchellus, a member of the family Cyprinidae, was once an important fishery species in peninsular India. However, it has been classified as 'Critically Endangered' (possibly Extinct) on the IUCN Red List of Threatened Species. Previously known as *Puntius pulchellus*, *Barbus pulchellus*, or *Barbodes pulchellus*, it was later reassigned to the genus *Hypselobarbus*.

This bentho-pelagic species inhabits the deeper sections of large streams and rivers along the base of the Western Ghats. It can grow up to 8 kg, making it a suitable candidate for composite fish culture. Including *H. pulchellus* in aquaculture could help diversify production while supporting conservation efforts. Juveniles and adults feed on filamentous

Hypselobarbus pulchellus

algae, aquatic weeds, grass, and water hyacinth roots, making them a potential alternative to grass carp. Although primarily herbivorous, *H. pulchellus* adapts its diet based on food availability.

David and Rajagopal (1975) studied the food and feeding habits of *Hypselobarbus pulchellus* using gut samples from 123 specimens ranging from 250 mm to 745 mm in length. They observed that the fish is primarily herbivorous, consuming a high proportion of vascular plants such as *Chara*, *Vallisneria*, *Hydrilla*, and *Ceratophyllum* species. *Chara* was the dominant food source, accounting for 18.8% to 66.25% of the diet. *Vallisneria* made up 35% of the diet in April and 12.55% in January and November. *Hydrilla* was present in January (35%), February (22.7%), March (16.2%), and November (9.2%).

Decayed tissues of aquatic plants and grass blades were more abundant in the diet during the post-monsoon period, peaking in August (62.5%), September (30%), and October (45.65%), with lower quantities in other months. Among animal components, *Paramecium* species were found in all months except January and May. Gastropods (*Vivipara* and *Pila* species) were more common when water levels were low, making up 21% of the diet in April and 45% in May. Insects and worms were nearly absent. *H. pulchellus* showed no significant correlation between its diet and plankton availability.

David and Rahman (1975) further studied the diet at different growth stages. Fry measuring 18 mm to 22 mm fed on zooplankton, diatoms, protozoa, and insect remains. Fish between 30 mm and 50 mm consumed decaying leaves, filamentous algae, and diatoms. As the fish grew, the proportion of higher plants in the diet increased. Adult specimens from tanks were found to consume aquatic plants along with small molluscs.

Gut length analysis from fry (18 mm, 34 mg) to adults (665 mm, 5.50 kg) indicated a gradual increase in gut length proportional to body size. The diet shifted from soft algae in early stages to tougher vegetation in adulthood. As an exclusive feeder on vascular plants, *Vallisneria*, *Hydrilla*, and *Chara* dominated its diet in the region of capture. Epiphytic diatoms were consumed incidentally, while small gastropods were an obligatory food source during low water levels in summer.

Basavaraja (2014) observed that captive *Hypselobarbus pulchellus* in farm conditions accepted Napier grass in addition to artificial floating feed. Studies by Barlaya et al. (2022) showed that dried meal of *Azolla* species and *Vallisneria* species could be incorporated into the diet at levels of up to 60% and 30%, respectively, for fingerling rearing.

Barbodes carnaticus (Jerdon, 1849)

Barbodes carnaticus (syn. *Puntius carnaticus*, *Barbus carnaticus*), commonly known as Cauvery or Carnatic carp, is an endemic and threatened species of the Western Ghats. It has been reported from rivers in Kerala, Tamil Nadu, and Karnataka. This species has an elongated, stocky body and grows larger than other members of its genus. In natural waters, it can reach a maximum weight of 12 kg and a length of 60 cm.

The species exhibits rapid growth in its first year, making it a strong candidate for freshwater aquaculture. It is also valued as a sport fish. *B. carnaticus* prefers large pools in rivers and streams, where adults tend to hide under bedrock, boulders, and inside caves. The species feeds on fruits and seeds that fall from the canopy. Its sub-terminal mouth is adapted for column feeding (Gupta et al., 1999).

Manojkumar (2008) studied the food and feeding habits of this species. The study examined 904 specimens, including 262 males (232–430 mm total length), 150 females (270–472 mm total length), and 480 indeterminate individuals (52–227 mm total length). The species has a relatively long gut, with a relative gut length ranging from 2.1 to 4. Junger et al. (1989) classified cyprinids with a relative gut length of 2 or more as herbivores. However, in *B. carnaticus*, the intestine is elongated and coiled, indicating an omnivorous diet with a preference for plant matter.

Barbodes carnaticus

Gut content analysis showed that *Barbodes carnaticus* consumed semi-digested plant matter (30–32%), filamentous algae (17–19%), diatoms (12–16%), semi-digested animal matter (18–26%), and seeds (3–12%). Miscellaneous material, including sand, accounted for 5–8% of the diet. Manojkumar (2008) classified the species as a herbi-omnivore, as plant material made up more than 50% but less than 80% of its diet. The species exhibited a voracious feeding habit, with a full gut recorded in most months of the study.

Semi-digested plant matter included leaves, roots, and stem fragments. Seeds were found in specimens from riparian zones. Filamentous algae regularly present in the gut included *Spirogyra*, *Ulothrix*, *Schizogonium*, *Calothrix*, *Bulbochaete*, and *Hormidium*. Molluscs such as *Pleurodiscus* and the unicellular ciliate *Uronema* were also recorded. Diatoms identified in the gut included *Dinophysis*, *Navicula*, *Closterium*, *Pinnularia*, *Fragilaria*, *Nitzschia*, and *Rhizosolenia*.

Semi-digested animal matter consisted mainly of insects (50–60%), including *Chironomus* larvae and pupae, *Tanypus* and *Ablabesmyia* larvae (Diptera), *Corixa* and *Micronecta* (Hemiptera), mayfly nymphs (Ephemeroptera), *Hydrophilus* larvae (Coleoptera), and dragonfly nymphs (Odonata). Remains of small fish and crustaceans were also found in the gut. Some samples contained sand.

Hypselobarbus kolus (Sykes, 1839)

The peninsular carp *Hypselobarbus kolus* (syn. *Barbus kolus*, *Gonoproktopterus kolus*, *Puntius kolus*), commonly known as the Shooting barb or Kolus barb, is endemic to the Western Ghats. It has been reported from Kerala, Karnataka, Tamil Nadu, and Maharashtra. The species is classified as 'Vulnerable' on the IUCN Red List of Threatened Species. It can reach a maximum length of 30 cm and is considered a good candidate for species diversification in composite fish culture.

H. kolus has a protrusible mouth and is euryphagic, consuming a wide variety of food. Its diet includes molluscs, insects, copepods, ostracods, diatoms, *Chlorophyceae*, grass seeds, and decaying plant matter. Studies have shown a correlation between feeding habits and food availability in the environment.

David and Rajagopal (1974) studied the food and feeding habits of *H. kolus* and found that it is not a major plankton consumer. The phytoplankton component in gut contents included Bacillariophyceae diatoms (3.5%), such as *Navicula*, *Pleurosigma*, *Diatoma*, *Synedra*, *Fragilaria*, *Surirella*, *Cocconeis*, *Gomphonema*, and *Cymbella*. *Chlorophyceae* species included *Spirogyra*, *Zygnema*, *Oedogonium*, *Mougeotia*, and *Cosmarium*. Plant matter, including decaying aquatic vegetation, grass blades, and grass seeds (35–40%), was more abundant in post-monsoon months (September and October).

The animal components in the diet of *Hypselobarbus kolus* included copepods, ostracods, insects, gastropods, and bivalves. Copepod remains consisted of appendages and crushed forms of *Cyclops*, *Diaptomus*, and nauplii stages. *Cypris* species (ostracods) were recorded in all months but in low numbers. The frequent presence of ostracods suggests that the fish browses on the gradually sloping shallow margins of reservoirs while feeding (David et al., 1969).

Insect components included chironomids, mayfly nymphs, corixid bug exoskeletons and appendages, and trichopteran larvae. Gastropods such as *Vivipara*, *Melanoides*, and *Gyraulus* (2–6 mm in size) were found in the gut. Bivalves, including *Corbicula* and *Unio* species, were also recorded.

Decayed organic matter, sand, mud, and semi-digested animal and plant tissue were present in the gut. Sand and mud were likely consumed while feeding near the bottom.

Plankton components included *Cyanophyceae* (*Oscillatoria*, *Anabaena*, *Merismopedia*, *Microcystis*), *Chlorophyceae* (*Pediastrum*, *Scenedesmus*), and *Conjugatophyceae* (*Closterium*, *Cosmarium*). Ostracod eggs, cladoceran remains, and annelid setae were also observed.

Hypselobarbus kolus

Labeo fimbriatus

Labeo fimbriatus (Bloch, 1795)

The fringed-lipped peninsular carp, *Labeo fimbriatus*, is widely distributed across India, Pakistan, Nepal, Bangladesh, and Myanmar. In the wild, it grows slowly, reaching a maximum length of 91 cm and a weight of approximately 3.5 kg (David et al., 1974). It is primarily herbivorous, grazing on algae, protozoa, rotifers, and diatoms that grow on submerged rocks and twigs (Talwar and Jhingran, 1991). Its ventrally positioned mouth and fimbriated horny lips make it well-adapted for bottom browsing. As a stenophagic feeder, it primarily consumes sessile epiphytic diatoms, indicating a selective feeding habit.

David and Rajagopal (1975) examined the gut contents of 190 specimens ranging from 203 mm to 636 mm in length. The diet consisted mainly of plankton. Diatoms were the dominant food source, followed by green algae such as *Spirogyra*, *Mougeotia*, and *Hormidium*. Blue-green algae, including *Oscillatoria*, *Anabaena*, and *Microcystis*, were present in very small quantities. Plant tissue was rarely observed.

Animal components made up a small fraction of the diet (0.4–3.1%), consisting mainly of copepods. Insect remains, primarily chironomid appendages, were also found in the gut contents.

The largest food component in *Labeo fimbriatus* was semi-decayed and decayed organic matter, which accounted for 37.5% of the diet. Sand and mud were also common, making up an average of 26.8% of gut contents. Miscellaneous items included lower crustacean eggs, annelid setae, and other unidentifiable material. The structure and position of the mouth, along with the presence of significant amounts of sand and mud in the gut, confirm its bottom-feeding behaviour.

Rajanna et al. (2015) conducted a study on *L. fimbriatus* in Vanivilas Sagar Reservoir, Karnataka, using 537 male and 589 female specimens. They found that gut contents consisted of 46.54% mud and sand, 20.54% diatoms, 17.13% decayed organic matter, 11.48% other algae, 3.32% semi-digested matter, and 0.98% miscellaneous material. Analysis of different size groups showed that larger fish had higher proportions of diatoms and semi-digested matter, followed by other food items.

Labeo kontius

Earlier studies (Keshavanath et al., 2002; Gangadhar et al., 2015, 2016) demonstrated that *L. fimbriatus* efficiently utilises periphyton during fry and fingerling rearing, as well as in grow-out culture.

Labeo kontius (Jerdon, 1849)

The peninsular carp *Labeo kontius*, commonly known as the pig mouth carp or Cauvery carp, is endemic to the Western Ghats. It has been recorded in rivers of Karnataka, Tamil Nadu, and Kerala. This species can be domesticated for pond culture, making it a valuable addition to aquaculture. It grows to a maximum length of 61 cm and is predominantly herbivorous. Its feeding habits vary by life stage, with adults and fingerlings feeding at the bottom and midwater levels, while spawn and fry feed near the surface (Mohanta et al., 2008).

Alikunhi and Rao (1952) analysed the stomach contents of 42 specimens ranging from 112 mm to 495 mm, collected from Hogenakkal, Mettur, Bhavani, Tanjore, and Chetput Fish Farm. Like most species in its genus, *L. kontius* is primarily a plant feeder, with animal matter making up only about 5% of its diet.

Filamentous algae and aquatic plant leaves accounted for 32.3% of gut contents. *Spirogyra* was present in 70% of specimens and constituted 10–80% of the gut contents, making up more than half of the filamentous algae consumed. *Oscillatoria* was found in 50% of specimens, contributing 3–70% of the diet. Diatoms made up 27% of the diet, with *Navicula* species alone contributing about 20%. Diatoms were almost always present, ranging from 10–60% of stomach contents.

Sand and mud were found in 80% of specimens, making up 30.5% of the average diet, though individual specimens contained between 10% and 80%. The animal component, consisting of insect parts, earthworm remains, copepods, and rotifers, accounted for only 5% of the diet. In half of the specimens, stomach contents were entirely plant-based.

The stomach contents of *Labeo kontius* indicate bottom-feeding behaviour and browsing on stones and other objects in shallow marginal areas. When consuming large quantities of filamentous algae, the fish also ingests epiphytic and embedded diatoms. Several *Navicula* species diatoms, present as both frustules and fresh cells, are found in the surface layers of bottom mud and are likely consumed during feeding.

Observations suggest that habitat influences feeding habits. Specimens from freshwater ponds had a higher proportion of planktonic algae and lower amounts of sand and mud in their gut compared to those from riverine environments. This suggests that the species adapts its diet to the available food when transitioning from lotic (flowing water) to lentic (still water) environments.

Post-larval specimens and early fingerlings reared in laboratory aquaria fed voraciously on zooplankton, including rotifers, cladocerans, and copepods. When available, they also consumed large amounts of phytoplankton, particularly *Microcystis*.

Tor khudree (Sykes, 1849)

The historic range of *Tor khudree*, the Deccan Mahseer, was restricted to the northern and central Western Ghats of India, specifically in the eastward-flowing Krishna River system and its tributaries in present-day Maharashtra, Telangana, and Karnataka. However, large-scale introductions of artificially bred fish have expanded its distribution across peninsular India, including the westward-flowing river systems originating from the southern Western Ghats (Jayaram, 2005). The species can grow up to 1.2 m in length and reach a weight of 50 kg in the wild (Froese and Pauley, 2019). It is valued for both recreational fishing and aquaculture. The ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR) has identified *T. khudree* as a potential species for cultivation.

Biju (2003) conducted a gut content analysis of *T. khudree* using 30 specimens from the Bharathapuzha River, ranging in length from 12 cm to 31 cm and in weight from 104 g to 410 g. The study found that semi-digested animal matter (mutilated flesh from various animals) was the dominant

Tor khudree

component, making up 52.3% of the diet. Other animal components included insect larvae, fish remains (bones and scales), and crustacean remains (appendages), with respective contributions of 5.2%, 3.2%, and 0.74%. Semi-digested plant matter, consisting of broken roots, leaves, and stems, accounted for 24.95% of the diet. Other components included diatoms (7.4%), filamentous algae (1.24%), sand (0.75%), detritus (2.99%), and miscellaneous substances (1.24%).

The study classified *T. khudree* as an omnivore with a strong preference for carnivorous food. The presence of sand and detritus in the gut supports its bottom-feeding habits. According to Kulkarni (1980), although *T. khudree* consumes small fish in certain months, it primarily depends on plant material, insect larvae, and molluscs.

Tor khudree is known to be a periphyton grazer. Juvenile fish feed on materials found on the substrate, including attached algae, aufwuchs (surface growths), insect larvae, snails, and occasionally shrimps and crabs. As a result, the stomach contents of smaller individuals primarily reflect benthic organisms. Larger fish (>25 cm) also feed on the bottom layer and aufwuchs attached to rocks and boulders. They consume aquatic vegetation along with leaves, flowers, fruits, and seeds from riparian vegetation when these plant materials settle on the substrate.

Keshavanath et al. (2002) reported that *T. khudree* efficiently utilises periphyton in grow-out culture. The relative gut length increases from 1.74 to 2.55 as the fish grows up to 30 cm in total length, after which it remains nearly constant. This range indicates an omnivorous feeding habit (De Silva & Somarathna, 1994).

The Sri Lankan *Tor khudree* (yellow mahseer) has been reported to feed on a variety of food sources. Willey (1903) documented its diet, which included crabs, molluscs, and small fish. Deraniyagala (1952) observed that it also consumed algal material, freshwater molluscs, and plant matter such as leaves and flowers that fell into the water. Fernando (1965) further noted the presence of insects and higher plants in its diet.

De Silva and Amerasinghe (1995) studied the feeding habits of Yellow Mahseer using specimens ranging from 5 cm to 60 cm in length. The fish was found to consume both animal and plant matter, leading to its classification as an omnivore. However, since its diet consisted mainly of aquatic insects and their larvae, the researchers further categorized it as an insecti-herbivore. As the fish grew, its diet shifted from predominantly animal matter to a higher proportion of plant material.

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