Indian Major Carps

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Introduction

Indian major carps are commercially cultured in India and the Indian subcontinent; catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) are considered the three major carps of India. A few medium and minor carps that grow to an appreciable size are also being farmed in fresh water. Indian major carps are usually cultured together in 'polyculture' rather than monoculture. The principle behind this polyculture system is the utilization of all available natural food resources at different trophic levels to achieve maximum production per unit area of water body (Jhingran, 1991).

Major carps are cultured not only in India but also in the entire Indian subcontinent, particularly Pakistan, Bangladesh, Nepal, Sri Lanka, Myanmar and other adjoining countries. Carp culture in India has a long history and can be traced back several centuries. Most of the farmed carps are marketed within the country for domestic consumption. In recent years, fillets, flakes and other value-added products of carps have been exported to Middle East countries. Surprisingly, carp production was not reported in the Food and Agriculture Organization (FAO) fish-production statistics until recently. In the past few years, Indian carp production has registered substantial increases. India is second in world carp production, next only to China. Of the 2 million t of aquaculture production of the country, a majority is from the farming of carps.

Although Indian major carps are traditionally cultured in freshwater ponds, recently success has been achieved in culturing these species in brackish-water ponds (where penaeid shrimp were cultured) after gradual acclimatizaion to saline water (up to 15 parts per thousand salinity). Concerted research efforts were also made in nutrition, feed and feeding of Indian major carps, in addition to culture practices.

Nutrient Requirements

Protein and amino acids

The optimal dietary protein requirement is affected by the nutritional value of the dietary protein and the level of non-protein energy in the diet. When sufficient energy sources, such as lipid and carbohydrates, are available in the diet, most of the ingested protein is utilized for protein synthesis. Adults of Indian major carps require 30% dietary protein for proper growth and survival. Fingerlings and fry of these carps require 35% and 40% dietary protein, respectively, for good growth (Sen *et al.*, 1978; Renukaradhya and Varghese, 1986). Mondal *et al.* (2000) reported that catla fry require 38.5% dietary protein for optimal growth and survival.

Indian major carps, like other animals, do not have an absolute requirement for protein but require a balanced mixture of indispensable and dispensable amino acids (Murthy and Varghese, 1998). Qualitative and quantitative amino acid requirements of Indian major carps were determined by conducting growth studies by feeding graded levels of test amino acids and at the same time keeping all other essential amino acids at the required level. Qualitative amino acid requirements of carps could also be estimated by employing carbon-14 (^{14}C)-labelled isotopes. Carcass (body) composition of amino acids gives only a rough estimate of requirements, which could be used in the absence of information on dietary requirements. Studies on the qualitative dietary requirement of carps have indicated that they require all the ten essential amino acids (EAA) that are known as indispensable for other commercial finfish studied so far. Quantitative dietary amino acid requirements of catla, rohu and mrigal for all ten amino acids are presented in Tables 19.1, 19.2 and 19.3, respectively. The cystine replacement value was estimated to be 50% in Indian major carps.

Lipids and fatty acids

Lipids, or fats, are required as a source of energy and essential fatty acids. Further, lipids serve as a carrier for fat-soluble vitamins. Fatty acids and phospholipids help to maintain the structural integrity of cell membrane. The gross lipid requirement of Indian major carps is 7–8% of the diet. Young fish require relatively more fat and more protein than adults.

All three Indian major carps were found to grow well when the diet contained 1% n-3 and 1% n-6 fatty acids. Body composition of Indian major carps contains a high proportion of n-3 fatty acids as well as n-6 fatty acids. Limited studies have been carried out on the dietary fatty acid requirement of Indian major carps.

The essentiality of highly unsaturated fatty acids (HUFA), such as eicosapentaenoic acid (EPA) (20:5n-3) and docosahexaenoic acid (DHA) (22:6n-3), has not been reported for Indian major carps. These carps are basically freshwater species and found to grow well even in the absence of HUFA.

Table 19.1. Dietary amino acid requirements of *Catla catla* (% dietary protein).

Amino acid	Fry	Juvenile/adult
Arginine	4.80*	5.63†
Histidine	2.45*	2.38†
Isoleucine	2.35*	2.75†
Leucine	3.70*	4.38†
Lysine	6.23*	6.86‡
Methionine	3.55*	3.00†
Phenylalanine	3.70*	4.50†
Threonine	4.95*	4.50†
Tryptophan	0.95*	1.03§
Valine	3.55*	3.60†

* Ravi and Devaraj (1991).
† Based on the unpublished results of the author.
‡ Satheesha and Murthy (2000).
§ Satheesha and Murthy (1999).

Table 19.2. Dietary amino acid requirements of *Labeo rohita*.

Amino acid	Per cent of diet	Per cent of dietary protein	Reference
Arginine	2.30	5.75	Murthy and Varghese (1995)
Histidine	0.90	2.25	Murthy and Varghese (1995)
Isoleucine	1.20	3.00	Murthy and Varghese (1996a)
Leucine	1.85	4.63	Murthy and Varghese (1997a)
Lysine	2.27	5.58	Murthy and Varghese (1997b)
Methionine*	1.15	2.88	Murthy and Varghese (1998)
Phenylalanine†	1.60	4.00	Murthy and Varghese (1996b)
Threonine	1.71	4.28	Murthy and Varghese (1996c)
Tryptophan	0.45	1.13	Murthy and Varghese (1997c)
Valine	1.50	3.75	Murthy and Varghese (1997d)

* Total sulphur amino acid (methionine + cysteine) is 1.42% (3.55% dietary protein).
† Total aromatic amino acid (phenylalanine + tyrosine) is 2.31% (5.77% dietary protein).

Carbohydrates

Carbohydrate is the cheapest nutrient and also a less expensive energy source for carps. Being herbivorous/omnivorous feeders, Indian major carps easily digest appreciable quantities of carbohydrates in the diet. A dietary level of 22–30% of carbohydrate has been found to be optimum for the growth of Indian major carps. Growth retardation and reduced feed efficiency is observed when the carbohydrate level exceeds 35% of the diet. Starch and dextrin are readily

Table 19.3. Dietary amino acid requirement of *Cirrhinus mrigala*.*

Amino acid	Per cent of diet	Per cent of dietary protein
Arginine	2.10	5.25
Histidine	0.85	2.13
Isoleucine	1.10	2.75
Leucine	1.70	4.25
Lysine	2.35	5.88
Methionine	1.27	3.18
Phenylalanine	1.60	4.00
Threonine	1.65	4.13
Tryptophan	0.43	1.08
Valine	1.40	3.50

* Unpublished data from studies conducted by the author employing casein and gelatin as intact protein sources (40% protein), together with crystalline amino acids.

accepted by Indian major carps. However, in practical diets, wheat flour, tapioca flour and rice flour are used as cheap sources of carbohydrate in the diet formulation. These ingredients also serve as natural binders in the diet. Carbohydrates spare some protein when protein is not available in sufficient quantities in diets. Absence of adequate dietary carbohydrate in carp diets may result in the utilization of protein as an energy source.

Vitamins and minerals

Thiamine has been found to be an essential vitamin for the growth and survival of several freshwater fish species. No studies have been carried out on the dietary requirement of Indian major carps for thiamine. However, it is estimated that 8–12 mg kg^{-1} diet fulfils the dietary requirement, depending on the life stage. In commercial diets, higher levels are included to allow for leaching and anticipated losses during diet processing and storage. Riboflavin is essential for Indian major carps. A deficiency of riboflavin results in fin erosion, anorexia, loss of body colour and cataracts in fish. The riboflavin requirement of Indian major carps has been estimated to be about 6–8 mg kg^{-1} diet. However, in commercial diets, as high an amount as 10 mg kg^{-1} diet or more is incorporated, since it is water-soluble and part of it may be lost due to leaching. It is estimated that the three Indian major carps require 10–12 mg niacin kg^{-1} diet for normal growth and survival. The dietary requirement of Indian major carps for pantothenic acid has been estimated to be 9–11 mg kg^{-1} diet.

It is recommended to use stable forms of vitamin C, such as ascorbate 2-monophosphate or ascorbate 2-sulphate, in carp diets due its unstable nature and leaching problems. Few studies on the dietary requirement of ascorbic acid in Indian major carps have been carried out; however, a dietary level of 300 mg ascorbic acid kg^{-1} diet appears sufficient for the normal growth and survival of

larvae and fry of rohu and mrigal. Tissue levels of vitamin C increased corresponding to dietary intake up to 1000 mg kg^{-1} diet in both rohu and mrigal. Disease resistance in respect of *Aeromonas hydrophila* was enhanced by vitamin C and lowest mortality was reported in rohu fed 600 mg vitamin C kg^{-1} diet and in mrigal fed 1000 mg kg^{-1} diet (Sobana, 1997). There are reports that ascorbic acid-free diets did not result in deficiency signs, mortality or significant growth variation in rohu when compared with diets with added ascorbic acid (Hasan *et al.*, 1993). In general, a dietary level of 100–150 mg ascorbic acid kg^{-1} diet has been found satisfactory for the normal growth of adults of Indian major carps. Deficiency of ascorbic acid leads to anorexia, poor growth, high mortality, fin necrosis, abnormal pigments, spinal curvature in mrigal (Agarwal and Mahajan, 1980; Mahajan and Agarwal, 1980a,b), haemorrhagic skin, microcytic anaemia and hypochronic anaemia in Indian major carps (Sobana, 1997).

Pyridoxine deficiency causes loss of appetite, oedema, nervous disorder, anorexia, hyperirritability and rapid gasping in fish. A dietary level of 6–8 mg pyridoxine kg^{-1} diet is recommended for Indian major carps. Dietary requirements for vitamin B_{12} have not been determined for Indian major carps, but a suggested dietary requirement is 0.01–0.02 mg kg^{-1} diet. The quantitative dietary requirements of Indian major carps for inositol range from 300 to 350 mg kg^{-1} diet. A dietary requirement of 5–8 mg biotin kg^{-1} diet was found satisfactory for Indian major carps. The quantitative dietary requirement of Indian major carps for folic acid appears to be 0.5–1 mg kg^{-1} diet. Dietary requirements of Indian major carps could be met at 500–600 mg choline kg^{-1} diet.

Vitamin A (retinoic acid) deficiency causes displacement of the eye lens and corneal thinning, poor growth, exophthalmia and depigmentation in carps. The dietary vitamin A requirement of Indian major carps appears to be 1500 IU. Vitamin D deficiency leads to depressed growth and muscle tetany in finfish, including carps. It is also important in the regulation of minerals, calcium and phosphorus. No quantitative requirement studies have been carried out on Indian major carps for vitamin D; however, a dietary level of 400–500 IU is suggested. The quantitative dietary requirement of vitamin E in Indian major carps appears to be 40–50 mg kg^{-1} diet. The dietary requirement of Indian major carps for vitamin K falls in the range of 5–10 mg kg^{-1} diet.

The dietary calcium requirements of Indian major carps has not been studied, but 4000–5000 mg calcium kg^{-1} diet is suggested. Calcium deficiency has not been detected in common carp (Ogino and Takeda, 1976; Lall *et al.*, 1985). Phosphorus deficiency results in poor food conversion, anorexia, poor bone mineralization, skeletal deformity, cranial deformity and other disorders in carps. Dietary levels ranging from 5000 to 6000 mg phosphorus kg^{-1} diet have been found to satisfy the requirement of Indian major carps. A dietary magnesium level of 500 mg kg^{-1} diet is optimum for Indian major carps, while 3–4 mg copper kg^{-1} diet has been found to satisfy their requirement. When supplemented at a level of 0.1 mg kg^{-1} diet in the diets of Indian major carp fry in nursery ponds, cobalt, in the form of cobalt chloride, enhanced growth and survival (Alikunhi, 1987). Quantitative dietary requirements of Indian major carps for other minerals have not been reported.

Practical Diets and Feeding

Supplementary feeding is essential to increase the production of carp fry in ponds. The average survival of Indian major carps during the early stages is rather low (about 30% from spawn to fry) and about 50% from fry to fingerling. This high mortality is due to lack of adequate and nutritionally balanced diets, and poor management practices.

The traditional or conventional diet used by small and rural fish farmers for the culture of Indian major carps is a mixture of rice bran and oilcake in equal proportions by weight. The diet consists of 1 : 1 rice bran and oilcake and usually contains 25–28% crude protein. However, this diet is not a nutritionally-balanced one. Most often, the oilcake is soaked in water for several hours and mixed with rice bran to make a dough and fed, in an uncooked form, twice daily at a rate of 10–20% of biomass in nursery ponds.

Nutritionally balanced diets were developed for carp juveniles and adults incorporating more ingredients than used prior to 1970 (Table 19.4). Varghese *et al.* (1976) formulated a pelleted diet for carps that contained 30% protein, incorporating fish-meal, and achieved 50% more production than with the traditional mixture of rice bran and oilcake. Good growth of common carp was recorded when feeding a pelleted diet containing silkworm pupae, prawn waste or fish-meal (Jeychandran and Paulraj, 1977). Jayaram and Shetty (1980) obtained higher growth of catla and common carp when they were fed with a diet containing silkworm pupae. A powder of dried duckweeds and cabbage leaves was incorporated in diets, but was found to be inferior as a complete diet for carp (Devaraj *et al.*, 1981). *Colocasia* leaf powder and fish silage were used, partially replacing fish-meal, in experimental diets for Indian major carps (Venugopal and Keshavanath, 1984). Silkworm faecal matter, slaughterhouse waste, soybean meal and squilla meal were used, replacing fish-meal, and a 25% higher growth than on fish-meal-based diets was recorded (Bhat *et al.*, 1986; Nandeesha *et al.*, 1989). Incorporation of earthworm meal, margarine, sardine oil and *Cassia tora* leaf powder in formulated diets enhanced the growth and survival of Indian major carps (Manissery *et al.*, 1988). Murthy and Devaraj (1990, 1991a,b) evaluated leaf powders of three floating aquatic weeds – namely, *Eichhornia, Pistia* and *Salvinia* – as low-cost ingredients partially replacing fish-meal in diets for carps and reported that the *Pistia*-based diet was found to be superior to the other two diets.

Fry of catla, rohu and mrigal 5–10 mm in size mainly feed on unicellular algae, while 10–20 mm fry feed on protozoans and other smaller zooplankton. Hatchlings of Indian major carps accept an artificial diet 2 days after their initiation to external food and grow well on oilcake, rice powder and black gram. Low-cost diets for carps were developed using locally available ingredients such as silkworm pupae, soybean (Chakraborthy *et al.*, 1973), fish and prawn powder (Mahajan and Yadav, 1974), petroleum protein and rice polish (Chakraborthy and Kar, 1975), powdered algae with fish-meal (Singh and Bhanot, 1988) and dried powder of *Nymphoides* and *Spirodella* weeds (Patnaik and Das, 1979).

Table 19.4. Important diet ingredients that are available for carp diets in India.

Ingredient	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Nitrogen-free extract (%)
Rice polish	12.6	14.5	17.3	7.5	n/a	n/a
Rice (broken)	10.1	12.6	11.3	19.3	10.2	36.5
Defatted rice bran	7.2	12.1	1.3	15.2	23.8	40.4
Wheat bran	12.3	15.8	4.3	8.7	n/a	n/a
Wheat (broken)	9.0	11.5	1.9	4.0	0.2	73.4
Wheat flour	12.6	14.5	3.7	2.7	2.3	64.2
Groundnut cake	10.0	42.0	7.3	13.0	2.5	25.2
Sunflower extract	8.0	31.0	2.1	18.4	1.5	39.0
Soybean meal	11.8	46.3	1.3	5.0	n/a	n/a
Rapeseed cake	11.0	35.9	0.9	13.2	6.9	32.1
Sesame cake	8.3	41.9	9.2	6.2	14.8	19.6
Mustard cake	8.5	30.8	9.3	6.2	10.3	34.9
Cottonseed cake	7.0	37.0	6.7	13.0	1.0	35.3
Gingely cake	9.0	34.0	7.8	7.9	3.1	38.2
Niger extract	7.0	35.0	2.0	19.0	3.5	33.5
Copra cake	12.0	22.0	6.5	12.2	5.2	42.1
Maize meal	13.5	9.5	4.0	4.0	1.5	67.5
Maize	10.4	4.6	7.8	3.5	1.0	72.7
Sorghum	10.0	9.0	2.8	3.0	0.1	75.1
Spirulina	8.7	50.5	1.0	2.1	11.0	26.7
Tapioca flour	11.5	3.1	2.3	2.0	2.3	78.8
Coffee pulp	2.3	14.0	1.2	20.8	8.2	43.5

n/a, not applicable.

A suspension diet was developed using rice bran, groundnut, squilla or small shrimp. The ingredients were mixed, cooked and passed through a 300–400 μm sieve and the filtrate was fed to carp spawn (hatchlings) several times a day (Alikunhi, 1987). In recent studies, leaf powders of mulberry and *Leucena leucocephala* and dried silkworm pupae were evaluated as effective ingredients for carp fry (Vijayakumaraswamy and Devaraj, 1994). Diets with graded protein levels for carp fry were developed using groundnut cake, rice bran and fish-meal as protein source and evaluated in the laboratory (Swamy *et al.*, 1988; Mohanty *et al.*, 1990). Mondal *et al.* (2000) have formulated diets with varied protein levels incorporating soy flour, fish-meal and rice bran as protein sources and evaluated them on catla fry. They obtained higher survival and food conversion when fish were fed a diet containing a 39% protein level.

A typical practical brood-stock diet formulation is given in Table 19.5. This diet contains 25–30% crude protein from locally available, less expensive ingredients and is fed at 2% of body weight day^{-1}. This diet helps in advancing the maturation and spawning of Indian major carps by 1–2 months. Further, it has resulted in increased fecundity and better seed quality.

Table 19.5. Proportion of different diet ingredients used in a typical brood-stock diet.

Ingredient	Percentage
Rice bran	25
Groundnut (peanut) cake	25
Fish-meal	10
Maize	10
Broken rice	10
Horse gram	10
Black gram	10
Vitamin and mineral mix	< 1

Several hormones and other products are used as diet additives or growth promoters in carp diets. Hormones are usually employed in the manipulation of sex in carps, while the same hormones incorporated at very low levels in diets are found to enhance the growth of carps. Hormones, such as 17α-methyltestosterone, when incorporated at 2.5–5 p.p.m. level in diets for common carp (Basavaraja *et al.*, 1989) and 1 p.p.m. for catla and rohu (Deb and Varghese, 1988), enhanced growth and survival. Other hormones, such as 19-norethisterone at a dietary level of 0.75 p.p.m. in rohu (Gangadhara *et al.*, 1998), diethylstilboestrol in common carp (Nanjundappa and Varghese, 1989) and human chorionic gonadotropic hormone at 5 p.p.m. in common carp (Keshavanath and Matty, 1994) and at 15 μg g^{-1} diet in *Labeo fimbriatus* (Jayaprakas and Sherly, 1996), enhanced growth compared with that in control groups.

The most common method of feeding employed in carp culture in India is hand-feeding, particularly by small and artisanal carp farmers. Diet is fed once daily at a rate varying from 2% to 4% of the biomass. Semimoist diets of various sizes and shapes are broadcast manually over the pond surface. Another popular method of feeding carp is bag feeding. Diet is added to an empty plastic bag, several holes (1–2 cm diameter) being made at the bottom of the bag. The bags containing diet are suspended from bamboo poles, which have been driven into the pond bottom, so that the lower end of the bag is under water. The entire diet is consumed within 2–3 h. Empty bags are removed, washed and dried before reuse the next day.

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