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Comparative Studies on the Seasonal Variations in the Nutritional Values of Three Carnivorous Fish Species

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ABSTRACT

Non-consumption of fish during summer months has become very common practice in the country. This behavior is attributed to the nutritional changes in fish due to onset of its breeding season. Studies were therefore, planned to assess the nutritional variations that might occur with the change of season and stage of fish. Three fish species viz. *M. seenghala*, *W. attu* and *C. morulius* were collected from pond area of Trimmu Headworks built over the junction of River Chenab and River Jhelum in Punjab, Pakistan. Proximate analysis data revealed that moisture, dry matter, ash and organic matter contents did not differ among species irrespective of type of species and season of the year. There was slight decrease in % ether extract in *W. attu*, little increase in *M. seenghala* but significant increase ($p<0.05$) in *C. morulius* when they moved from summer to winter. Crude protein contents remained same in both seasons in *M. seenghala* and *W. attu*. Drastic decrease in crude protein was however, observed in *C. morulius* when it entered in winter. Values of condition factors were similar in *M. seenghala* and *C. morulius* but were quite lower ($p<0.05$) than *W. attu*. The latter species also showed significant increases in condition factor on the start of winter season. When nutritional values of these species adult were compared with herbivorous species viz. *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* and common carp, incredible differences were observed. Protein contents in carnivorous species always stood above 85% and values of ether extract did not exceed 6-13%. Contrarily highest protein percentage in herbivorous fishes was 68% and amount of ether extract was almost double to those of carnivores. It can be deduced that there is not much difference in nutritional values of fish in different seasons of the year except *C. morulius*. Moreover, nutritional value of carnivorous fish species was far better than herbivores.

Key Words: Carnivorous fish; Herbivores; Proximate analysis

INTRODUCTION

Mystus seenghala is a euryhaline estuarine catfish. It feeds and thrives well in low salinity and when salinity exceeds 10‰, it migrates to low salinity waters (Pandian, 1966). Its increasing demand in export market and subsequently high local prices has increased fishing pressure on this species, which has considerably reduced its routine catches up to endangered limits. Like *M. seenghala, Wallagu attu,* called Asian Silurid catfish is also a threatened species. Young ones are insectivores, while adults are strong carnivores and feed on fishes, shrimp and mollusks. Other than living organisms it also voraciously feeds on dead fishes or other animals present in the surrounding environment (Hossain *et al*., 2008). Both these species are widely distributed in Indian sub-continent countries, Bangladesh, India, Pakistan, Nepal, Burma, Srilanka, Vietnam, Thailand, Cambodia and Afghanistan. Snakehead also called murrel, economically important member of the genus *Channa,* is distributed from China to India, Ceylon and Southeast Asia, in rivers, lakes, swamps, marshes, canals and ponds. In Thailand it is found throughout the country, except in the mountain region. It is one of the most common staple food fish in Thailand and other parts of Southeast Asia and has been regarded by the Chinese as food fish for healing wounds (Rahim, 2009). In nature, Snakehead is a voracious carnivore, feeding mainly on live animals. Small fry feed mainly on zooplankton and insect larvae, while fingerlings and adult commonly feed on invertebrates, frogs and smaller fish (Boonyaratpalin *et al*., 1985). These fishes have lot of production potential and fetch very high prices when marketed. It can be a valuable addition if introduced in the present fish culture system.

Labeo rohita, Cyprinus carpio, Cirrhinus mrigala, Catla catla and *Hypophthalmicthys molitrix,* on the other hand are all herbivorous fast growing fishes. With their non-competitive feeding behavior, they are comfortably poly-cultured under semi-intensive fish culture system. They are easy to breed and very economical in culture. Their food can be easily produced by regular applications of inorganic and cheaper organic fertilizers. Though these fertilizers transfer lot of diseases, create eutrophication and oxygen depletion

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problems, still they are widely used, because of their low cost and easy availability (Blessington *et al*., 1973). Stocking density and production per unit area are quite low when compared with other countries in the world. Low protein supplementary feed is regularly applied and use of balanced feed is still far ahead due to technological, ecological and economical reasons. These carps have dominant share in current fish culture practices and subsequent production level.

Body composition or biochemical composition means the concentration of macro and micro-nutrients in fish carcass in relation to their counterparts (Dempson *et al*., 2004). Their values however, vary considerably within and between species, and also with size, sexual condition, feeding, time of the year and physical activity (Ali *et al*., 2005). Body composition can give idea about age classes of the same species or can compare nutritional differences between and among the species. These values also give estimation of food composition of fish, its physiological condition (Salam & Davies, 1994) and can serve as guide for any future feed formulations for fish in captivity (Dempson *et al*., 2004). Sometimes it can help in genetic selection of better traits. Data like this could be useful for development of bio-energetics, feed requirement and waste out put models for these fish species (Cho & Bureau, 1998). These values can also give a good estimate of seasonal nutritional variations, which can help consumer's choices and preferences for fish consumption. Most of the research in this direction deals with cause and effect studies (means that feed of known nutritional values is offered to fish & its effect on body composition is determined). Nutrient rich diets are offered to fish and their effect is evaluated in terms of growth performance and nutrients retained in the body (Babalola & Apata, 2006; Ogunji *et al*., 2007). Ali *et al.* (2006) determined the body composition of *L. rohita*, *C. mrigala*, *H. molitrix* and *C. catla* collected from different ponds with variable water depths. Similarly Memon *et al*. (2010) determined the body composition and fatty acid profile of *W. attu*, *Oreochromis mossambicus*, *L. calbasu*, *Bagarius bagarius*, *L. gonius*, *Clupisoma garua*, *Aorichthys aor* and *Eutropiichthys vacha* from Indus river. All these studies have been conducted at different places and ecological regions.

Studies have not been conducted to determine the body composition of these carnivorous and herbivorous species simultaneously in different seasons of the year (Therefore, objectives of these studies were to 1) determine the seasonal variations in the nutritional values of three carnivorous fish species viz. *W. attu*, *M. seenghala* and *C. morulius* during summer and winter as well as at different developmental stages and (2) tompare the nutritional values of these species with of Chinese and Indian major carps.

MATERIALS AND METHODS

Sampling site: Fish samples both carnivores and herbivore fish species were collected from pond area of Trimmu Head Works (district Jhang) built over junction of River Jhelum and River Chenab-the two major rivers of Punjab province.

Fish species sampled: Three carnivorous fish species viz *Mystus seenghala, Wallagu attu, Channa morulius* and 5 herbivorous fish species viz *Labeo rohita, Cyprinus carpio, Cirrhinus mrigala, Catla catla* and *Hypophthalmicthys molitrix* were selected for these studies. There were three size groups in carnivorous fish varieties but only one in herbivorous due to their uniform feeding behavior at different stages of life (Table I-III).

Collection of samples and transportation: Nine herbivorous fish species and 9 carnivorous fish species of each weight group were captured by Gill Nets and by long lines respectively from their natural habitat. Herbivorous and the first two size groups of carnivorous were collected only in the month of May while adult carnivores were sampled in May and December, 2007, for the comparison of seasonal variations if they exist. At the time of removal from water all the fishes were alive hence were euthanized in MS222 for comfortable transportation. The dead specimens were blotted dry, weighed and measured on the site to avoid dehydration effects. To suppress bacterial decomposition and spoilage process, the samples were embedded in dry ice and were safely transported to the laboratory. Prior to analysis, the scales were removed; fishes were eviscerated, washed and dressed according to Standard Operating Procedure (Crissey & Spencer, 1998). All samples were immediately frozen at 20°C until initiation of analytical work.

Proximate analysis: All the samples were analyzed in triplicate following AOAC (1995) in Research Laboratory, Zoology department, Bahaul-Din-Zakria University Multan. For determination of moisture contents, whole fish was placed in a pre-weighed aluminum foil tray in an electric oven calibrated at 65-80^{0}C till constant weight. Dry matter recovered was subtracted from original weight to estimate the weight of water evaporated during heating process. One gram of organic matter was drawn from dry fish and transferred to pre-weighed heat resistant China clay crucibles. The crucibles were carefully placed in a Muffle furnace, set at 500^{0}C, for 7 h. The incinerated sample was cooled in desiccator and weighed for ash determination. Lipid contents were extracted in chloroform and methanol mixture (ratio 1:2 v/v) following the method of Bligh and Dyer (1959), modified by Salam and Davies (1994). Dried and well pulverized sample (3 mg) was mixed into 10 mL solution of above solvents and stirred well with a glass rod. The mixture was left over night and then centrifuged. The clear supernatant was removed carefully into well washed, dried and pre-weighed small glass bottles and was placed in an oven at 40 to 50^{0}C to evaporate the solvent. The lipids present in bottle were weighed and subtracted from total weight to determine actual weight of lipids recovered. Crude protein was determined by Micro-Kjeldahl method (%Nx6.25), which involves digestion of sample and then distillation for N determination.

Statistical analysis: Data collected were subjected to one way analysis of variance (ANOVA) for recognition of statistical significance among means of various parameters observed during the course of experimental work. Statistical significance of differences among species were distinguished by Duncan's Multiple range test ($p<0.05$).

RESULTS

Water contents: Water contents did not differ among all the three carnivorous species irrespective of the time of the year. Slight season oriented differences were present but not species oriented (Table I). Differences were very prominent when water contents were compared with those present in herbivorous fish species and were significantly ($p<0.05$) lower than carnivores (Table III). Variation in water contents was more prominent in herbivores, being the highest (72.8%) in *Labeo rohita* and silver carp (*Hypophthalmichthys molitrix*) and the lowest (65.6%) in common carp (*Cyprinus carpio*). The remaining values fell in between these two extremes (Table II). When moisture contents of different size groups of carnivorous fish sp. were compared among themselves, the values were close to each other but were significantly($p<0.05$) higher than herbivores irrespective of the size of carnivore fish species.

Dry matter contents: Like water contents there was no difference in dry matter contents of carnivores. In herbivores vice versa was true. Where moisture was high, dry matter decreased and where moisture was low, dry matter increased. The highest dry matter was recovered from common carp carcass and the lowest from that of *Labeo rohita* and silver carp, which were significantly ($p<0.05$) higher than their counterparts as well as from those of carnivorous fish species (Table I-III).

Ash contents: Very high values (13.9-20.7%) were observed in herbivorous varieties and were significantly ($p<0.05$) higher than carnivores, which ranged from 2.3 to 5.7% (Table I─III). The highest was in *Catla* and the lowest in common carp (Table III). On the other hand in carnivores, highest ash contents were observed in *C. punctataus* and the lowest in *M. seenghala* (Table I). Among carnivores ash contents were significantly higher ($p<0.05$) in *W. attu* and *C. punctatus* than *M. seenghala* but these differences mitigated in winter. Surprisingly up to ±400 gm size fish, ash contents almost remained uniform but in adult fish ash contents did differ when compared among species. Among herbivorous fish species *C. catla* showed the highest ash contents (19.7%), while common carp the lowest (9.7%) (Table III).

Protein contents: *Channa morulius* showed unusually high protein contents in summer (93.8%) and low in winter (73.5%). When these values were compared with other carnivores, there were no differences in summer but protein contents of *C. morulius* considerably reduced and in winter and were significantly ($p<0.05$) lower than *W. attu* and *M. seenghala* (Table I). When different size groups of carnivores were compared among themselves, lowest protein contents were present in small fish (±100 g) and highest in adult (±1000 g) (I & II). When same values were compared with herbivores, the protein contents in adult carnivores were significantly higher than those observed in herbivores. Nevertheless protein contents of the smallest carnivores were equal to herbivores (Table II & III). There was proportionate increase in protein contents with fish size increment, means that protein contents and fish size were positively correlated.

In herbivores maximum protein was observed in *L. rohita* and the lowest in *C. catla*. The protein values in other species lay in between these two extremes (Table III). When these species were compared among themselves, differences were statistically not distinguishable ($p<0.05$).

Lipid content: Lipid content also called ether extract represents all the compounds, which are soluble in organic solvents. Lipid contents were uniform among all the carnivores except in *Channa morulius,* where lipid content elevated unexpectedly and touched the value of 26.4% in winter. All the other values ranged from 6.1 to 13.0. Apparently some of them gave the impression of significant variations but tangible data variations totally neutralized the differences. Lipid contents in smaller fishes were approximately similar to those of adults and were also uniform among different species (Table I & II). Contradictory to these, herbivores displayed significantly higher ($p<0.05$) lipid contents than the carnivorous fishes (Table III), which ranged in herbivores from 18.5 to 21.9%. When these values were compared among herbivores, common carp showed the highest lipid contents and *Labeo rohita* the lowest. Like carnivores, differences however, were not statistically discernible in herbivorous too.

Organic content: Organic contents were uniform among three carnivores as well as in herbivores when compared among them. But when they were compared across two groups, the organic matter was significantly higher ($p<0.05$) in carnivores than that of herbivores (Table I & III).

Condition factor: Values of condition factor were almost similar though little higher in herbivores, which might be due to some morphological differences except in *Wallagu attu,* which surprisingly showed quite escalated values in summer (10.5) and unbelievably high in winter (20.5). These values were significantly higher than all the species included in these studies (Table I & III).

DISCUSSION

As it is obvious from the results of the current studies, seasonal variations have bearing on nutritional quality but it was true only in *C. morulius* but not in *W. attu* and *M. seenghala.* Remarkable changes were observed in protein and lipid contents when *C. morulius* moved from summer to winter (Table I). The reason for this variation is not clear at the moment. Piggott (1990) and Tsuchiya (1961) reported that fat contents vary in fish with season, species and geographical region. Age variation and stage of maturity in

Table I: Seasonal variations in the body composition of *Mystus seenghala*, *Wallagu attu* and *Channa morulius*

Proximate composition parameter	% present in fish(Mean ± SD)					
	Mystus seenghala		*Wallagu attu*		*Channa morulius*	
	Summer	Winter	Summer	Winter	Summer	Winter
Moisture (%)	80.7±3.5[a]	77.1±2.3[a]	80±3.9[a]	75.8±2.3[b]	80.8±1.9[b]	79.9±0.9[b]
Dry matter (%)	19.3±3.5[a]	22.9±2.3[a]	20.0±3.9[a]	24.2±2.3[a]	19.1±1.9[a]	20.1±0.9[a]
Ash (%)	3.9±0.6[a]	2.3±0.4[a]	5.0±0.5[b]	3.5±1.6[a]	5.6±1.1[b]	5.7±0.7[b]
Ether extract (%)	9.5±3.9[a]	13.0.±3.5[a]	11.6±3.6[a]	9.6±5.7[a]	6.1±1.7[b]	26.4±7.6[b]
Organic matter (%)	96.1±0.6[a]	97.7±0.4[a]	95±0.5[a]	96.5±1.6[a]	94.4±0.7[a]	94.3±0.7[a]
Crude protein	90.4±3.9[a]	86.9±3.5[a]	88.3±3.5[a]	90.3±5.7[a]	93.8±1.7[a]	73.5±7.6[b]
Condition factor	0.5±0.1[a]	0.4±0.1[a]	10.5±0.1[a]	20.5±0.07[a]	0.7±0.1[a]	0.8±0.1[a]

Table II: Size related variations in the proximate body composition of *Mystus seenghala*, *Wallagu attu* and *Channa morulius*

Fish species	Weight (gms)	Proximate composition parameters (Mean±S.D.)			
		Protein	Total lipids	Moisture	Ash
Mystus seenghala	112.5±7.5	65.2±3.1[a]	12.9±2.5[a]	80±3.5[a]	4.1±1.2[a]
	445.7±20.5	71.5±4.5[b]	10.6±2.1[a]	82.3±4.1[a]	4.3±1.5[a]
Wallagu attu	116.6±8.9	66.2±6.9[a]	11.5±3.1[a]	81.3±2.4[a]	4.9±2.0[a]
	460.6±19.8	73.5±9.8[a]	10.0±1.1[a]	80.1±3.3[a]	5.1±1.9[a]
Channa morulius	102.6±7.5	60.1±2.7[a]	12.6±3.1[a]	83.4±2.1[a]	5.2±2.1[a]
	405.4±9.2	65.9±3.5[b]	11.1±2.1[a]	83.2±3.1[a]	5.6±2.3[a]

Table III: Body composition of herbivorous fish species

Proximate composition parameters	*Catla catla*	*Cirrhinus mrigala*	*Cyprinus carpio*	*Hypophtha-lmicthys molitrix*	*Labeo rohita*
Moisture (%)	67.9±1.2[a]	68.6±1.9[a]	65.9±2.3[a]	71.9±2.0[a]	71.7±2.0[a]
Dry matter	24.9±2.1[a]	25.7±1.8[a]	30.9±1.5[a]	22.8±1.4[a]	23.1±1.4[a]
Ash (%)	20.7±1.6[a]	18.7±2.0[a]	13.9±1.6[b]	14.9±1.8[b]	15.2±2.1[b]
Total lipids (%)	18.9±1.7[a]	19.5±2.7[a]	21.9±1.9[a]	21.8±2.6[a]	18.5±1.8[a]
Organic matter (%)	80.3±2.4[a]	81.5±2.4[a]	89.5±3.6[b]	84.7±3.2[b]	85.9±3.1[b]
Crude protein (%)	61.1±2.4[a]	61.9±4.4[a]	65.9±7.9[a]	62.8±4.1[a]	67.8±2.5[a]
Condition factor	1.02±0.03[a]	1.07±0.2[a]	2.1±1.3[a]	1.2±0.04[a]	1.5±0.04[a]

Figures with different superscript letters are significantly different from each other at p<0.5)

the same species contributed significantly to the level of total lipid contents. Similarly Slitka *et al*. (1998) found substantial differences in lipids in salmon (*Salmo salar*), which increased during winter. These studies do confirm our observations on lipids but reasons for significant variations in protein contents still remains to be explained. Further these studies favorably fit with our observations on *C. morulius* but not with its counterparts where body contents remained uniform irrespective of the season of the year.

Ayas *et al*. (2005) identified in *C. carpio* that the muscle tissue fat levels were the lowest at the end of reproductive period, which increased again when fish started feeding. These studies do corroborate with ours in case of *M. seengala* and *W. attu* but contradicts our observations on *C. morulius*. Like *C. carpio,* the former two species might have sufficient time to compensate the nutritional depletions occurred during summer (breeding season) and they maintained the original level up to onset during winter season.

Ali *et al*. (2001) determined body composition of *C. punctatus* from two different sites (river & fish farm). They reported 52%, 49% protein and 31.44, 24.26% lipids. Being the same genus and similar feeding behavior these values are well under estimated even these are far lower than they determined later on in herbivorous, *C. catla*, *C. mirgala* and *H. molitrix*, which ranged from 62.3 to 68% and lipids 17.3 to 22.7%. These values are quite contradictory and the former negates later due to generic/species differences and its carnivorous nature. The same authors also tried to find out effect of brackish water and water depth on body composition but results were insignificant. Nevertheless our values on herbivorous fish species are quite in line with theirs. It means that minor changes in salinity and volume of water has nothing to do with body composition. Situation is really perplexing and unbelievable in *C. punctatus* in which protein contents are significantly lower than herbivorous and far lower than *C. morulius* we observed in current studies.

When different size groups of carnivorous fish species were compared, protein was lowest in ±100 g fish and highest in adult but correlation was quite positive with size of fish. Kalay *et al*. (2008) determined the length weight relationship and changes in body composition with age. They observed that protein contents decreased with age, while fat contents increased with no effect on other elements like Cu, Zn and Fe. They also reported negative correlation between protein and lipid levels with age/size. Contradictory to the previous findings, in current studies protein kept on increasing with age/size while lipids declined accordingly. Studies of Memon *et al*. (2010) were really surprising, who determined body composition of eight

Indus river species viz. *W. attu*, *O. mossambicus*, *L. calbasu*, *B. bagarius*, *L. gonius*, *C. garua* and *A. aor*. Interestingly protein contents remained uniform though feeding habits of test species ranged from herbivorous, carnivorous and voraciously carnivorous. There were exceptions too. Lipid contents were very low in *W. attu* (0.85%) but very high in *Eutropiichthys vacha* (18.32%). Their observations can also not be taken for guaranteed, because due to generic and huge feeding differences, the body composition values cannot overlap so closely.

Nevertheless, studies of Gunther *et al*. (2007) partially confirm our findings showing that the moisture contents decreased, while protein, lipids, ash and phosphorous increased as weight of lake trout and hybrid F1 (lake trout × brook trout) increased Oduor-Odote *et al*. (2008) found that lipids in fish vary greatly which is related to feed intake, migratory swimming or sexual changes in connection with spawning. Higher lipids may be due to preparation for spawning. Lipids vary in different parts of fish body and also they show enormous variation in different seasons of the year. Previous and our studies further verify that changes in moisture, protein, and phosphorous are function of body weight, while lipid content appears to be function of body weight and may be simultaneously affected by lipid contents of diet (Javed *et al*., 1992).

Yamamoto *et al*. (2005) and later on Yang *et al*. (2010) reported that essential amino acid supplementation effect on animal growth is markedly influenced by the nutritional status of the animal. Effect of essential amino acids was more prominent in those fishes fed on low protein diets than those fed on higher protein diets (Naeem *et al*., 2011). Like previous studies body composition of herbivorous fish species is a true reflection of their natural food. Situation was however, different in carnivores which ate less protein diet (herbivore fish species ~ 65% protein on dry weight basis) but displayed much higher percentage (~85%) in the body. This mechanism of conversion, qualitative and quantitative synthesis and accumulation of excess protein than taken in the food, needs further explorations and investigations on these carnivorous fish species.

It can be concluded that generally there is no seasonal variations in body composition of fish though exceptions are always there. Protein contents increase and fat decrease with age in carnivorous varieties, while vice versa is true in herbivores. This appears that there is no hard and fast rule applicable universally to all the fish species. Body composition varies from species to species and changes with its own pre-determined set of principles.

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