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Effect of Feeding Habit, Size and Season on Proximate Composition of Commercially Important Fishes from Lentic Water Bodies of Indus River at Ghazi Ghat, Pakistan

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ABSTRACT

The present study was undertaken to analyze the effect of feeding habit, size and season on body composition of six commercially important wild fishes. The fishes were captured in summer and winter months. The water, ash, lipid and fat contents (%) were determined. One way ANOVA was used to analyze statistical significance of data. The water, ash, lipid and fat contents (%) were significantly different ($P<0.05$) between fish groups of different feeding habits. At species level, % water contents (77.64±1.96) and % ash contents (3.24±0.40) of *Wallago attu* (carnivore), % ash contents (4.19±0.82) of *Aorichthyes aor* (carnivore), % lipids contents (9.95±3.11) and % protein contents (17.20±2.09) of *Barbodes sarana* (omnivore) were significantly different ($P<0.05$) from other species. There was no significant difference between various size groups for body composition parameters of most of fish species except for % water (73.23±2.17, 77.76±1.13), % ash (3.88±0.90, 5.64±2.63) and % lipid contents (3.86±0.65, 6.88±1.28) of *Labeo rohita*; and % water (71.67±2.95, 74.3±3.01), % ash (5.73±0.92, 5.77±0.92), % lipid (5.13±1.29, 6.34±2.09) and % protein contents (14.81±1.60, 16.18±1.29) of *Oreochromis mossambicus*. The season related significant effect ($P<0.05$) was demonstrated for % water contents of *Barbodes sarana* (66.16±1.15 in summer, 68.27±1.30 in winter); % lipid contents of *Barbodes sarana* (14.18±2.63 in summer, 8.94±1.32 in winter) and *Labeo rohita* (6.45±1.66 in summer, 4.69±1.55 in winter); and % protein contents of *Barbodes sarana* (15.03±2.40 in summer, 18.20±1.23 in winter), *Aorichthyes aor* (15.81±0.61 in summer, 14.16±2.02 in winter), *Wallago attu* (16.62±1.34 in summer, 14.53±1.92 in winter) and *Labeo rohita* (13.19±1.55 in summer, 14.87±1.83 in winter). In conclusion, several significant species specific effects in body composition parameters related with feeding habit, size and seasons were demonstrated.

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Authors' Contribution
MA designed the study. SWA and MZH conducted fish sampling. AAN performed the experimental work. SH and RI statistically analyzed the data. MZH, AL and MA wrote the article.

Key words
Carnivore, herbivore, proximate composition, seasonal effect, Indus River.

INTRODUCTION

The proximate body composition of fish is considered as the analysis of concentrations of macro and micro-nutrients in fish body in relation to their counterparts that include moisture, crude fat, crude protein, ash and carbohydrate contents of fish (Cui and Wootton, 1988; Dempson *et al.*, 2004) and includes the analysis of water, protein, fat and ash contents of the fish (Love, 1980). The chemical composition of fish body is a good indicator of physiology and health (Salam and Davies, 1994; Saliu *et al.*, 2007). Body composition values are significant for various aspects of fisheries science. These values can be helpful in genetic selection of better traits (Gjerde and Gjedrem, 1984; Gjedrem, 1997), development of bio-energetics, feed requirement and waste output models (Cho and Bureau, 1998), estimation of food composition of fish (Salam and Davies, 1994), effects of hormones on fish growth (Ashraf and Meade, 1993) and seasonal nutritional variations (Babalola and Apata, 2006; Ogunji *et al.*, 2007).

The values of fish body composition parameters vary considerably not only within and between species (Weatherly and Gill, 1987), but also with age and size (Lawson *et al.*, 1998; Paul *et al.*, 1998; Anthony *et al.*, 2000), gender (Lawson *et al.*, 1998; Paul *et al.*, 1998), feeding (Cui and Wootton,1988; Shulman *et al.*, 2005; Moss *et al.*, 2009) and season (Grigorakis *et al.*, 2002;

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Levesque *et al*., 2002; Saeed, 2013).

Labeo rohita, Cirrhinus mrigala and *Catla catla* are economically important herbivorous fast growing fishes of Indo-Pak sub-continent (Talwar and Jhingran, 1992). The body composition of *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla* has been determined from different ponds with variable water depths (Ali *et al.*, 2006). The body composition and fatty acid profile of two carnivorous fishes *Wallago attu*, *Aorichthys aor* and an omnivorous fish *Oreochromis mossambicus* from Indus River been determined by Memon *et al.* (2010). Ashraf *et al.* (2011) has described the body composition of three carnivorous fishes in different seasons. No studies have bee done on body composition of *Barbodes sarana*, one of the indigenous omnivorous fish in Pakistan.

However, there have been very little studies on seasonal effects on body composition parameters of these commercially important fishes in Pakistan. The present study was undertaken to evaluate the effect of feeding habit, size and season on body composition parameters of commercially important fishes from lentic water bodies near the River Indus at Ghazi Ghat, Dera Ghazi Khan, Pakistan.

MATERIALS AND METHODS

Fish sampling

Fish samples were collected using seine nets of different mesh sizes from natural lentic water bodies located near Indus River at Ghazi Ghat, Dera Ghazi Khan, Pakistan. Three herbivorous fish species (*Labeo rohita*, *Cirrhinus mrigala* and *Catla catla*), two omnivorous fish species (*Oreochromis mossambicus* and *Barbodes sarana*) and two carnivorous fish species (*Aorichthyes aor* and *Wallago attu*) were captured in summer (April, May, June, July and August) and winter (November, December, January and February) months during the year 2002-2003, for the studies. The live fishes were euthanized in MS222. The fish specimens were blotted dry and weighed on digital electronic balance (MP 3000 Chyo, Japan) to the nearest 0.01 g. The specimens were embedded in dry ice to avoid dehydration and bacterial decomposition and transported to the laboratory. The scales free, eviscerated, washed and dried fish specimen were immediately stored at -20ºC until initiation of biochemical analysis.

Proximate analysis

For estimation of water contents, weighed fish specimen was placed in a pre-weighed aluminum foil tray in an electronic oven at 65ºC for 5-7 days till constant weight. The weight of obtained dry mass was subtracted from original weight to determine the amount of water evaporated during drying process and described as % water content. For further analysis, each dry carcass was crushed, powdered, homogenized and preserved in glass bottles. For estimation of ash content, 1 g of homogenized sample was taken in pre-weighed heat resistant china clay crucibles and put in a Muffle furnace (Sybron Thermolyne, 1300) for 7 h at 500ºC, cooled in desiccators, reweighed to calculate ash content and described as % ash wet body weight. For estimation of lipid, dry extraction method developed by Bligh and Dyer (1959) and later modified by Salam and Davies (1994) was adopted. The homogenized sample (25 mg) was mixed in 5 ml of chloroform and methanol mixture (1:2 v/v), stirred well, kept overnight and then centrifuged. The supernatant was removed into pre-weighed small glass bottles and placed in an oven at 45 ºC to evaporate the solvent. The lipids present in glass bottle were weighed and total lipids in dry body mass were determined and described as % fat wet body weight. For estimation of crude protein, Micro-Kjeldahl method (%N × 6.25) was used which involves digestion of sample and then distillation for nitrogen determination (AOAC, 1990).

Statistical analysis

One way analysis of variance (ANOVA) was carried out to determine the statistical significance for means of various fish body composition parameters, followed by post-hoc least significance difference (LSD) test, using Statistix statistical software version 8.1.

RESULTS

Water content

Water contents (%) were significantly different (df = 2, F = 45.13, $P<0.001$) among fish groups. A post hoc LSD test revealed that the water content (%) of omnivorous fish group were significantly different, both from herbivore and carnivore ($P<0.05$) (Fig. 1). An overall significant difference was found between water contents (%) of studied fish species (df = 6, F = 25.96, $P<0.001$). A post hoc LSD test revealed that the water contents (%) did not differ among the three herbivore fishes and one carnivore fish *i.e. Aorichthyes aor* (Table I). However, the water contents (%) of other carnivore fish *i.e.*, *Wallago attu* were significantly different from all other fishes (Table I). There was no significant size related difference among water contents (%) for most of fish species, except *Cirrhinus mrigala* (df = 1, F = 4.12, $P<0.05$) (Table II). Likewise, there was no significant season related difference among water contents (%) for most of fish species, except *Barbodes sarana* (df = 1, F = 9.24, $P<0.01$) (Table III).

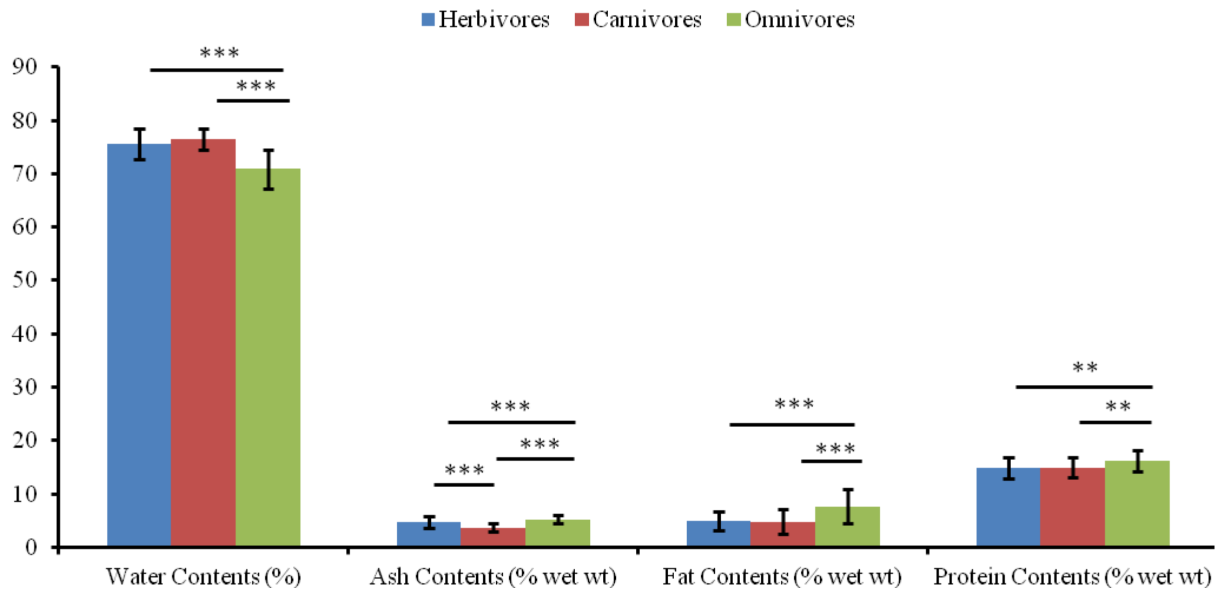

Fig. 1. Comparison of body composition parameters (Means ± SD) of three major fish group (n = 70 for herbivores, n = 36 for carnivores, n = 41 for omnivores). Asterisk indicates significant difference between the fish groups (** = P<0.01, *** = P<0.001, one way ANOVA).

Table I.- Body composition parameters (Means ± SD) of herbivorous, carnivorous and omnivorous fish species.

Fish species	N	Water (%)	Ash (%)	Crude Fat (%)	Crude Protein (%)
Herbivorous					
Catla catla	24	75.19 ± 3.04^b	4.80 ± 0.89^b	5.06 ± 1.48^c	14.86 ± 2.24^b
Cirrhinus mrigala	22	75.73 ± 2.74^b	4.87 ± 0.68^b	4.19 ± 1.48^{bc}	15.15 ± 1.85^b
Labeo rohita	24	75.54 ± 2.90^b	4.63 ± 1.51^{bc}	5.36 ± 1.97^b	14.44 ± 1.93^b
Carnivorous					
Aoricthyes aor	18	75.44 ± 1.33^b	4.19 ± 0.82^c	5.46 ± 2.62^b	14.88 ± 1.55^b
Wallago attu	18	77.64 ± 1.96^a	3.24 ± 0.40^d	4.08 ± 1.67^c	15.00 ± 2.29^b
Omnivorous					
Barbodes sarana	19	68.24 ± 2.11^d	4.58 ± 0.35^{bc}	9.95 ± 3.11^a	17.20 ± 2.09^a
Oreochromis mossambicus	22	73.10 ± 3.20^c	5.74 ± 0.71^a	5.68 ± 1.77^b	15.43 ± 1.59^b

The mean values with different superscript letters are significantly different from each other (LSD test) at P<0.05.

Ash content

Ash contents (%) were significantly different (df = 2, F = 23.70, P<0.001) among fish groups. A post hoc LSD test revealed that the ash content (%) of herbivore, carnivore and omnivores were significantly different from each other (Fig. 1). An overall significant difference was found between ash contents (%) of studied fish species (df = 6, F = 13.85, P<0.001). A post hoc LSD test revealed that the ash contents (%) of the two carnivore fish *i.e.*, *Aorichthyes aor* and *Wallago attu* were significantly different from all other fishes (P<0.05). Likewise, ash contents (%) of one omnivore fish *i.e.*, *Oreocromis mossambicus* were significantly different from other fish species (P<0.05) (Table I). There was no significant size related difference among ash contents (%) for all of fish species (P>0.05) (Table II). There was also no significant season related difference among ash contents (%) of fish species (Table III).

Lipid content

Lipid contents (%) were significantly different (df = 2, F = 21.70, P<0.001) among fish groups. A post hoc

Table II.- Size related variations in the proximate body composition parameters of herbivorous, carnivorous and omnivorous fish species.

Fish species	Weight (g)	Proximate composition parameters (Means ± SD)			
		Water (%)	Ash (%)	Crude fat (%)	Crude protein (%)
Herbivorous					
Catla catla	68.35±26.66 (n = 8)	76.91±1.97	4.84±0.85	3.35±0.72	14.87±1.78
	145.64±30.43 (n =9)	74.88±3.07	4.94±0.65	4.47±1.59	15.63±1.94
	223±26.22 (n = 7)	75.82±2.70	4.76±0.53	4.96±1.75	14.41±1.70
Cirrhinus mrigala	124.91±8.95 (n = 8)	73.30±2.11^{b}	5.19±0.51	5.49±1.29	15.97±2.46
	265.95±62.16 (n = 8)	76.38±2.90^{a}	4.51±1.16	4.96±1.71	14.04±1.52
	508.5±135.05 (n = 6)	78.02±3.33^{a}	4.46±0.21	3.76±0.17	13.73±2.94
Labeo rohita	78.16±17.27 (n = 6)	73.22±2.17^{b}	5.64±2.63^{a}	6.88±1.28^{a}	14.22±1.28
	147.28±29.04 (n = 7)	75.67±3.45^{ab}	3.88±0.90^{b}	6.27±2.66^{a}	14.14±2.52
	280.75±55.20 (n = 6)	76.30±2.52^{a}	4.52±0.68^{ab}	4.15±0.50^{b}	14.99±1.56
	50364.21±64.21 (n = 5)	77.76±1.13^{a}	4.64±0.33^{ab}	3.86±0.65^{b}	13.71±1.05
Carnivorous					
Aoricthyes aor	67.95±31.84 (n = 6)	75.40±0.56	4.36±0.74	4.47±0.64	15.76±0.73
	143.54±26.97 (n = 7)	75.48±1.15	4.00±0.67	5.66±2.84	14.83±1.64
	223±2.82 (n = 5)	75.37±3.94	4.83±1.80	6.79±5.11	12.98±0.63
Wallago attu	75±30.65 (n = 6)	77.37±0.57	3.36±0.15	3.165±0.58	16.08±0.30
	141.51±24.09 (n = 7)	77.78±1.86	3.17±0.46	4.54±1.75	14.46±2.57
	233.25±32.16 (n = 5)	77.38±5.10	3.45±0.31	3.11±2.25	16.04±2.53
Omnivorous					
Barbodes sarana	54.88±18.58 (n =9)	67.37±1.98	4.69±0.38	11.45±4.20	16.45±2.89
	159.58±29.38 (n =10)	69.03±2.10	4.53±0.33	8.78±1.44	17.65±1.11
Oreochromis mossambicus	74.68±15.84^{b} (n =10)	71.67±2.95^{a}	5.77±0.37^{b}	6.34±2.09^{a}	16.18±1.29^{a}
	131.15±30.58^{a} (n = 12)	74.3±3.01^{b}	5.73±0.92^{a}	5.13±1.29^{a}	14.81±1.60^{b}

The mean values with different superscript letters are significantly different from each other (LSD test) at P<0.05.

LSD test revealed that the lipid content of omnivore were significantly different from, both herbivore and carnivore (Fig. 1). An overall significant difference was found between lipid contents (%) of studied fish species (df = 6, F = 18.21, P<0.001). A post hoc LSD test revealed that the lipid contents (%) of one omnivore *i.e. Barbodes sarana* were significantly different from all other fishes (P<0.05) (Table I). There was no significant size related difference among lipid contents (%) for most of fish species (P>0.05), except *Labeo rohita* (df = 1, F = 6.03, P<0.01) (Table II). Likewise, there was no significant season related difference among lipid contents (%) for most of fish species, except *Barbodes sarana* (df = 1, F = 27.45, P<0.001) and *Labeo rohita* (df = 1, F = 6.79, P<0.05) (Table III).

Protein content

Protein contents (%) were significantly different (df = 2, F = 7.57, P = 0.001) among fish groups. A post hoc LSD test revealed that the protein contents (%) of omnivore were significantly different from both herbivore and carnivore (P<0.05) (Fig. 1). An overall significant difference was found between protein contents (%) of studied fish species (df = 6, F = 4.37, P<0.001). A post hoc LSD test revealed that the protein contents (%) of one omnivore *i.e. Barbodes sarana* were significantly different from all other species (P<0.05) (Table I). There was no significant size related difference among protein contents (%) for most of fish species (P>0.05), except *Oreochromis mossambicus* (df = 1, F = 4.77, P<0.05) (Table II). Likewise, there was no significant season related difference among protein contents (%) for several of fish species. However, the protein contents (%) were significantly different for *Barbodes sarana* (df = 1, F = 27.45, P<0.01), *Aorichthyes aor* (df = 1, F = 4.89, P<0.05), *Wallago attu* (df = 1, F = 5.73, P<0.05) and *Labeo rohita* (df = 1, F = 5.10, P>0.05) (Table III).

DISCUSSION

In present study, we found that there was an overall significant difference for body composition parameters

Table III.- Effect of seasonal changes on proximate body composition parameters (Means ± SD) of herbivorous, carnivorous and omnivorous fish species.

Fish species and season	Weight (g)	Water (%)	Ash (%)	Crude fat (%)	Crude protein (%)
Herbivorous					
Catla catla					
Summer (n = 10)	131.61±78.90	75.82±3.25	4.79±0.52	4.41±0.75	14.95±2.38
Winter (n = 12)	130.33±57.04	76.12±2.40	4.81±0.72	3.73±1.39	15.29±1.73
Cirrhinus mrigala					
Summer (n = 10)	265.75±71.53	73.98±2.05	5.31±0.95	5.97±1.99	14.72±1.74
Winter (n = 11)	245.17±156.53	76.71±2.42	4.46±0.79	4.66±1.25	14.09±1.51
Labeo rohita					
Summer (n = 11)	93.89±37.82	74.90±3.22	5.43±2.54	6.45±1.66[a]	13.19±1.55[a]
Winter (n = 13)	285.36±127.07	76.12±2.65	4.28±0.76	4.69±1.55[b]	14.87±1.83[b]
Carnivorous					
Aoricthyes aor					
Summer (n = 08)	94.72±46.65	75.78±0.98	4.25±0.60	4.14±1.03	15.81±0.61[a]
Winter (n = 07)	162.85±38.13	75.52±1.43	4.22±1.18	6.08±3.23	14.16±2.02[b]
Wallago attu					
Summer (n = 07)	98.14±37.23	76.79±1.40	3.37±0.17	3.19±0.87	16.62±1.34[a]
Winter (n = 08)	168.46±47.25	77.89±2.19	3.21±0.49	4.34±2.00	14.53±1.92[b]
Omnivorous					
Barbodes sarana					
Summer (n = 07)	62.62±9.29	66.16±1.15[b]	4.59±0.30	14.18±2.63[a]	15.03±2.40[b]
Winter (n = 08)	120.09±55.78	68.27±1.30[a]	4.58±0.39	8.94±1.32[b]	18.20±1.23[a]
O. mossambicus					
Summer (n = 09)	82.33±23.37	72.33±3.27	6.04±0.76	6.07±2.03	15.52±1.72
Winter (n = 11)	117.48±41.17	73.38±3.28	5.62±0.67	5.52±1.76	15.45±1.57

The mean values with different superscript letters are significantly different from each other (LSD test) at $P<0.05$.

between fish groups of different feeding habits. The omnivores group was significantly different both from that of carnivores and herbivores (Fig. 1). The diet of the fish differs qualitatively at different times of the year and is therefore likely to cause variation in some body constituents (Habashy, 1973). In different environmental conditions, the body composition of the same fish may change in relation to differences in water quality and feeding conditions in addition to other factors such as age, size, season, spawning period etc (Javed *et al.*, 1992; Oliveira *et al.*, 2003). In present study, fat contents (%) of omnivores were higher than both carnivores and herbivores (Fig. 1). Lipids in fish vary greatly which is related to feed intake, migratory, swimming or sexual changes in connection with spawning (Oduor-Odote and Kazangu, 2008). Ashraf *et al.* (2011) demonstrated that herbivore species exhibited significantly higher lipid content, while protein content were significantly higher in carnivores compared to herbivores. Still another study has reported that protein contents remained uniform though feeding habits of the studied species ranged from herbivorous to carnivorous (Memon *et al.*, 2010). Therefore, the body composition parameters of fish species may/may not vary with feeding habit. There may be interaction of several other factors such as age and size (Lawson *et al.*, 1998; Paul *et al.*, 1998; Anthony *et al.*, 2000), gender (Lawson *et al.*, 1998; Paul *et al.*, 1998) and season (Grigorakis *et al.*, 2002; Levesque *et al.*, 2002) which could exert influence on body composition parameters.

The lower protein and fat value of young compared to adult fish, both freshwater and marine have often been documented (Marais, 1990; Javed *et al.*, 1990; Javed *et al.*, 1992, Salam and Davies, 1994, 1997). Lipid contents in small sized fish were approximately similar to those of large sized, only with slight decrease in large sized for different species of carnivores including *Wallago attu*; while protein contents demonstrated significant increase with age/size in carnivores (Ashraf *et al.,* 2011). In the present study, we observed a slight increase in fat, and a decrease in protein content for one carnivore species *i.e*. *Aorichthyes aor,* while for other carnivore species *i.e. Wallago attu*, no increasing/decreasing trend in fat contents (%) and protein contents (%) with size was observed. Our results deviate from those of Ashraf *et al.* (2011) who demonstrated no significant difference in fat contents of herbivores related with size. However, our study demonstrated a significant difference in ash and fat contents (%) related to size groups in one herbivore species *i.e*. *Labeo rohita*, while no significant difference was observed for other herbivores *i.e*. *Cirrhinus mrigala* and *Catla catla.* It has also been reported that protein contents (%) decreased with age, while fat contents increased (Kalay *et al.,* 2008). In present study, protein content (%) decreased with size in one herbivore pecies *i.e*. *Cirrhinus mrigala*, and no definite decreasing/increasing trend in protein contents (%) related with size was observed in other herbivores *i.e*. *Labeo rohita* and *Catla catla.* While, fat contents (%) increased in *Catla catla* (herbivore), and slightly decreased with size in other herbivores *i.e*. *Labeo rohita* and *Cirrhinus mrigala.* Therefore, there is mixed trend for an increase/decrease in protein and fat content (%) in herbivore, omnivore and carnivore fish species in present study. In another study, an increase in protein and fat with increasing size has been observed in *Mystus bleekeri* and *Aristichthys nobilis* (Naeem and Ishtiaq, 2011; Naeem and Salam, 2010). A reduction of 6% and 10% in protein content (%) for the smallest and largest salmon respectively has been observed during winter; while a reduction in protein content from 6% and 7% in trout of different size groups (Berg and Bremset, 1998). Therefore, it is evident that the body composition parameters of the fish may/may not vary with size of the fish. There could also be influence of other factors like feeding, breeding period, metabolism and season (Moss *et al.,* 2009; Shulman *et al.,* 2005; Guinea and Fernandez, 1997; Shiari *et al.,* 2002; Grigorakis *et al.,* 2002).

Temporal variability in body composition has been attributed to season and year. Growth rate and body composition of fish is affected significantly by water temperature (Guinea and Fernandez, 1997; Person-Le Ruyet *et al.,* 2004) of fish. The metabolism of fish increases in summer and decreases in winter (Goddard, 1996; Guinea and Fernandez, 1997; Bureau *et al.,* 2002). Fat contents vary in fish with season, species and geographical region (Piggott and Tucker, 1990; Tsuchiya, 1961). However, several research works including present study demonstrate contradictory results regarding seasonal effects on body composition parameters. There was no significant effect of season on fat and lipid contents (%) of *Wallago attu* and *Mystus seenghala* (Ashraf *et al.,* 2011). This finding is partly similar with our results where there was no significant seasonal effect on fat content of carnivore fish (Table III). However, in our study, protein content of carnivore fish showed significant seasonal effect. Another study demonstrated substantial increase in lipids during winter in a carnivore fish *i.e*. *Salmo salar* (Slitka *et al.,* 1998). Ashraf *et al.* (2011) demonstrated significant seasonal effect on ash contents (%) in *Wallago attu.* However, in present study, there was no significant seasonal effect on ash contents (%) of *Wallago attu* (Table III). A substantial decrease in protein contents (%) in summer in *Channa morulius* (carnivore fish) has been demonstrated (Ashraf *et al.,* 2011). Fat contents (%) increased in winter and the protein contents (%) decreased in winter in carnivore fish (Table III).

In present study, we also observed significant effect of season on lipid contents (%) and protein contents (%) of an omnivorous species *i.e*. *Barbodes sarana*, both of which increased in winter. Lipid content (%) is dependent on time of year and is attributable to corresponding changes in prey availability, temperature and sexual condition (Craig, 1977). Strong seasonal changes have been associated with prey availability (Foy and Paul 1999; Paul *et al.,* 1998). Annual differences in body composition have been described to fluctuations in food supply ultimately arising from long term climatic processes (Moss *et al.,* 2009; Shulman *et al.,* 2005).

In carps, the herbivore fishes, there has been found a decrease in fat content (%) during winter (Habashy, 1973). The lipid contents (%) were found to be affected by the seasonal variation in the tissues of an herbivore species *i.e*. *Labeo gonius* (Deka *et al.,* 2012). In present study, lipid contents (%) and protein contents of one herbivore fish *i.e*. *Labeo rohita* showed significant decrease in winter (Table III). In winter, when the water temperature falls, the fish utilizes a part of stored nutrients, namely fat and protein, in its metabolic activities. At the same time, the fish starts to develop its gonads, and at the beginning of spring, it reaches full ripeness. The development of gonads results in the consumption of additional amount of stored nutrients, especially the fat contained in the muscle (Zaboukas *et al.,* 2006; Salem *et al.,* 2006, 2013).

It is evident that the phenomenon of variations in body composition parameters of fish is complex. The body composition parameters of fish depend on several individual environmental factors like water temperature, season, water quality, food availability and/or intrinsic factors like metabolism, age, size and spawning period etc. However, several of these factors are dependent on each other and thus may interact to influence the body composition of fish.

CONCLUSIONS

On the basis of our findings, we conclude that there are species specific variations in body composition parameters of fish related with feeding habits, size and season.

Statement of conflict of interest

Authors have declared no conflict of interest.

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