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Reproduction and feeding habits of the River Catfish *Eutropiichthys vacha* (Hamilton, 1822) (Siluriformes, Schilbidae) in an impacted habitat: Kotri hydrodam, River Indus, Pakistan

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Abstract

Reproduction and feeding habits of *Eutropiichthys vacha* were studied in Kotri hydrodam, a man-made and human impacted stretch of the Indus River, Pakistan during 2005-2006. A total 303 specimens were sampled and analyzed for maturity stages and gonadal development and food and feeding habits assessed from gut contents. Results showed male dominance over females: sex ratio 1.16:1.0. Minimum size at sexual maturity was 13.9 cm total length (TL). Mean fecundity ranged 1.38×10^4 to 2.17×10^5. Gonado-somatic index (GSI) was 0.1-2.5 and 0.3-6.5 for males and females, respectively. Highest GSIs were recorded in April. We observe an ontogenic dietary shift in *E. vacha*: young are omnivorous with insects dominating diet while adults are omni-piscivores with *Puntius ticto* accounting for 35.4% of species. Other species were *Colisa* spp., juveniles of *Channa* spp. and some cyprinids. Feeding intensities were lowest in April at peak of spawning. The intensities increase rapidly after spawning indicating voracious feeding in *E. vacha*. Feeding intensities in adults are low during the cold season. These results provide for assessment of spatial-temporal variations in feeding intensity in *E. vacha* while GaSI and diet composition reveal information on environmental shifts and ecosystem fluctuations in the impacted habitats of the River Indus for sound fisheries management.

Key words: Schilbeid catfish; *Eutropiichthys vacha*; Reproduction; Feeding habit; River Indus

Introduction

The river catfish *Eutropiichthys vacha* (Siluriformes, Schilbidae) is an economically important freshwater fish and is widely distributed in Indus River basin of across northern India, southern Nepal and Bhutan, through Bangladesh and Myanmar to the far western areas of Thailand. (Talwar and Jhingran 1991; Menon 1999; Riede 2004). The fish is popular among consumers (Hasan et al. 2002) and is commercially important as a food- and game fish species in Pakistan (Soomro et al. 2007). Moreover, there is a strong export market in the Middle East and European markets and also the entire demand for this fish species in the domestic market is met through capture from rivers. Consequently, the sound management of the wild stocks is critical.

The commercial catches of *E. vacha* in the Indus River are on the decline and the species has been reported as "vulnerable" in some regions (Mirza and Bhatti 1999; Mijkherjee et al. 2002). Knowledge on the reproduction, food and feeding habits as well as various aspects of its biology are important for sound management of its fishery. However, despite the numerous studies on this species, information on its reproduction, food and feeding habits have clearly been lacking for the lower Indus River and the situation is further augmented by the construction of the numerous hydrodams for power generation, flood control and irrigation. Furthermore, this type of information is useful for the development of management strategies that aimed at conserving the riverine biodiversity associated the *E. vacha* fishery (Turan et al. 2005). Therefore, knowledge on the reproduction, food and feeding habits *E. vacha* in the habitats where it is distributed is needed for the sound management of its fishery as well as for successful commercialization and conservation of the species to recompense declining wild catches. Moreover, information on reproduction, and food and feeding aspects forms an important guide for assessment of nutritional requirements and trophic status for aquaculture selection and for formulation of commercial feeds. Further, this information is also important in development of trophic models in order to understand the ecosystem of the species both in the natural environment as well as within culture facilities (Lopez-Peralta et al. 2002; Bachock et al. 2004). Consequently, the lack of such crucial information on the river catfish *E. vacha* has been a hindrance to the sustainable management of the species in the wild and exploitation of its full potential for aquaculture. Therefore, the present study investigated the reproduction and food and feeding habits of wild river catfish *E. vacha* in the Kotri hydrodam on the River Indus, south Pakistan in order to provide the much needed information for exploitation of its full potential for both capture and culture fisheries.

Materials and methods

Study area and sampling

The Indus River, originating in the Tibetan plateau, enters Pakistan via the Gilgit-Baltistan area (Bhatti, 1999; Albinia, 2008) and flows in a southerly direction for ~3,180 km before discharging into the Sapta Sindhu delta of Pakistan (Bhatti, 1999). The Kotri hydrodam straddles 25º 26' N and 68º 19' E measuring 920 m across the River Indus, Hyderabad, southern Pakistan and is the last hydrodam on the River Indus. Below, the river runs about 100 km before discharging into the Arabian Sea near the port city of Karachi. Together with Sukkur and Thatta, the Kotri hydrodam is one of the major fishing centres along the Sindh course of the lower reaches of the River Indus (Bhatti 1999).

Monthly samples were collected from the small-scale commercial fish landing site at Jamshoro, on the Kotri hydrodam over a period of one year. The samples were chilled in ice and transferred to the laboratory for analysis. Total length (TL, cm) and body weight (BW, g) were taken using a using a digital slide calipers (accuracy 0.1 cm) and weighing balance (accuracy 0.1 g), respectively.

Reproduction in Eutropiichthys vacha

The reproductive aspects *E. vacha* were studied from a total of 281 adult specimens. The fish were sexed and TL and BW measurements of each individual fish recorded. The specimens were then dissected to remove the gonads and the gonad weight (GW, g) recorded against each specimen. The maturity stages of the river catfish *E. vacha* were classified based on both macroscopic study of the gonads and microscopic examination of ova. In the females, the ovaries form a U shaped loop of two lobes that open to the outside by a common duct and differentiate as maturity progresses along with the enlargement in size and change in colour. In the males, the testes first as slender thread structures in the vent area of abdomen, changing to prominent strips as maturity progresses, and at full maturity, the testes extend to the anterior region of the body cavity.

Ova samples were sampled from the ovary at the mid-section (Bowden et. al. 1990) to obtain the most advanced oocytes stages (Teshima et al. 1989). The ovary tissues were stored in a 1:9 formalin-water solution buffered with 20 g/l sodium acetate before analyses. The gonad maturity stages were assigned to five-stage maturity phases based on macroscopic and microscopic examination of the ovaries (Hinckley, 1986; Morrison, 1990). Sample ovaries were then embedded in paraffin, thin sectioned to a 4-µm thickness, and stained and counterstained with Haematoxylin and Eosin according Moe (1969) as adopted by Tessy (1994). All microscopic examinations were conducted under a binocular microscope (Nikon Eclipse E200, Nikon, Japan). The ovaries were then fixed in Gilson’s fluid for gravimetric analysis. Preserved ovaries were washed and cut into three sections, and the total number of eggs estimated according to the method by Bagenal and Braun (1978), as follows. Three sub-samples were obtained from the anterior, middle, and posterior sections of the ovaries and the number of eggs counted in each sub-sample. The total fecundity (F) was then estimated using the equation: $F = (GW \times N_S) / W_S$; where GW is the weight (g) of the gonad while N_S and W_S are the number of eggs and weight (g) of the sub-sample, respectively. The gonad cycle was determined monthly from the gonado-somatic indices (GSI) using the formula: $GSI = (GW \times 100) / BW$; where GW and BW are the gonad weight and body weight, respectively. Physico chemical parameters including water temperature were measured using a portable digital meter (Ecoscan-Temp6, Eutech, Netherlands).

Food and feeding habits of Eutropiichthys vacha

A total of 303 specimens were used for the analysis of food and feeding habits. The specimens were dissected and the entire gut contents including the examined visually both by naked eye and under a binocular microscope (Nikon Eclipse E200, Nikon, Japan). Stomach fullness was determined by the Hynes (1950) gravimetric method and categorized into five levels as; 100 %, 75 %, 50 % and 25 % full, and 0 % or empty. The stomach contents were then placed in a Petri dish suspended in water and the food items identified to the lowest possible taxon using identification keys for microscopic freshwater life (Ward and Whipple 1959) and the fish prey identified according to species keys Talwar and Jhingran (1991). Further, digested materials were categorized into digested and semi-digested. The percent volume of major gut items was estimated by the points method adopted from Pillay (1952). Gastro-somatic index (GaSI) was then calculated according to Dadzie et al. (1998), as follows: GaSI = 100 [SW / BW], where SW and BW are the weight (g) of the stomach contents and body weight (g), respectively. The percentage and degree of fullness of the gut was also calculated as an indicator of the feeding intensity.

RESULTS

The mean monthly temperature was 27° C during February and increased gradually to 30° C in April and maximum at 32.5º C in August. The lowest temperatures were recorded in January, at 16.5º C. The monthly variations in mean water temperature during the sampling period are shown in Fig. 1.

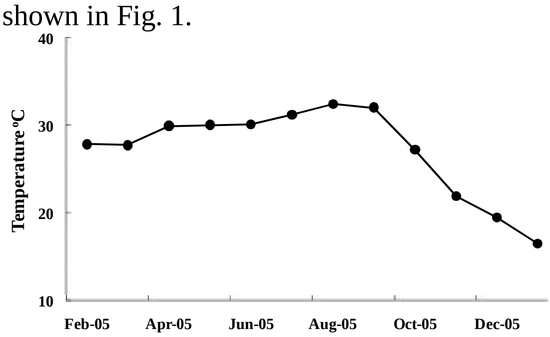


Fig. 1 Monthly change in water temperature in the River Indus at the Kotri hydrodam, Pakistan during the present study

Maturity stages and Gonado-somatic index in Eutropiichthys vacha

The minimum size of female *E. vacha* with mature ovary was 13.9 cm. The minimum and maximum sizes were 17.3 and 31.5 cm, and 13.9 and 34.0 cm in males and females respectively, confirming comparatively larger females than males in this species. Further, sex ratios were 1.0:1.16 male: females, with female population dominant over males.

In the classification of gonad maturity determined by observing the morphological conditions of ovaries and ova diameter, five stages were identified in *E. vacha* (Table 1):

Stage-I: Immature: Pale cream, thin ovaries with no visible ova granules with low calculated GSI. Stage-I individuals were most abundant during September to October.

Stage-II: Preparatory: Reddish-orange ovaries with average ova diameter 0.31±0.11 mm. Stage-II individuals occurred during December to February.

Stage-III: Maturing: Large yellowish, highly vascularised ovaries, visible ova and mean ova diameter 0.57±0.12 mm. GSI was highest. Individuals only occurred in April.

Stage-IV: Spawning: Yellowish smaller ovaries filling about 60% of abdominal cavity with heterogeneous oocytes. The spawning season was marked by a decline in GSI during late April to early May.

Stage-V: Spawned: Flaccid, hemorrhagic ova with wide size variations averaging 0.17±0.08 mm ova diameter. Stage-V individuals occurred from May to July.

In the present study, GSI increased gradually from February and reached peak in April. It declined in May and remained low during June through October (Fig. 2) resuming a gradual increase at the start of November.

GSI is closely linked to fecundity as a measure of the potential reproductive capacity of an individual (Bengal 1978). In the present study, the mean fecundity of *E. vacha* varied from 13,800 eggs in individuals of 14 cm TL (and 30.2 g BW,

Table 1. Maturity conditions of the River Catfish *Eutropiichthys vacha* population at the Kotri Barrage, Pakistan**,** based on macroscopic and microscopic examination.

Maturity stage	Condition	Macroscopic examination	Microscopic examination
Stage I	Immature	Ovary is short, transparent, lobes fresh coloured thread-like strucutres, no eggs vissible; gonads tucked in body cavity (occupy <20%).	Ova 0.06-0.6 mm Ø. Male testes slender white threads. Testis formed by spermatogonia, no tubules.
Stage II	Developing / Preparatory	Ovaries translucent, occupy ~50% body cavity. First batch of eggs separate from immature stock, appear translucent to whitish.	Separate ova ~0.2-0.4 mm Ø. Male testes think/whitish, ~30% body cavity. Testis with spermatogonias, spermatocytes and spermatids.
Stage III	Maturing / Pre-spawning	Ovaries translucent to opaque, occupy > 90% length of body cavity, consists of immature and maturing ova.	Ovarian lamellae present, oocytes with more cortical alveoli oocytes in advanced stages. Anterior stage oocytes present.
Stage IV	Spawning	Yellowish/Orange, volumous, with blood vessels, occupy 60% body cavity. Eggs discernible and opaque.	Vitellogenic oocytes present, % ripe oocytes higher. Seminiferous tubules filled with spermatozoa.
Stage V	Spent	Flaccid, wrinkled/empty, smaller size than Stage 4, occupy <50% of abdominal cavity. Hemorrhagic appearance with heteregeneous oocytes	Post-ovulatory follicle in higher concentration. Testis in regression, cells fused, increased 1° and 2° spermatocytes.

1.6 g GW) to 88,400 eggs in 30 cm TL individuals (and 180.0 g BW, 5.2 g GW). Only one individual of 26.5 cm TL (and 139.2 g BW, 11.3 g GW) recorded a fecundity of about 217,100 eggs and was excluded from fecundity correlation analysis. Analysis of the correlation coefficient and regression for fecundity with TL, BW and GW of *E. vacha* showed high correlation between fecundity and GW (r^2=0.9911), TL (r^2=0.8652) and BW (r^2=0.6318). The regression between fecundity and TL, BW and GW were best described as shown in Fig. 3.

Food and feeding habits of Eutropiichthys vacha

A total of 303 specimens were examined. Out of the total specimens, 92.3% (276 individuals) recorded either semi-digested or whole juvenile fishes or adults of small fishes in their stomachs. The fish food items were mainly comprised of prey from two cyprinid genera; *Colisa* spp. and *Channa* spp. The rest of the individuals recorded varied food items including crustaceans (copepods and shrimps), chironomid insect larvae and pupae, aquatic plants and sediment particles.

Food size classes showed that young *E. vacha* (length classes <13.0 cm) consumed mainly plankton (cyanobacteria, diatoms and desmids), copepod and decapod crustaceans and macrophytes (Fig. 4a). Length classes >14.0cm fed mainly on aquatic chironomid insects, decapod crustaceans, annelids and small forage fish or juveniles of larger fish species (Fig. 4b).

Therefore, the young of *E. vacha* appear to be omnivorous shifting to Omni-carnivorous feeding at adult stages. However, chironomid insect larvae and pupae, copepods and decapod crustaceans especially shrimps appear to dominated the diet of *E. vacha*.

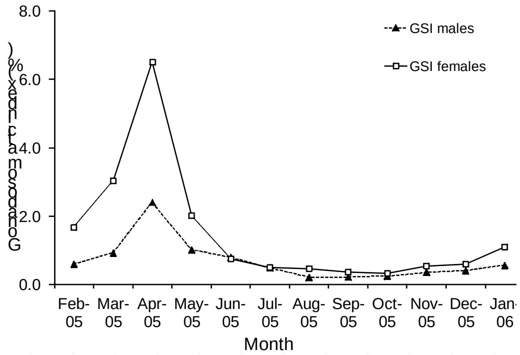


Fig. 2 Monthly change in the gonado-somatic index of male and female *Eutropiichthys vacha* population at the Kotri hydrodam, Pakistan

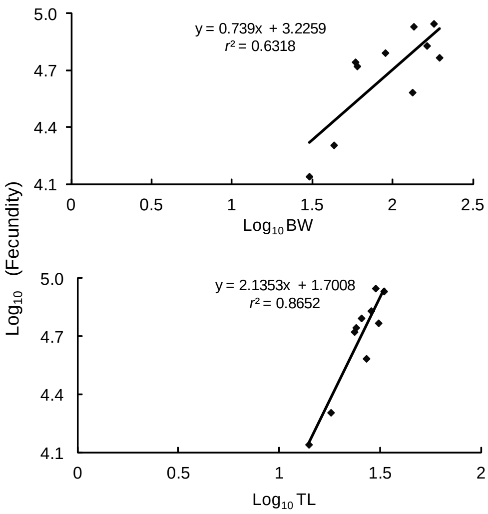


Fig. 3 Relationship of fecundity with total length (TL), body weight (BW) and gonad weight (GW) of *Eutropiichthys vacha* population at the Kotri hydrodam, Pakistan

The percentage of chironomids in *E. vacha* diet was consistently high throughout the study with higher values during August-November. Crustaceans also occurred all year round but with higher values during February-March. Other food items including macrophytes and algae remained comparatively low. Semi digested materials including sediments were recorded throughout the study especially in young individuals.

Length classes >14.0 TL were omni-piscivores on *Puntius ticto,* juveniles of carps, *Colisa* sp. and young of *Channa* spp. with *P. ticto* as the most dominant fish food item (Fig. 4b). This indicates that *E. vacha* occupies a high trophic level in these habitats.

Feeding intensities of Eutropiichthys vacha

The feeding intensities were studied by tabulation of % composition of food items against length classes and GaSI values calculated for the adult specimens. Results showed that GaSI varied with season with higher values in February-March but declined in April. In May, higher GaSI values were recorded in June-November (summer) followed by a decline in December-January (Fig. 5). Similarly, analysis of feeding intensities using degree of gut fullness confirmed lower % of empty stomachs from February peaking in April when close to 100% of individuals recorded empty stomachs. During May-August, feeding intensities increased as confirmed by the decrease in % of empty stomachs recording lowest values in September. June-July recorded almost full stomachs in 100% of the individuals. Generally, the % of full stomachs during each season was higher

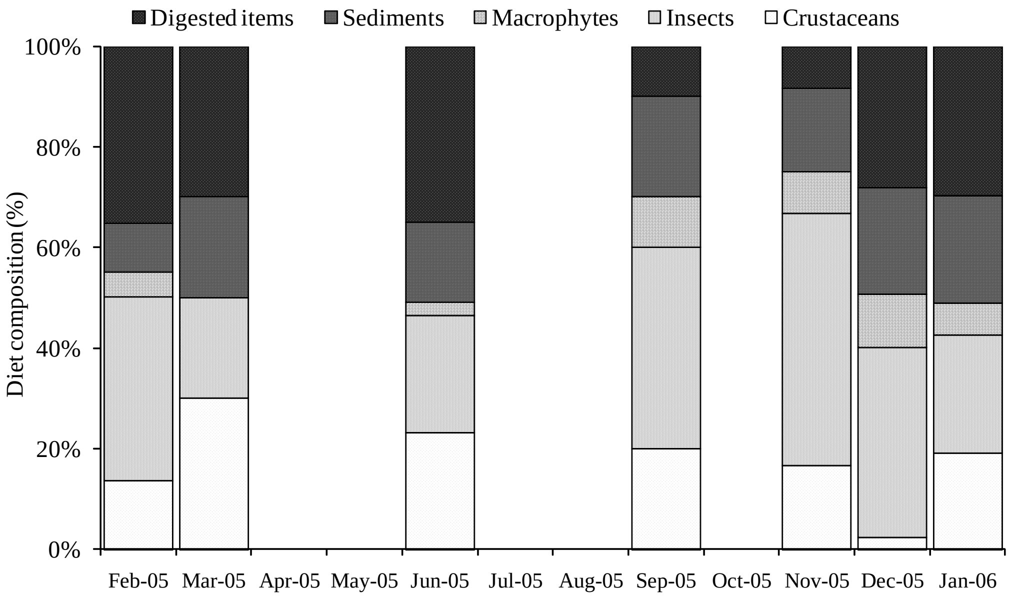
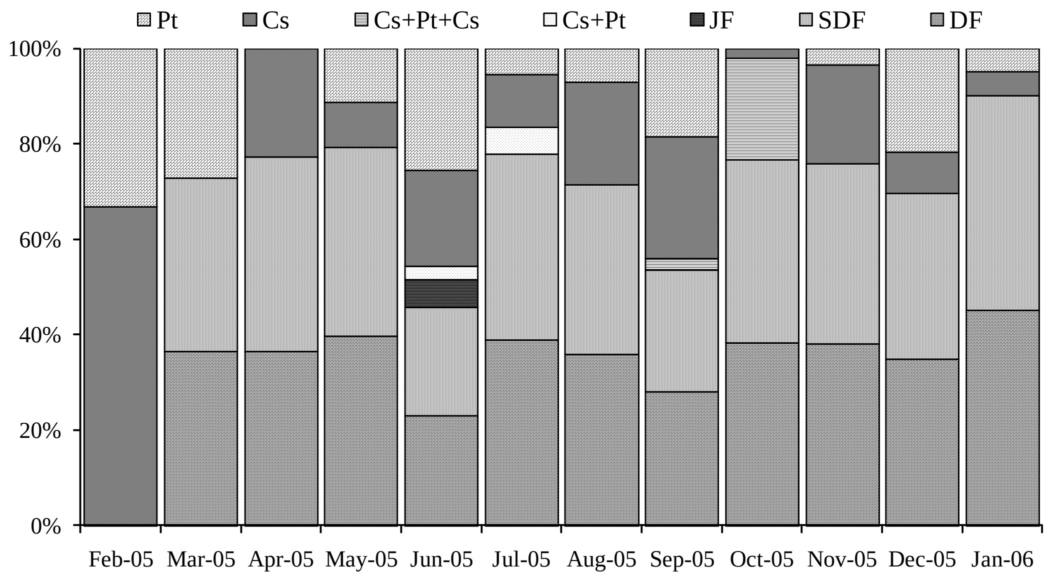


Fig. 4a Percentage of different food items recorded in the guts of young *Eutropiichthys vacha* population at the Kotri Hydrodam, Pakistan



Key: DF= Digested food items; SDF= Semi-digested fishes; JF=Juvenile fish; Cs+Pt = *Colisa* sp. + *Punctius* ticto; Cs+Pt+Cs = C*olisa* sp. + *Punctius ticto* + *Channa* spp.; Cs=Colisa sp.; Pt = *Punctius ticto*

Fig. 4b Percent occurrence of different food items found in the gut of adult *Eutropiichthys vacha* population at the Kotri hydrodam, Pakistan

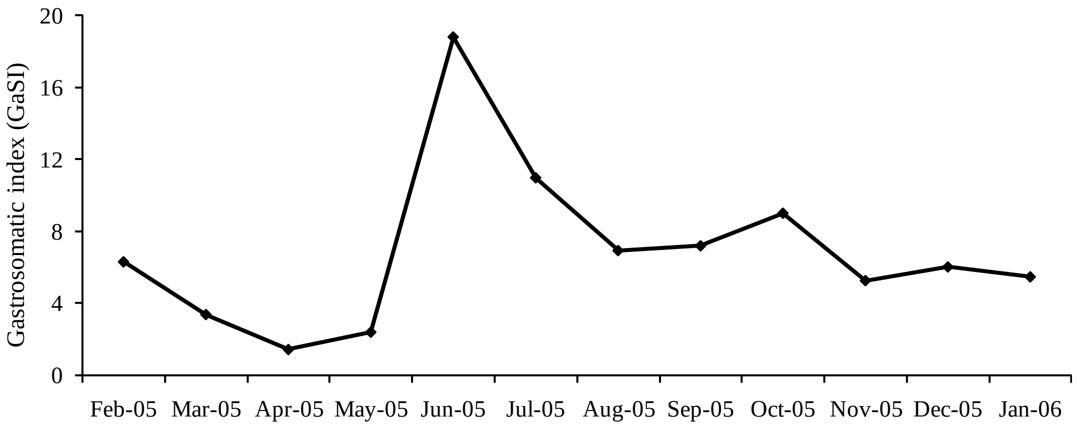


Fig. 5 Monthly change in the gastro-somatic index (GaSI) of *Eutropiichthys vacha* population at the Kotri hydrodam, Pakistan

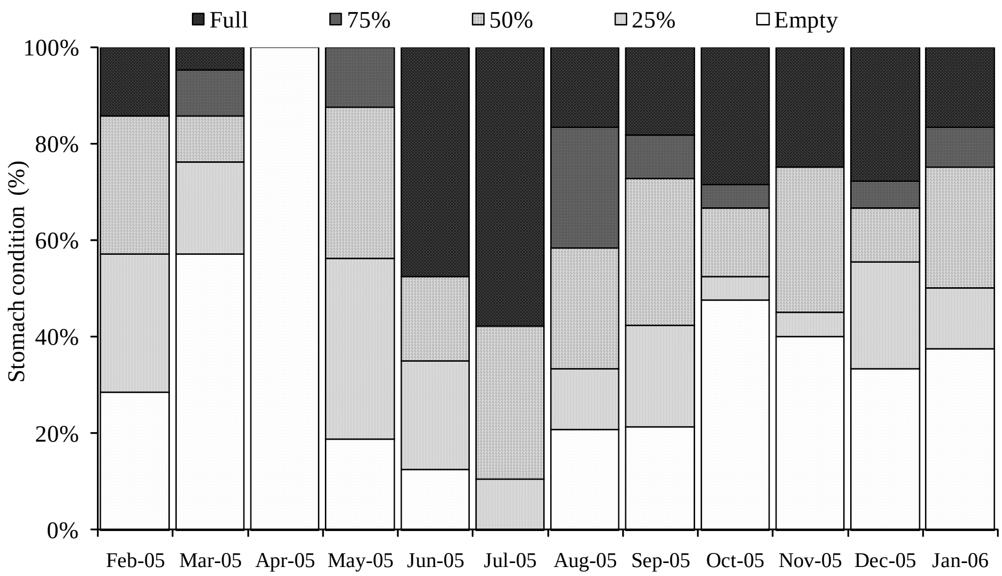


Fig. 6 Monthly change in percentage of stomach with different feeding intensities in *Eutropiichthys vacha* population at the Kotri hydrodam, Pakistan

than the total empty stomachs observed during the study as shown in Fig. 6.

Discussion

In this study, 1.16:1.0 male: female ratio indicated male dominance in the population. However, Azadi et al. (1990) recorded a female dominant population while studying *E. vacha* in Kaptai Lake, Bangladesh. The variations in sex dominance in the two populations may be attributed to environmental factors especially temperature

(Conover and Kynard 1981; Baroiller and D'Cotta 2001). Food availability also influences sex ratios favouring female dominance in food-rich environments (Msiska and CostaPierce, 1997). Therefore, differences between lotic Kotri hydrodam; an habitat associated with low food availability and lentic, often eutrophic food-rich Lake Kaptai may account for variations in sex rations between the two areas.

Further, Nikolsky (1963) noted that females require better environmental conditions and development of female populations is impacted by deteriorating environmental conditions. Hypoxia or low dissolved oxygen levels have been shown to favour male dominance in populations due to the effect on sexual development and sex differentiation (Shang et al. 2006). The present results are further supported by Narejo et al. (1998) who recorded a male dominant population in *Tenualosa ilisha* in the Indus River confirming likelihood of male-dominance in lotic environments.

In the present study, GSI was highest in April while in Lake Kaptai (Azadi et al. 1990) noted highest GSI in May. This may be attributed differences in water temperatures: higher at 27-30^{o} C in April at Kotri hydrodam compared occurrence of similar temperatures later in July in Kaptai Lake with unstable thermoclines and thermal stratification occurring in summer, March-May (Azadi et al. 1990). Other studies confirm the importance of temperature in regulating gonadal maturation and reproduction in fishes (Mironova 1977; Msiska and Costa Pierce 1977; Ridha et al. 1998). Chmilevskiy and Lavrova (1990) reported low temperature (<20°C) may inhibit the division of the primary sex cells and gonia blocking transition to prophase meiosis and differentiation in the female gonads was suppressed in low temperature (Chmilevskiv, 1995). Therefore the variations in GSI may be directly linked to variations in temperatures throughout the year.

The fecundity of *E. vacha* in the Kotri hydrodam relatively high compared to other species. In the Lake Kaptai Azadi et al. (1990) reported similar fecundities: of 5040 -351000. The high fecundity is attributed to the smaller egg size (<0.6 mm). In this study, fecundity was well correlated with TL and BW. Correlation between fecundity and body size has also been shown in other species: *Plotosus canius* (Khan et al. 2002), *Colisa fasciata* (Banu et al. 1984), *Puntius stigma* (Islam et al. 1990) and *Gudusia chapra* (Kabir et al. 1998) among others.

Food and feeding habits of *E. vacha* indicate it as an omnivore to omni-carnivore, feeding on fish, crustaceans, insects and aquatic macrophytes. Food items varied widely, with clear demarcation between the <13.0 cm length size classes and the >14.0 cm length size class group. Ontogenetic shifts in food items have been noted in earlier studies (Welcomme, 1979; Dadzie et al. 2000). Moreover, due to a small mouth gape, young *E. vacha* can only ingest small fish prey shifting to larger food items with increased feeding intensities coinciding with maturation of *E. vacha* at 14.0 cm TL. The shift in feeding habits from omnivory to omni-piscivory at onset of maturity is associated with increased nutritional requirements for maturation. Ndombour et al. (2007) reported similar ontogenic diet shifts at the onset of maturation in three Cichlid species.

In the present study study, two small

sized fishes; *P. ticto* and *Colisa* spp. were the main preferred prey of mature *E. vacha*. This may due to their wide distribution and higher abundances in Indus River making them easy target prey for this species. Juvenile cyprinid carps in the diet especially during September and October 2005 coincides with higher prey abundance associated with the carp breeding season closely linked to the June to August monsoon season.

GaSI results showed that feeding intensities varied widely throughout the year. Low GaSI values were recorded during March-May. This indicates that feeding intensities in adult *E. vacha* decreased towards the onset of spawning and feeding stopped during the peak of the spawning season. Furthermore, as the gonads increase in size filling most of the abdominal cavity, stomachs shrink to their lowest. Similar observations were noted in *Oreochromis niloticus* in Abu-Zabal Lake in Egypt (Kariman et al. (2009), *Hotoscopelus kroyeri* in the Northwest Atlantic (Mazhirina and Filin 1987) and *Trachurus trachurus* off Portugal (Garido et al. 2008) among others. Highest % of full stomachs was recorded during June, which also correlated with higher GaSI indicating that feeding intensities increased rapidly soon after spawning. Thus, the voracious feeding in *E. vacha* at the end of spawning is partly aimed at post spawning recovery.

The present study provides information on reproduction and feeding habits of the River Catfish *Eutropiichthys vacha* which is important for defining sustainable exploitation of this species in the impacted hydrodam habitats. The study uses basic methods of analysis for food and feeding habits, and calibration of data on feeding intensities can be used as a tool to evaluate spatio-temporal variations in feeding intensity in the other impacted habitats as well as in the lotic environment rivers. The feeding habits were evaluated using both GaSI indices and diet composition and it is hoped that stomach fullness data can be used as a variable in interpreting environmental shifts and ecosystem fluctuations in the hydrodams for comparison with the main River Indus. Therefore, the study presents crucial information for comparison with the non-impacted stretches if the river for development of an ecosystem-based fisheries management for the Indus River Schilbeid catfish.

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