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Fish Assemblage Structure of the Köprüçay River Estuary (Antalya-Turkey)

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This study is summarized from the author's Ph.D. Thesis

Abstract

The spatial and temporal fish species assemblages were analyzed in the Köprüçay River Estuary. Fish were sampled monthly by different nets from October 2006 and March 2008. A total of 2419 individuals distributed in 12 families and 23 species were collected. The most numerically abundant species were *Mugil cephalus* (32,9%) and *Liza aurata* (17,4%). The fish comprised 11 freshwater, 9 marine, 1 estuarine and 2 migrant. Evenness and diversity index showed a consistent seasonal pattern. Canonical correspondence analysis indicated that salinity correlated with the seasonal pattern in the fish assemblage.

Key words: Community composition, Salinity, Estuary, Köprüçay River, Mediterranean

1.Introduction

The ecological and socio-economic importance of estuaries has been well documented in temperate and tropical environments (Ruedo, 2001). Estuaries and coastal lagoons are used by large numbers of fish as nursery sites, migration routes, feeding and/or breeding areas. For these reasons, Estuaries represent important environments, which support high levels of fish production (Malavasi *et al.*, 2004). Fish assemblages in estuaries can include larvae, juveniles and adults of species of both marine and freshwater origin, with migratory or sedentary behaviour (Chicharo *et al.*, 2006). In Mediterranean, many researchers have focused on the distribution, abundance and seasonal variation in estuarine fish communities. Temporal and spatial distribution of fish species in estuaries varies, depending on factors salinity, temperature, turbidity, dissolved oxygen (DO), freshwater inflow, structural attributes of habitat, depth, geographic distance from the estuary mouth, and hydrography (Akın *et al.*, 2005). Many authors have also shown that Fish assemblages in estuaries exhibit strong short and long-term variability, due to environmental fluctuations (Koutrakis *et al.*, 2000, Garcia *et al.*, 2003, Matic-Skoko *et al.*, 2005). Many estuaries remain poorly or completely unstudied. These vitally important fish nursery habitats are subjected to major anthropogenic alterations such as freshwater abstraction, impoundments, artificial canalization, introduction of alien species, pollution and over fishing. In Mediterranean estuaries of Turkey, information about the fish assemblage composition and seasonal or spatial variation in density and biomass is rare, with the exception of studies in Koycegiz Lagoone Estuary (Akın *et al.*, 2005) and the Goksu River Estuary (Küçük *et al.*, 2007). The Köprüçay Estuary is a permanently open estuary situated Belek coast of Turkey. The Köprüçay Estuary has been affected by large-scale anthropogenic influences, mainly the substantial development of Tourism activities and the increasing population in the catchment. Fish assemblage composition of Köprüçay Estuary are still poorly understood. The aims of the present study were (1) to describe the seasonal pattern in the community of fishes, and (2) to analyze environmental factors influencing or controlling spatial or temporal variations in community structure.

2.Material and Methods

2.1.Study Site

The Köprüçay River is located in western part of Taurus Mountains which is the longest tectonic unit extending between southwest and southeast of Anatolia. It springs from Isparta and flows to Mediterranean Sea in Antalya. It can be classified as permanently open and maximum depth of about 8 m. The total length of the main channel is approximately 185 km. The main channel of the estuary (Köprüçay-Antalya) was divided into two areas (upper and lower estuary) according to physicochemical gradients. The upstream area is characterized by agriculture farming, the lower estuary area is dominated by Tourism activities.

2.2. Sampling collection and data analysis

Six sampling stations [(Lower Estuary, Site1- mouth; Site2-small lagoon lake; Upper Estuary (Sites 3-4-5-6)] were selected in different parts of the Estuary (Denizyaka and Boğazkent Village, Serik 36°49'44.39" N 31°10'21.95"E-36°53'10.00" N 31°09'25.16"E). Fish species were caught monthly between October 2006 and March 2008 (18 sampling dates) with gill nets of various mesh sizes (310 m total long; 10, 17, 23, 30 mm bar lengths), fish traps and fyke nets. Water quality parameters were measured at each survey site at the start of each field. Temperature (C), salinity, pH and oxygen concentration were determined by using WTW 340*i*. Secchi depths were estimated by Secchi disk. Water quality parameters were analysed using ANOVA to measure the significant difference among sampling sites. Captured fishes were anesthetized, then fixed in 4% formalin in the field. Fish specimens were identified to species level according to Aksiray (1987) and Geldiay and Balik (1988), Fish species in Köprüçay Estuary have been categorized in terms of salinity preference and migratory behaviour into marine, migratory, estuarine and freshwater (Araujo *et al.*, 1999). Exotic or native taxa were identified by reference to Innal and Erk'akan (2006). The fish samples were weighed for biomass determination to the nearest 0.1 grams (g). The fish community were characterized using either the species richness S (total number of species obtained at each sampling), or the Shannon-Wiener diversity index H'. Distribution of individuals was measured by the uniformity or 'Evenness' index, J (Magurran, 1988). A two-way ANOVA was used to test for significant differences in environmental variables, species richness, and abundance among sites and months. Prior to analysis of variance, all variables were tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Cochran tests). Associations between species abundance and log-transformed environmental variables were examined with the canonical correspondence analysis (CCA) using CANOCO (Ter Braak and Smilauer, 2002). To reduce the effects of rare species, only species catching in two or more sites were included in CCA. Interset correlations between environmental variables (Salinity, Dissolved oxygen and Secchi depth) and CCA axes were used to assess each variable's contribution. MonteCarlo permutation analysis simulation and the forward selection option within the CANOCO package were used to test the significance ($P<0.05$) of each variable's contribution to each CCA axis.

3. Results

3.1. Environmental parameters

Water quality parameters are given in Figure 1. Although water temperature tended to decrease from site 1 (mouth) to site 6, this decrease was not statistically significant ($p>0.05$). Mean monthly Secchi depth did not show a strong seasonal pattern. Mean monthly Secchi depth varied from a minimum of 0.3 m to a maximum of 1.3 m. Secchi depth were significantly different between sites ($p<0.05$). Salinity values ranged from 0.2 to 20.2. The highest and lowest mean salinity values were measured for summer and winter months, respectively. Salinity showed a spatial gradient along the length of estuary. Decreasing progressively from the mouths to the upstream sites. This decrease was statistically significant ($p<0.05$). Mean monthly pH values did not show a strong seasonal pattern. pH readings were not significantly different between sites. Dissolved Oxygen concentration varied from a minimum of 6 mg/l to a maximum of 9.5 mg/l. Dissolved Oxygen concentration were not significantly different between sites ($p>0.05$).

3.2. Fish community composition

Twenty three fish species, representing 12 families, were recorded in the Köprüçay Estuary. A total of 2419 individuals (401.4 kg total biomass) was caught throughout the study. Cyprinidae was the family most represented in terms of number of species. Cyprinidae was followed in species number by Mugilidae (five species) and Salmonidae (two species). In contrast, the remaining families (Clupeidae, Anguillidae, Atherinidae, Clariidae, Engraulidae, Moronidae, Poeciliidae, Sciaenidae, Sparidae) were all represented by one species. Members of the Mugulidae family were among the most abundant species, accounting for 51.9% of the total catch.

The most abundant species were *M. cephalus* (32.9%). *L. aurata* (17.4%), *Cyprinus carpio* (11.3%), which comprised 61.6% of the total sample. Fishes have been categorized as marine, estuarine, freshwater and migratory species. The marine species of Köprüçay Estuary, with nine species (39.1%), represented the highest abundance (60.0%) and biomass (55.2%). The freshwater species, with eleven species (47.8%), represented 35.7% of abundance and 33.2% of biomass. The migrant species, with two species (8.7%), represented 4.0% of abundance and 11.6% of biomass. The Estuarine species represented only one species (*Atherina boyeri*). Six introduced species comprised

26.1% of the catches in terms of number of speciemens. Five (*Carassius auratus, Carassius gibelio, Oncorhynchus mykiss, Pseudorasbora parva, Gambusia holbrooki*) of these species are alien species of Turkey.

3.3. Spatial and temporal variation in fish abundance and species richness

Spatial and temporal variation in species richness (number of species sampled), biomass, and diversity indices (Shannon–Wiener diversity index and evenness index) of fish community are given in Table 2 and 3. Number of Species varied from 7 (December 2007 and February 2008) to 16 (April 2007) in Köprüçay Estuary. Based on the Shannon-Wiener's diversity index (H'), the highest ecological diversity was recorded in April 2007 (2.45) and the lowest in December 2007 (1.55). In the other hand, the evenness index had its highest value in March 2007 (0.78) and the lowest in August 2007 (0.48). Highest H′ value was found in Sites 2 (Small lagoon lake). In general, Number of Species and values of Shannon diversity index was higher during fall and spring-summer months than winter months. Number of Species and values of diversity index exhibited a strong spatial and temporal variation throughout the study.

Fish abundance was highest during October-November 2006 and May-October 2007. *M. cephalus* and *L. aurata* achieved their peak abundance in these months. The highest and lowest mean abundance values were obtained at Sites 2 (Small lagoon lake) and 4. The period between January-March 2007 and December 2007-March 2008 was characterized by low biomass.

Canonical correspondence analysis ordination plot for sites and species, illustrating distribution patterns based upon environmental conditions is given in Figure 2. Within the measured environmental variables, temperature, salinity and pH values showed strong correlation ($p < 0.05$) between each other. Thus, only the salinity parameter was taken into CCA analysis. CCA eigenvalues of the first four multivariate axes were 0.298 (CCA1), 0.050 (CCA2), 0.021 (CCA3), and 0.043 (CCA4). Correlations between species and the environmental parameters axes are high for the first three axes (0.98, 0.93 and 0.97). The first and second axes modeled 72.1% and 14.3% of species data, respectively, and they cumulatively accounted for 87.5% of the variance of species-environment relationships modeled by CCA. Among the three examined environmental factors, Salinity best explained the seasonal pattern of species composition in Köprüçay Estuary.

4. Discussion

According to this study, 23 species permanently or temporarily occupy the study area. Number of fish species of Köprüçay Estuary is fewer than the most studies such as Richmond River Estuary (Australia, 64 species) and Clarence River Estuary (Australia, 66 species) (West and Walford, 2000); Strymon River Estuary (Greece, 43 species) and Rihios River Estuary (Greece, 29 species) (Koutrakis *et al.*, 2000); more than Kakanui River Estuary (New Zealand, 20 species) (Jellyman *et al.*, 1997); Solway River Estuary (England, 22 species) (Elliott and Dewailly, 1995),Waitaki River Estuary (New Zealand, 16 species), Clutha River Estuary (New Zealand, 14 species), Waiau River Estuary (New Zealand, 14 species) and Mohako River Estuary (New Zealand, 13 species) (Jellyman *et al.*, 1997). The present study showed similar number of species values with that reported by Araujo *et al.* (1999) for Upper Thames Estuary. Comparisons of species numbers between different estuaries are difficult because sampling sites and sampling methods vary. Occurrence, distribution and movement of fishes in estuary systems are certainly determined by a complex combination of both biotic and abiotic factors (Martino and Able, 2003; Jaureguızar *et al.*, 2006; Sosa- Lo´pez *et al.*, 2007).

Of the 23 species recorded in the Köprüçay estuary, 11 are freshwater, 9 are marine, 1 is estuarine species and 2 are migrating in and off the river during their life cycle. The functional group of the Köprüçay estuary was mainly composed of freshwater species in terms of number of species. The reason for the dominance of freshwater species may relate introduce of new species in estuary. 6 of freswater species were introduced by anthropogenically in Köprüçay Estuary. Most of the alien species appeared in low numbers and were mainly catched from upstream sites of estuary. The occurence of *Carassius gibelio* and *Gambusia holbrooki* in the mouth of estuary during this study, is due to the tolerance of fluctuating environmental conditions in this system.

Members of Mugilidae represented the highest biomass (44.6%) in Köprüçay Estuary. Of the five mugilid species captured during this study. *M. cephalus* and *L. aurata* were the most common. The dominance of Mugulids in the Köprüçay Estuary is typical of many estuaries worldwide (Koutrakis *et al*., 2000, Tzeng *et al,*, 2002). The dominance of various species of Mugilidae, especially the juveniles, suggests that this family of fish is able to exploit this habitat successfully. Mugilidae are in general, euryhaline and able to tolerate wide fluctuations in water temperature and salinity (Whitfield, 1998). Juveniles of *M. cephalus*, *L. aurata, Sparus aurata* were recorded in Köprüçay Estuary. This result suggests that Köprüçay estuary is utilized by marine species for nursery area. Estuaries enhance growth and survival of juvenile fish because they provide high food availability, low predation risk, warm water temperatures and protection from- adverse weather conditions (Abookire *et al*., 2000).

Species richness was higher during fall and spring-summer months than winter months. Similar results reported in previous studies (Spach *et al*., 2004; Akın *et al*., 2005; Prato, 2010). This study also shows considerable changes in diversity during the study period. The wide range (1.55 - 2.45) of Shannon-Wiener diversity index reflects the large numbers of species that use the lagoon on a seasonal basis. Seasonal change in the specific diversity was also observed in other studies of fish populations in the previous studies (Selleslagh and Amara, 2007; Shervette *et al*., 2007; Leung and Camargo, 2005; Barreiros *et al*., 2009).

Salinity was the most important parameter influencing the distribution of species between sites (Permutation tests and forward selection methods also showed that this variable was the most important variable) Spatial patterns in estuarine species assemblages are mainly correlated with salinity. The main effects of salinity seem to be in controlling the distribution of fish and in the attraction of larvae, post- larvae and juveniles into the estuaries (Elliott and Hemingway, 2002). Research on fish assemblages in estuaries has shown that salinity plays a major role in shaping assemblage structure (Wagner and Austin, 1999; Plavan *et al*., 2010; Marshall and Elliott, 1998, Neves *et al*., 2011).

5. Conclusion

This study showed that changes in salinity regime could influence the structure of fish assemblages in the Köprüçay River Estuary. It is inhabited by more than 23 fish species, some of which are very rare and previously unstudied. The fish assemblage was dominated by few species that varied in abundance and biomass. Due to antropogenic pressures such as tourism and fisheries, it is necessary to effectively to protect and monitor this important fish habitat.

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Figure 1. Water quality parameters of Köprüçay Estuary

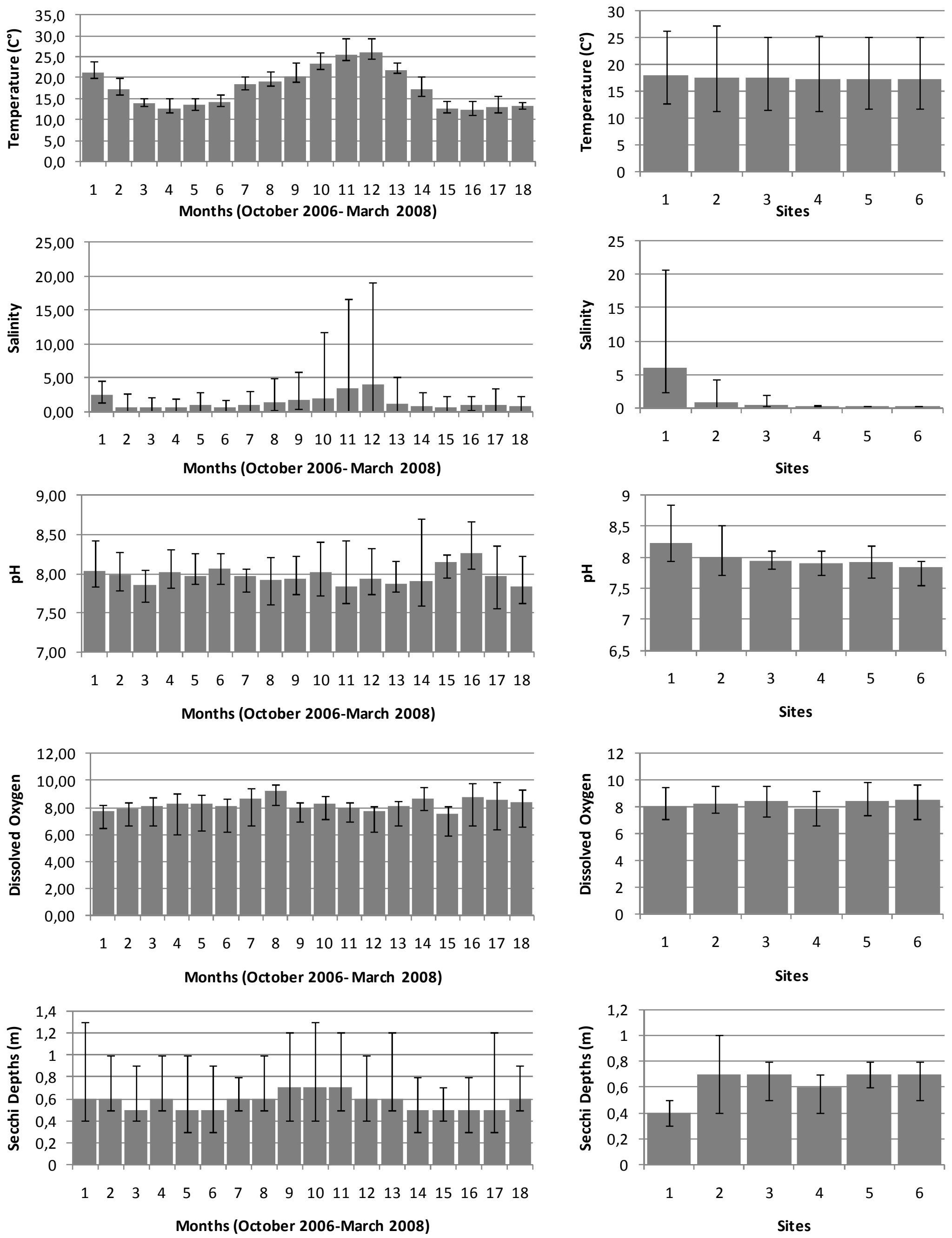

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Table 1. Fish species of Köprüçay Estuary

Species	Category			N	%	Occurence (%)	Biomass (kg)	Biomass%
	Origin	Habitat	Life cycles					
Mugil cephalus	1	2	1	796	32.91	100	116.83	29.11
Cyprinus carpio	1	1	2	274	11.33	94.44	63	15.7
Liza aurata	1	2	1	420	17.36	100	55.9	13.93
Anguilla anguilla	1	3	2	72	2.976	100	45.19	11.26
Dicentrarchus labrax	1	2	2	166	6.862	100	39.58	9.86
Clarias gariepinus	1	1	2	79	3.266	83.33	32.35	8.06
Vimba vimba	1	1	2	301	12.44	100	19.56	4.87
Capoeta antalyensis	1	1	2	126	5.209	100	16.31	4.06
Chelon labrosus	1	2	2	31	1.282	50	5.87	1.46
Umbrina cirrosa	1	2	2	8	0.331	22.22	1.65	0.41
Alosa fallax	1	3	2	25	1.033	22.22	1.48	0.37
Sparus aurata	1	2	1	15	0.62	27.78	0.85	0.21
Carassius gibelio	2	1	2	4	0.165	11.11	0.75	0.19
Oncorhynchus mykiss	2	1	2	3	0.124	5.56	0.44	0.11
Liza saliens	1	2	2	6	0.248	16.67	0.4	0.1
Carassius auratus	2	1	2	2	0.083	5.56	0.36	0.09
Salmo trutta macrostigma	1	1	2	2	0.083	5.56	0.28	0.07
Liza ramado	1	2	2	3	0.124	11.11	0.19	0.05
Carassius carassius	2	1	2	2	0.083	5.56	0.15	0.04
Atherina boyeri	1	4	1	8	0.331	11.11	0.12	0.03
Engraulis encrasicolus	1	2	2	7	0.289	11.11	0.06	0.02
Pseudorasbora parva	2	1	2	4	0.165	5.56	0.05	0.01
Gambusia holbrooki	2	1	1	65	2.687	27.78	0.03	0.01
Total				2419	100		401.4	100

Table captions; origin 1,2 (1-native; 2-alien); habitat 1,2,3,4 (1-freshwater; 2-marine; 3-migrant, 4- Estuarine); life cycles 1,2 (1-juvenile + adult individuals; 2- only adult individuals)

Table 2. Spatial variations of biomass, shannon and evenness index

Parameters	Sites					
	1	**2**	**3**	**4**	**5**	**6**
Number of Taxa	9	19	8	8	8	11
Number of Individuals	504	933	326	212	231	213
% of individuals	20.84	38.57	13.48	8.76	9.55	8.81
biomass	78.00	161.90	51.40	35.80	36.20	38.10
% of biomass	19.43	40.33	12.81	8.92	9.02	9.49
Shannon index	1.37	2.00	1.73	1.67	1.67	1.73
Evenness index	0.44	0.39	0.70	0.67	0.66	0.51

Table 3. Temporal variations of biomass, shannon and evenness index

Date	Number of Taxa	Number of Individuals	% of individuals	Biomass (kg)	% of Biomass	Shannon index	Evenness index
October.2006	12	159	6.57	24.90	6.20	2.00	0.62
November.2006	10	148	6.12	27.00	6.73	1.95	0.70
December.2006	9	104	4.30	20.20	5.03	1.90	0.74
January.2007	8	95	3.93	15.80	3.94	1.78	0.74
February.2007	8	81	3.35	12.50	3.11	1.80	0.76
March.2007	8	91	3.76	14.50	3.61	1.83	0.78
April.2007	16	133	5.50	20.80	5.18	2.45	0.73
May.2007	11	154	6.37	29.00	7.22	2.10	0.74
June.2007	14	184	7.61	30.70	7.65	2.16	0.62
July.2007	13	159	6.57	24.90	6.20	2.04	0.59
August.2007	13	184	7.61	31.20	7.77	1.84	0.48
September.2007	11	192	7.94	28.70	7.15	1.68	0.49
October.2007	10	191	7.90	27.00	6.73	1.88	0.65
November.2007	9	143	5.91	24.50	6.10	1.70	0.61
December.2007	7	114	4.71	18.10	4.51	1.55	0.68
January.2008	8	94	3.89	18.40	4.58	1.72	0.70
February.2008	7	93	3.84	15.10	3.76	1.57	0.68
March.2008	9	100	4.13	18.10	4.51	1.85	0.70

Fig. 2. Site and species scores in the CCA axes.