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The Effect of Disturbances to Habitat Quality on Otter (*Lutra lutra*) Activity in the River Kızılırmak (Turkey): a Case Study

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Abstract: Habitat restriction for otters living in a small part of the Kızılırmak River occurred due mainly to 3 causes: dam construction at the upper end, heavy pollution by oil refinery effluent at the lower end and man-made activities such as housing and angling in-between. Sprainting activity was measured to assess habitat use by otters within the area and differences were shown between the sites. Compared to site II, higher sprainting activity was found at the site below the dam (site I), where habitat quality was poorer, as indicated by the water quality index (BMWP), diversity indices (Simpson's and Shannon-Wiever) and riparian quality index (QBR). This was due to the relatively more stable standing water formed at the foot of the dam, offering sufficient food availability at this site throughout the year. A site further downstream (site II) had higher river water and riparian habitat quality but flow variations caused by dam operations led to the occurrence of less suitable food conditions for otters at various times of the year. The food items found in spraints from the 2 sites revealed that otters fed on more fish at site I. No spraints were found in the lowest part of the study area (site III), where heavy pollution occurred due to oil refinery discharge. Incorporation of the previously developed habitat quality indices into otter activity for habitat use was attempted in this study and these indices appeared to be promising tools for the establishment of management strategies for otters.

Key Words: Otter (*Lutra lutra*), sprainting activity, habitat quality, biotic index (BMWP), riparian quality index (QBR)

Kızılırmak (Kırıkkale, Türkiye) Nehrindeki Su Samuru (*Lutra lutra*) Aktivitesi Üzerine Habitat Kalitesindeki Bozuklukların Etkisi: Örnek Çalışma

Özet: Kızılırmak nehri üzerindeki küçük bir alanda yaşayan su samuru başlıca üç nedene bağlı habitat daralmasına maruz kalmıştır; araştırma bölgesinin üst kısmındaki baraj yapılanması, alt kısmındaki petrol rafineri atıklarından dolayı kirlenme ve bu iki bölge arasında yerleşim ve balıkçılık gibi faaliyetleri içeren insan aktiviteleri. Su samurunun dışkı aktivitesi, su samurunun bu bölgedeki habitat kullanım özelliğini tespit etmek üzere ölçülmüştür ve dışkı aktivitesi istasyonlar arasında farklılıklar göstermiştir. Su kalite biyotik indeksi (BMWP), biyoçeşitlilik indeksleri (Simpson's ve Shannon) ve doğal kıyı vejetasyonu indeksinin de (QBR) işaret ettiği üzere, daha düşük habitat kalitesi gösteren baraj seti çıkışındaki istasyon I'de (istasyon II ile karşılaştırıldığında) daha yüksek dışkı aktivitesi tespit edilmiştir. Bunun nedeni, baraj seti altında kalan bu bölgede yıl boyunca su samuruna yeterli besin bulunmasını sağlayacak daha sabit bir durgun su kütlesinin bulunmasıdır. Nehrin daha alt bölgesinde kalan istasyon (ist. II), daha yüksek nehir su kalitesi ve doğal nehir kıyı vejetasyonu kalitesine sahip olmasına rağmen, baraj suyunun salınması uygulamalarının neden olduğu akış değişiklikleri, yılın değişik zamanlarında daha az uygun olan besin şartlarının oluşumuna yol aşmıştır. Bu iki istasyondan toplanan dışkı örneklerindeki besin artıkları, su samurunun istasyon I'de daha fazla balıkla beslendiğini ortaya koymuştur. Çalışma bölgesinin en alt kısmına rastlayan petrol rafinerisi atıklarının bulunduğu bölgedeki istasyon III'de dışkıya rastlanmamıştır. Bu çalışmada, habitat kalite indeksleri, su samurunun habitat kullanımına dair aktivitesiyle ilişkilendirilmeye çalışılmıştır. Bu indeksler, su samuru için yönetim stratejilerinin geliştirilmesinde kullanılabilecek araçlar olarak gözükmektedir.

Anahtar Sözcükler: Su samuru (*Lutra lutra*), dışkı aktivitesi, habitat kalitesi, biyotik indeks (BMWP), doğal kıyı vejetasyon indeksi (QBR)

Introduction

Marked declines in otter (*Lutra lutra*) numbers worldwide have usually been associated with 2 main factors, habitat destruction and pollution (Maugh, 1975; Macdonald and Mason, 1983; Delibes et al., 1991; Laws, 1993; Mason 1998; Mason and Wren, 2001; Roos et al., 2001). Accidental mortality was also occasionally important, particularly for depleted populations (Green, 1991; Baker et al., 2004).

Amongst the other factors accounting for disturbances to otter populations, elevated levels of contaminants from discharges into rivers are of particular importance due to their easier access to water courses as a result of rapid urbanisation and industrial activities since

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the middle of the last century. Organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and heavy metals have been frequently stated to be the cause of the decline of otters in Europe (McDonald and Mason, 1994; Murk et al., 1998; Mason and Wren, 2001).

Habitat destruction induced by humans can occur in various ways. For example, a healthy habitat in pristine state could become poorer in quality due to the removal of riparian vegetation, where otters spend much of their time (Jefferies, 1989). Indirect effects of bankside and within-river management may also occur through the reduction of the food supply of otters, especially given the fact that fish is the major food item (Kruuk et al., 1993). Oscillations in river flow due to the building of dams or water abstraction for irrigation were also noted to have profound negative effects on otter distribution (Humborg et al., 1997).

Since the presence of the otter as one of the top predators indicates a healthy environment (Mcdonald and Duplaix, 1983), the conservation of otter populations might be extrapolated to the elimination of concerns about environmental issues in relation to the well-being of humankind. Understanding the relationship between the status of otter populations and environmental deterioration through man-made activities requires an understanding of the environmental biology of otters, including their distribution, feeding habits, and reproduction, if their conservation or restoration is intended (DEFRA, 2001).

In the IUCN Red List of threatened species the otter in Turkey could not be classified due to the lack of information (Foster-Turley et al., 1990). Up-to-date studies relating to its distribution and ecology in Turkey are insufficient in number (Albayrak, 2000) to guide the setting up of legislative measures and management programmes needed for the conservation of otters. In this study, therefore, the aim was to increase our understanding of the current status of the otter in a case study in the stretch of its habitat that included various types of disturbance, such as pollution, building of a dam and agriculture related intrusions.

Materials and Methods

A 5-6 km stretch along the River Kızılırmak was walked to measure sprainting activity between September 2000 and July 2002. Attention was paid to ensure that a total of 9 surveys were conducted to cover each season of the year so as to avoid bias from seasonality differences in sprainting activity. The time and number of surveys are given in Table 2. Other evidence such as footprints and sightings were also recorded with either photographs or video tape recordings but they are not given in this paper. Each spraint found was stored in a specimen tube, labelled and taken to the laboratory. Spraints were air dried at room temperature. Following the removal of mucus by soaking each spraint in a solution of the oxidising agent 'Steradent' (Webb, 1976), the spraints were washed through a sieve of 0.5 mm mesh and dried again. They were then gently broken up by hand and examined under a binocular microscope. All prey remains were assigned to 1 of 6 food categories: fish, amphibian, reptile, bird and unidentified prey. The remains in the spraints were identified by comparison with reference collections and the keys given by Webb (1976).

The study area was divided into 3 sections based on otter activity, including spraint distribution and nesting locations. Site I was selected as the area surrounding the nesting location of the first otter, extending 100 m below and 2.5 km above the nest, while site II included the nesting location of the second otter, located a further 2 km downstream from site I. Site III was 100 m downstream from site II, selected in an area affected by an oil refinery effluent outflow. Measurements and collected materials were evaluated for each site separately.

Habitat quality was assessed at the river and riparian sites using multimetric approaches.

Benthic invertebrates were sampled as closely as possible to sites where chemical and physical measurements for water were taken. The sampling at different sites took place at approximately the same time of the day. A Surber sampler, consisting of a net (250 mm) with a hinged frame, was used to collect the animals. The frame quadrat enclosing 0.09 m^2 was pushed onto the substratum and locked into place against the current flow. The stones and gravel within this area were then lifted and stirred so that invertebrates were dislodged into the net. Four replicates were collected from each site to obtain a representative sample. Samples stored in polyethylene bags in the field were sorted alive in the laboratory because moving animals were easier to see and extract from the accompanying debris. A small amount of material was sorted at a time, in a white tray under good illumination. Animals were removed and preserved in 90% alcohol in specimen tubes. The animals were then identified and counted under microscopy. Taxonomic resolution was made at family level. The identification of individuals was performed according to Macan (1970) and confirmed, using Fitter and Manual (1995) and Mellanby (1963) when needed.

Biological quality of the river water was assessed by an adaptation of the biotic index Biological Monitoring Working Party (BMWP) score. This index uses macroinvertebrate samples identified to family level only, and takes no account of their abundance. Each family is given a score, between 1 and 10, depending on their perceived susceptibility to pollution (Mason, 1991). Pollution-intolerant families have high scores and pollution-tolerant families low scores. A site score is obtained by summing the individual scores of the families present. Sites are then assigned to 1 of 5 classes of water quality (Armitage et al., 1983; Mason, 1991; Rico et al., 1992).

Of the several diversity indices, Simpson's Index (D), which proposes nonparametric measures of heterogeneity, and the Shannon-Wiever Index (H) were used in this study (Krebs, 1994). Simpson's Index takes into account both richness and equitability. This index makes no assumptions about the shape of abundance curves (Krebs, 1994). It varies between 0 and S (where S = number of species present);

$$D = 1/\Sigma P_i^2$$

where P is the proportion of total individuals in the ith taxon.

The Shannon-Wiever Index assumes that individuals are randomly sampled from an indefinitely large population:

$$H = \Sigma\, Pi \log Pi$$

where Pi is estimated from Ni/N as the proportion of the total population of N individuals belonging to the ith species (n_i).

The QBR index (Qualitat del Bosc de Riberia) was adapted to our sites for the assessment of riparian habitat quality. This index includes the calculation of scores for the riparian area, based on 4 components: total riparian vegetation cover, cover structure, cover quality and channel alterations. The summation of scores obtained from each part gives a final score between 0 and 100. The riparian quality of the site is then assigned to 1 of 5 classes according to this final score (Table 1) (Munné et al., 2003).

Results

Sprainting activity

Spraints were found around the 2 nesting locations of otters in an array of around 5 km stream order. The spraints found in the upper part of the first location indicated that otter activity extended to the mouth of the dam along a 2.5 km stretch. Spraints were also found in the lower part of the first location but up to a distance of about 100 m. Twenty spraints were collected at site I (2.5 km of upper and 100 m of lower part of first location). The number of spraints was lower in spring-summer surveys (April/May 2001 and July 2002) compared to those in colder months (September 2000, January, February 2002) (Table 2). At site II the sprainting activity was only upstream of the second otter location. The frequency of spraints was lower in spring and summer surveys, similar to site I. No spraints were found in the downstream stretch of the second location, probably due to the oil refinery effluent outflow situated just 100 m below this location. Site III, selected in this polluted area, did not have any spraints at all during the study period (Table 2).

Diet range

The dominant food of otters in the study area was fish, comprising 73% and 68% of the whole diet composition at sites I and II, respectively. A statistical comparison of the diet composition between sites I and II did not reveal any significant difference (t-test, $P > 0.05$). However, slight differences in the diet composition of otters between sites I and II were detected, the percentage of fish and amphibians being slightly higher at site I (Figure). The fish species found in the spraints belonged to the family Cyprinidae. The species *Cyprinus carpio* and *Tinca tinca* were the most numerous at the study site on the Kızılırmak River (personn. comm. with local fishermen).

River and riparian habitat quality

Site differences were detected in physico-chemical parameters measured during the study. Site I had lower mean values of temperature and dissolved oxygen and higher mean total dissolved solids (TDS) compared to site

Table 1. Quality classes according to the QBR index (Munné et al., 2003) and BMWP index (Armitage et al., 1983).

Quality class	QBR	Quality class	BMWP
Riparian habitat in natural condition	‡ 95	Very clean water	101-120
Some disturbance, good quality	75-90	Evidence of mild pollution effects	61-100
Disturbance important, fair quality	55-70	Polluted waters (altered system)	36-60
Strong alteration, poor quality	30-50	Very polluted waters (very altered system)	16-35
Extreme degradation, bad quality	† 25	Strongly polluted waters (strongly altered system)	< 15

Table 2. Total numbers of spraints recorded on selected sites along the Kızılırmak River on 9 occasions. The numbers in brackets denote the number of surveys conducted in the corresponding month.

Dates and number of surveys	Number of spraints		
	Station I	Station II	Station III
September (2) 2000	6	4	-
April (1) and May (2) 2001	4	3	-
January (1) and February (1) 2002	9	6	-
July (2) 2002	1	2	-

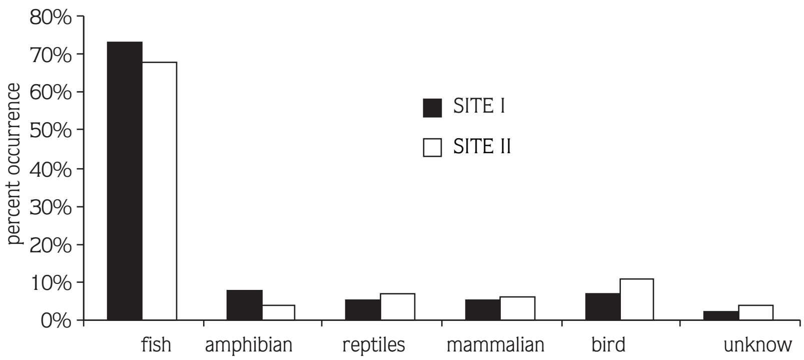

Figure. Percent occurrence of food items in otter spraints collected at stations I and II.

II. Markedly low pH values and high TDS and salinity values were detected at site III, clearly indicating the effect of effluent (Table 3).

The highest number of invertebrate families was found at site II (Table 4). This site also supported a considerable proportion of Gammaridae and, although lower in number, Agriidae. Site I was represented by a lower number of families, including families sensitive (Gammaridae) and moderately sensitive (Planaridae, Hydropsychidae) to pollution. The fauna of site III was restricted to pollution tolerant taxa, Tubificidae and Lumbriculidae. Site differences in terms of invertebrate fauna were also well expressed by the diversity indices and BMWP scores. Simpson's and Shannon-Wiever indices and BMWP score had the highest values at site II and were represented with relatively lower values at site I, whereas they differed considerably at site III, being markedly low (Table 4). River water quality at site I was assigned to "poor water quality", at site II to "very polluted waters" and at site III to "extremely poor community" based upon the BMWP scores of quality ranges (Tables 1 and 4).

Table 3. Average values and standard errors (n = 5) of physico-chemical variables measured on the selected sites along the Kızılırmak River.

	Station I	Station II	Station III
Water temperature (ºC)	15.63 ± 0.66	20.77 ± 2.85	20.70±2.89
Oxygen (mg/l)	10.72 ± 0.70	13.13 ± 2.67	7.41±0.47
Oxygen saturation (%)	113.67 ± 6.60	129.00 ± 6.38	83.00±6.16
pH	7.10 ± 0.08	7.49 ± 0.01	5.75 ± 0.12
Salinity (mg/l)	0.80 ± 0.00	0.80 ± 0.00	1.33 ± 0.05
Total dissolved solids (mg/l)	1119.33 ± 13.52	770.00 ± 32.25	2151.00 ± 93.73
River flow velocity (cm/s)	12.00 ± 0.82	18.67 ± 2.05	14.56 ± 2.05

Table 4. BMWP scores calculated using invertebrate family tolerance scores, the diversity indices calculated using the number of counted individuals of each family and the QBR index values calculated at each station.

Family name	Number of individuals			Family Tolerance Score		
	Station I	Station II	Station III	Station I	Station II	Station III
Gammaridae	24	36		6	6	-
Hydropsychidae	2	5		5	5	-
Baetidae	-	1		-	4	-
Tipulidae	-	1		-	5	-
Chironomidae	10	18		2	2	-
Sphaeriidae	26	23		3	3	-
Glossiphonidae	-	3		-	3	-
Planorbidae	-	2		-	3	-
Planaridae	3	5		5	5	-
Agriidae	-	1		-	8	-
Tubificidae	-	-	69	-	-	-
Lumbriculidae	-	-	4	-	-	1
Total	65	95	73		-	1
Simpson’s index	3.095	4.074	1.115			
Shannon-Wiever index	0.55	0.725	0.092			
BMWP score				21	44	2
QBR index				35	55	20

According to QBR index values calculated for riparian habitat quality, site I (QBR value: 35) was classified as “strong alteration, poor quality”, site II (QBR value: 55) indicated “disturbance, fair quality” and site III (QBR value: 20) was assigned to “extreme degradation, bad quality” (Tables 1 and 4).

Discussion

Spraints are frequently used to monitor otter populations indirectly. Although the validity of using spraints has been debated on some occasions (Kruuk and Conroy, 1987; Mason and Macdonald, 1993; Strachan and Jefferies, 1996), some behavioural features of otters, such as being secretive and largely nocturnal (as well as thinly distributed), make spraints a better predictor for assessing their presence and habitat preferences (Delibes et al., 1991; Hutchings and White, 2000). Other methods, which include the examination of fur-harvest data from commercial trappers, interviews with local residents, recording of footprints and sightings and application of mark-recapture techniques or radiotransmitters, are either relatively unreliable or impractical (White et al., 2003).

In our study, following the discovery of 2 individual otters on the River Kızılırmak, several methods including diurnal observations, recording by video camera, interviews with local residents, assessment of footprints and collection of spraints were applied to monitor and thus find out their current status. Spraints were most useful for deriving some information about their life history related to the habitat with the surrounding terrestrial environment.

Although the presence of otters at the upper part of the Kızılırmak River was stated in an observational study by Albayrak et al. (1997), this was 250 km from our study area. Since no historical data about the existence of this otter population were found in our study area, and since the habitat in which they live at this part of the Kızılırmak River seems to have been isolated from the upper part by a chain of 3 dams, the past history of this population and the relation to other populations along the Kızılırmak River remain unclear. Further, the results on sprainting activity showed that otters in our study were forced to live in a habitat only 5 km long with 2 barriers, the dam at the upper end and severe pollution from the oil refinery at the lower end. Intense human activities (i.e. housing, horticulture, fishing and recreational activities) also exert constraints on the otters, even within the scope of the habitat studied. However, otters were known to have quite broad habitat tolerances, allowing them to survive in a wide variety of habitats ranging from forests to moorland and agricultural and even housing and industrial areas (Kruuk, 1995).

The pattern of sprainting activity showed some variations and this was in accordance with the differences detected within the study area. Habitat quality indices and diversity indices indicated a poorer quality of both river water and riparian area at site I than at in site II. The poorer river water quality at site I was probably due to the water released from a bottom outlet of the dam. Different physical, chemical and biological variables in the downstream river are affected by the upstream reservoir in various ways. The effects of the dam are more pronounced immediately below the dam compared to further downstream, due to rapid changes in the river. Decreases in oxygen and pH and increases in nutrients, dissolved and particulate organic matter were often reported in the river water below outlets (Straskraba et al., 1993; Straskraba and Tundisi, 1999). Water quality variables, including lower pH, oxygen and flow velocity, and higher TDS concentrations at site I compared to at site II were in agreement with the general pattern found in the literature (Table 3). The diversity indices and biotic index also supported the view that the river quality at site I was lower than that at site II. The poorer riparian habitat quality at site I, however, could be attributed more to human disturbances than to the direct influence of the dam. At this site, human activities such as housing and horticulture applications and recreative intrusions by anglers were much more intensive due to the site offering an attractive physical environment. However, the number of spraints at site I was always higher than that at site II, except for in July 2002. This might be associated with food availability because the spraints at site I were found more frequently around the stony area of the river, where the reservoir outflow formed a relatively deeper and wider water column kept in the bed the whole year. Compared to downstream sites, which experienced flow oscillations leading to complete drying up or very low water density incapable of supporting fish populations at certain times of the year, this site seemed to be more suitable for otters because of the uninterrupted opportunity for feeding activity throughout the year. Fish, being the major food item for otters, were found to be at a higher percentage in spraints obtained from site I and this also supported the idea that site I was more suitable in terms of availabity of food for otters. Kruuk et al. (1993) found a correlation between otters' use of streams and fish density. Sjoåsen (1997) also showed that the presence of otters was associated with lakes and rivers with high fish biomass production. White et al. (2003) similarly concluded that there was a very significant positive correlation between otter sprainting and trout density but the association was unimodal, first increasing with the trout density and then decreasing with higher trout density. The researchers stated that the sites with the highest trout density were important angling ones and thus human disturbances were discouraging otters from inhabiting these sites. Numerous studies have suggested that low levels of human disturbance and riparian cover were of less importance to otter habitat use than was prey abundance (Prenda and Granado-Lorencio, 1996; Kranz and Toman, 2000; Madsen and Prang, 2001). Copp and Roche (2003) stated that quarrying and angling activities in the vicinity of Amwell Nature Reserve (England), where otters were introduced to help recovery, did not deter the otters.

Despite a higher quality of habitat characteristics in both river water and riparian areas at site II, otters were more active at site I, as indicated by the spraints in our study area. The existence of dens or resting places at each unpolluted site and the different sprainting activities between these sites might be attributed to the behavioural plasticity that otters utilise in an already strained habitat to gain maximum benefits for survival. Low water flow at the lower reaches of the river (site II) resulting from the effect of the dam could therefore be an unsuitable condition at certain times of the year, while the standing water at the mouth of the dam and the available fish in it (site I) might be attractive throughout the year (Jiménez and Lacomba, 1991).

Site III was heavily polluted by the effluent from an oil refinery. Although the discharges and the river water could not be analysed for waste products, both the river bed and surrounding bankside for about 150 m downstream were black, with a heavy smell of oil, indicating an obvious severe damage to this site. Water quality variables, including very low pH and high TDS and salinity, were also distinctive evidence of such pollution. Furthermore, the diversity indices and river water and riparian habitat quality scores were markedly low. These results were concordant with the absence of spraints at this site, and suggested that otters might not be able to live permanently in such acidified conditions (Mason and Macdonald, 1987; Mason, 1995).

Habitat cover is known to be an essential element for otters but the aspects of the cover and its minimum requirements are as yet unknown (Mason, 1995). In the literature, specific elements of the bankside cover were utilised for the assessment of the relationship between otter activity and habitat cover. For example, a high otter activity was associated with cover of *Phragmites* on irrigation channels and *Salix* and *Rubus* on rivers in uplands (Macdonald and Mason, 1985). Mason (1995) found that there were significant correlations between the number of otter signs and the density of mature *Fraxinus excelsior* and *Acer pseudoplatanus* trees and the number of potential holts. A similar approach was used in some other studies in different countries, i.e. Scotland (Jenkins and Burrows, 1980; Bas et al., 1984), England (Macdonald and Mason, 1988), Spain (Adrian et al., 1985; Delibes et al., 1991), Germany (Prauser, 1985) and Greece (Macdonald and Mason, 1985). In our study, to evaluate the existing relationship between sprainting activity and habitat quality another approach was used. Some metrics such as BMWP and QBR (Armitage et al., 1983; Munné et al., 2003) developed for habitat quality assessments specific to some countries (England and Spain, respectively) were derived to incorporate sprainting activity. Although the results showed that these metrics might be indicative of the relationship between the 2 parameters mentioned above, some generalisations concerning their validity for the use of these methods could only be made following further applications in areas with a wider coverage of distribution.

Conclusion and Implications for Conservation

Several researchers (Turan, 1984; Albayrak, 2000) have stated that the otter has a wide distribution in Turkey, particularly in most rivers and lakes around the Black Sea and in some rivers draining into the Aegean Sea. However, this was largely based on sightings during small scale surveys or on accounts given by local residents. Therefore, as stated earlier by the otter specialist group of IUCN/SSC (Foster-Turley et al., 1990), a full field survey of this country with its many important wetlands is still urgently required today to give priority to otter conservation. Our study has reported the presence of otters in central Anatolia and may be considered to have made a contribution to information about the otter distribution in Turkey. Emphasis has also been placed on the habitat use of otters in relation to threats such as oil pollution, dam construction and human activities involving horticulture and recreation. It was clearly observed that heavy pollution formed a barrier to otter activity at the downstream site of the Kızılırmak River within the study area. The otter showed behavioural plasticity along the unpolluted sites. The site with better riparian and river water quality was used for resting while the site with more disturbances (i.e. angling, horticulture, housing) was visited more by otters mainly because fish, as the main food item for otters, was available throughout the year (Macdonald and Mason, 1982).

The otter is known to occupy freshwater habitats with characteristics necessary for its survival, such as food and available shelter (Ruiz-Olmo et al., 2002). A worldwide feature of the dramatic decline in otter populations has generally been the disturbance of their habitat by various causes, mainly habitat destruction and pollution. Turkey should be no exception to this because rapid industrialisation and urbanisation have been undertaken in the last 2 decades with no controlling measures due to the priority being given to economic development. A nationwide strategy for the conservation of otters is therefore needed to save them from the fate of those in most of western Europe.

References

Adrian, M.I., Wilden, W. and Delibes, M. 1985. Otter distribution and agriculture in southwestern Spain. 17th Congr. Int. Un. Game Biologists, Brussels, September, 17-21.

Albayrak, İ. 2000. Contribution to the understanding of otter distribution in Turkey. (in Turkish), special issue for otter, Tabiat ve İnsan Dergisi 34: 3-7.

Albayrak, İ., Pamukoğlu, N. and Aşan, N. 1997. The status of otter in Turkey. (in Turkish). Tabiat ve İnsan Dergisi 31: 10-11.

Armitage, P.D., Moss, D., Wright, J.F. and Furse, M.T. 1983. The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. Water Research 17: 333-347.

Baker, P.J., Harris, S., Robertson, C.P.J., Saunders, G. and White, P.C.L. 2004. Is it possible to monitor mammal population changes from counts of road traffic casualties? An analysis using Bristol's red foxes *Vulpes vulpes* as an example. Mammal Review 34: 115-130.

Bas, N., Jenkins, D. and Rothery, P. 1984. Ecology of otters in northern Scotland, V. The distribution of otter *Lutra lutra* faeces in relation to bankside vegetation on the river Dee in summer 1981. J. Appl. Ecol. 21: 507-513.

Copp, G.H. and Roche, K. 2003. Range and diet of Eurosian otters *Lutra lutra* (L.) in the catchment of the River Lee (south-east England) since re-introduction. Aquatic Conserv: Mar. Freshw. Ecosyst. 13: 65-76.

DEFRA. 2001. Science in action for biodiversity–A report of the biodiversity research working group 1998-2001. Department of Environment, Food and Rural Affairs, PB 6035, London.

Delibes, M., Macdonald, S.M. and Mason, C.F. 1991. Seasonal marking, habitat and organochlorine contamination in otters (*Lutra lutra*): a comparison between catchments in Andalucia and Wales. Mammalia 55: 567-578.

Fitter, R. and Manual, R. 1995. Lakes, rivers, streams and ponds of Britain and North West Europe. Harper Collins Publishers, London.

Foster-Turley, P., Macdonald, S. and Mason, C.F. 1990. Otters–An action plan for their conservation. In: International Union for Conservation of Nature and Natural Resources (Eds. IUCN/SSC Specialist Group). p. 62. An IUCN Publication, c/o Chicago Zoological Society, Brookfield, Illinois, USA.

Green, R. 1991. The impact of hunting, poaching and accidents on otter survival and measures to protect individual animals. In: Proceedings V. International Otter Colloquium Hankensbüttel 1989 (Eds., Reuther C., Röchert, R.). Habitat 6: 171-190.

Humborg, C., Ittekkot, V., Cociasu, A. and Bodungen, v.B. 1997. Effect of Danube river dam on Black Sea biogeochemistry and ecosysytem structure. Nature 386: 385-388.

Hutchings, M.R. and White, P.C.L. 2000. Mustelid scent-marking in managed ecosystems: implications for population management. Mammal Review 30: 157-169.

Jefferies, D.J. 1989. The changing otter population of Britain 1700-1989. Biol. J. Linnean Society 38: 61-69.

Jenkins, D. and Burrows, G.O. 1980. Ecology of otters in northern Scotland I. Otter (*Lutra lutra*) breeding and dispersion in mid-Deeside, Aberdeenshire in 1974-1979. Journal of Animal Ecology 49: 713-735.

Jiménez, J. and Lacomba, J. 1991. The influence of water demands on otter (*Lutra lutra*) distribution in Mediterranean Spain. In: Proc. Vth Int. Otter Colloqu. (Eds., Reuther, C., Rochert, R.). Habitat 6: 249-259.

Kranz, A. and Toman, A. 2000. Otters recovering in man-made habitats in central Europe. In: Mustelids in a modern world-management and conservation aspects of small carnivore: human interactions, (Ed., Griffiths, W.I.) Backhuys Publishers, Leiden 163-183.

Krebs, C.J. 1994. Ecological methodology. 2nd edition. Benjamin Cummings, Menlo Park, California.

Kruuk, H. 1995. Wild otters: Predation and populations. Oxford University Press, Oxford.

Kruuk, H., Carrs, D.N., Conroy, J.W.H. and Durbin, L. 1993. Otter *Lutra lutra* numbers and fish productivity in rivers of North East Scotland. Symposium of Zoological Society of London 65: 9-13.

Kruuk, H. and Conroy, J.W.H. 1996. Concentrations of some organochlorines in otters (*Lutra lutra* L.) in Scotland: implications for populations. Environ. Pollut. 96: 13-18.

Laws, E.A. 1993. Aquatic pollution: an introductory text, 2nd edition. John Wiley and Sons, Inc., New York.

Macan, T.T. 1970. A Guide to freshwater invertebrate animals. Longman, London.

Macdonald, S.M. and Duplaix, N. 1983. The otter, symbol of our threatened fauna. Naturopa 45: 14-19.

Macdonald, S.M. and Mason, C.F. 1982. The otter in central Portugal. Biological Conservation 22: 207-215.

Macdonald, S.M. and Mason, C.F. 1983. Some factors influencing the distribution of *Lutra lutra*. Mammal Review 13: 1-10.

Macdonald, S.M. and Mason, C.F. 1985. Otters, their habitat and conservation in Northeast Greece. Biological Conservation 31: 191-210.

Macdonald, S.M. and Mason, C.F. 1988. Observations on an otter population in decline. Acta Theriologica 33: 415-434.

Macdonald, S.M. and Mason, C.F. 1994. Status and conservation needs of the otter (*Lutra lutra*) in the Western Palaearctic. Council of Europe, Strasbourg, France.

Madsen, A.B. and Prang, A. 2001. Habitat factors and the presence or absence of otters *Lutra lutra* in Denmark. Acta Theriologica 46: 171-179.

Mason, C. F. 1995. Habitat quality, water quality and otter distribution. Proc. II It. Symp. on Carnivores. Hystrix 7 (1-2): 195-207.

Mason, C.F. 1991. Biology of freshwater pollution. 2nd ed. John Wiley and Sons, Inc., New York.

Mason, C.F. 1998. Decline in PCB levels in otter (*Lutra lutra*). Chemosphere 36: 1969-1971.

Mason, C.F. and Macdonald, S.M. 1987. Acidification and otter (*Lutra lutra*) distribution on a British river. Mammalia 51: 81-87.

Mason, C.F. and Macdonald, S.M. 1993. PCB and organochlorine pesticide residues in otter (*Lutra lutra*) spraints from Welsh catchments and their significance to otter conservation strategies. Aquat. Conserv. 3: 43-51.

Mason, C.F. and Wren, C.D. 2001. Carnivora. In: Ecotoxicology of wild mammals. (Eds., Shore, R.F., Rattner, B.A.). John Wiley and Sons, Chichester, pp. 315-370.

Maugh, T. H. 1975. Polychlorinated biphenyls: still prevalent, but less of a problem. Science: 178, 388.

Mellanby, H. 1963. Animal life in freshwaters. Chapmann and Hall Ltd.

Munné, A., Prat, N., Solà, C., Bonada, N. and Rieradevall, M. 2003. A simple field method for assessing the ecological quality of riparian habitat in rivers and streams: QBR index. Aquatic Conserv: Marine and Freshwater Ecosystems 13: 147–163.

Murk, A.J., Leonards, P.E.G., van Hattum, B., Luit, R., van der Weiden, M.E.J. and Smit, M. 1998. Application of biomarkers for exposure and effect of polyhalogenated aromatic hydrocarbons in naturally exposed European otters *(Lutra lutra)*. Environ. Toxicol. Pharmacol. 6: 91-102.

Prauser, N. 1985. Vorkommen von Fischottern (*Lutra lutra* L. 1758) und ihre Abhangigkeit von der Struktur verschiedener Habitat-Zonen der Wumme-Niederung. Z. Ang. Zool. 72: 83-91.

Prenda, J. and Granado-Lorencio, C. 1996. The relative influence of riparian habitat structure and fish availability on otter *Lutra lutra* L., sprainting activity in a small Mediterranean catchment. Biological Conservation 76: 9-15.

Rico, E., Rallo, A., Sevillano, M.A. and Arretxe, M.L. 1992. Comparison of several biotic indices based on river macroinvertebrate benthic community for assessment of running water quality. Annls. Limnol. 28(2): 147-156.

Roos, A., Greyerz, E., Olsson, M. and Sandegren, F. 2001. The otter (*Lutra lutra*) in Sweden- population trends in relation to ΣDDT and total PCB concentrations during 1968-99. Environmental Pollution 111: 457-469.

Ruiz-Olmo, J., Lafontaine, L., Prignioni, C., López-Martin, J.M. and Santos-Reis, M. 2002. Pollution and its effects on otter populations in South-Western Europe. In: Proceedings of the First Otter Toxicology Conference. (Eds., Conroy, C.V.H., Yoxon, P., Gutleb, A.C.). International Otter Survival Fund, Broadford, Scotland, pp. 63-82.

Sjoåsen, T. 1997. Movements and establishments of reintroduced European otters *Lutra lutra*. Journal of Applied Ecology 34: 1070.

Strachan, R. and Jefferies, D.J. 1996. Otter survey of England 1991-1994. The Vincent Wildlife Trust, London.

Straškraba, M. and Tundisi, J.G. 1999. Guidelines of lake management. Volume 9, Reservoir water quality management. International Lake Environment Committee Foundation, pp.1-224, Japan.

Straškraba, M., Tundisi, J.G. and Duncan, A. 1993. Comparative Reservoir Limnology and Water Quality Management. -291 pp., Kluwer Academic Publishers, Netherlands.

Webb, J.B. 1976. Otter spraint analysis. Mammal Society Publication, London.

White, P.C.L., McClean, C.J. and Woodroffe, G.L. 2003. Factors affecting the success of an otter (*Lutra lutra*) reinforcement programme, as identified by post-translocation monitoring. Biological Conservation 112: 363-371.