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Caption: *Cyrtodactylus myintkyawthurai*, endemic to Myanmar. Medium: Water colours on watercolor sheet. © Aakanksha Komanduri



Population, distribution and diet composition of Smooth-coated Otter *Lutrogale perspicillata* Geoffroy, 1826 in Hosur and Dharmapuri Forest Divisions, India

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Abstract: Living in different aquatic ecosystems, otters play a vital role in maintaining aquatic species assemblages, particularly fish communities. Thus their wellbeing indicates the health of wetland ecosystems. Smooth-coated Otter *Lutrogale perspicillata*, a piscivorous mustelid, is widely distributed across Asia. Its population is declining due to habitat transformation, pollution and hunting. This study aimed to understand the ecological requirements of the species by assessing its distribution and its determinants, population and diet composition along the Cauvery River in Hosur and Dharmapuri Forest Divisions. Through monthly extensive surveys between December 2010 and February 2011, covering 62.5 km of Cauvery from the Karnataka border to Palar River junction, this study identified and mapped a 31 km stretch from Dubguli (Yellolapatti) to Biligundlu (Musulumaduvu) as an otter distribution area. Comparison of ecological parameters including bank type, water depth, river width, human disturbance, vegetation cover and water current with the distribution pattern of otters across 125 blocks revealed that water depth and vegetation cover influenced otter distribution positively, while human disturbance had negative influence (these three variables explained 54% of variation in otter distribution). Based on direct sightings, seven different groups consisting of 36 individuals were estimated as the minimum population. The mean group size was 3.8 ± 0.16 (range: 2–7) individuals. Twenty-one otter spraints were analyzed to determine diet composition, revealing that otters feed on insects, molluscs, crabs, fish, frogs, reptiles and birds. Fish constituted the bulk of otter diets. Conservation measures like reducing anthropogenic pressures (e.g., fishing, cattle pens, tourism), increasing awareness of sustainable fishing to stakeholders, and instituting long-term monitoring programs are suggested for the long-term conservation of otters in the study area.

Keywords: Carnivora, Cauvery River, determinants, diet, group size, Hosur and Dharmapuri Forest Divisions, Mustelidae, population, water depth influence.

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INTRODUCTION

Otters are piscivorous mustelids belonging to the family Mustelidae and subfamily Lutrinae. Of the five species of otters found in Asia, three occur in India: the Smooth-coated Otter *Lutrogale perspicillata* (Image 1), the Eurasian Otter *Lutra lutra*, and the Oriental Small-clawed Otter *Aonyx cinerea* (Hussain 1993; Prater 1998; Reuther 1999; Menon 2003; Raha & Hussain 2016). The Smooth-coated Otter is distributed widely throughout India south of the Himalaya (Pocock 1949; Prater 1971; Hussain 1993) and also in Myanmar, Indonesia, Kampuchea, Laos, Malaysia, Vietnam, southwestern China, and Brunei, with an isolated subspecies, *L. perspicillata maxwelli*, found in the marshes of southern Iraq (Mason & Macdonald 1986).

Living in different aquatic ecosystems (Pardini 1998), otters play a major role in maintaining aquatic species communities, particularly fish communities (Sivasothi 1995; Anoop & Hussain 2005). They are health indicators of wetland ecosystems, being sensitive to degradation of habitat and the food chain (Erlinge 1972). Loss of wetlands habitat, reduction in prey species, disturbances from developmental projects and poaching are the major threats to otter survival in India (Nagulu et al. 1999a,b; Meena 2002). The Smooth-coated Otter is presently listed as a 'Vulnerable' species on the IUCN Red List (de Silva et al. 2015), Appendix I in CITES (CoP 2019) and is protected under Schedule II in Indian Wildlife (Protection) Act (1972). Despite their wide distribution and vital role in the wetland ecosystem, not much attention has been paid to understand their ecology. The existing populations of the species and their habitat have never been systematically surveyed throughout India (Hussain & Choudhury 1997). Systematic data on their habitat, distribution, population, and feeding ecology are essential for conservation planning and management of the species in India.

In southern India, the species has been studied in Periyar Tiger Reserve, Kerala (Anoop 2001; Anoop & Hussain 2005) and in the Cauvery River in Karnataka (Shenoy 2005; Shenoy et al. 2006), in particular the Cauvery Wildlife Sanctuary. This study aimed to cover the entire range of the species in Cauvery River to evaluate the current distribution, population, group size, and diet.

Study Area

The study was carried out along the Cauvery River within Hosur and Dharmapuri Forest Divisions, stretching from Ichiebara (12.198 N, 77.593 E) to the junction of



Image 1. Smooth Coated Otter *Lutrogale perspicillata*

Palar (11.953 N, 77.676 E), a tributary of the Cauvery (Image 2) between December 2010 and August 2011. The river stretches over 62 km and varies in altitude from 307 m upstream to 236 m downstream. Cauvery is a major perennial river, the eighth largest river of the subcontinent and ranks as a medium river on the global scale (Jayaram 2000). It provides water to most areas in Karnataka and Tamil Nadu states. The Cauvery originates at Talakaveri (12.198 N, 77.593 E) in Kodagu district of Karnataka in the Western Ghats at an altitude of 1,341 m. From the edge of the Western Ghats, within sight of the Arabian Sea, to the Bay of Bengal, the river traverses through nearly 770 km in a roughly north-west to south-east direction. It passes through the Western Ghats, the Deccan Plateau and the Eastern Ghats, crossing diverse habitats ranging from high altitude shola forests to the dry scrub jungles of the plains (Jayaram 2000). It has 29 major tributaries and its basin receives rainfall from the south-west and north-east monsoons with a major share from south-west monsoon. The river basin in the study area provides natural habitat to a diverse highly threatened mammalian species. The riparian habitat offers an important habitat to the Smooth-coated Otter (Baskaran et al. 2010). The river basin and its adjoining areas in Hosur-Dharmapuri Forest Divisions are subject to severe anthropogenic pressure in terms of cattle grazing, MFP collection, fishing, tourism, and pilgrimage.

MATERIALS AND METHODS

Mapping of otter habitats

To map the distribution of otter and its habitats, the 62.5 km of the Cauvery River falling within the study area was marked into 125 survey blocks of 500 m and surveyed by foot on a monthly basis from

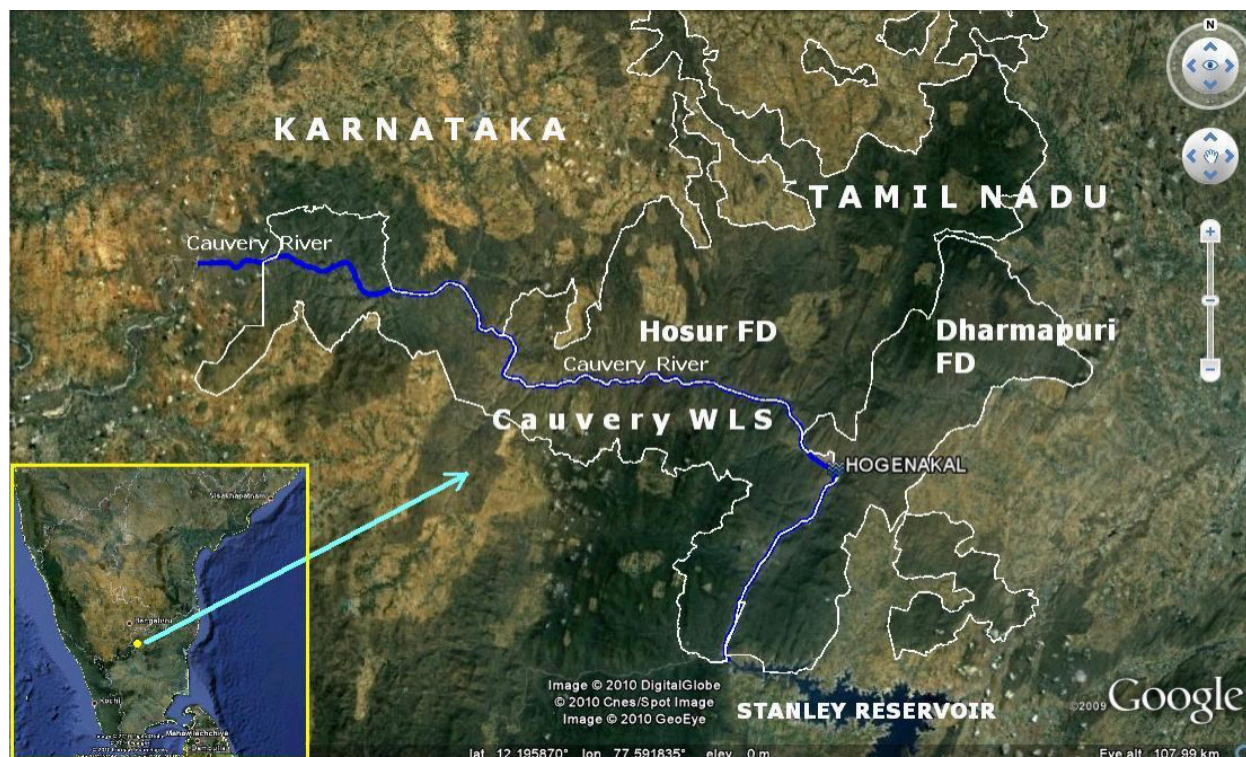


Image 2. Map showing the study area Cauvery River along Hosur-Dharmapuri Forest Divisions in Tamil Nadu with adjoining forest division the Cauvery Wildlife Sanctuary in Karnataka.

December 2010 to February 2011. During each survey, the presence or absence of otters based on direct sightings and indirect evidence was recorded in each block. All approachable islands within the river were also surveyed. The indirect evidences considered for their presence include spraints (fecal matter), tracks, holts, food remains, and scrapes (Ottino & Giller 2004). Spraints were categorized according to consistency and degree of bleaching, they were considered fresh when found with moisture and strong odour, old when intact but without moisture and odour, and very old if disintegrated without moisture and odour. The tracks, holts and food remains were divided into three different categories based on moisture, appearance (disturbed/undisturbed), condition in case of food remains (fresh/old/very old) and when found with spraints their status was taken into account for categorization. At every sighting of otters and their evidence, the geographical location (latitude and longitude) and the survey block number were noted down using a global positioning system (GPS). Superimposing the otter location geocoordinate into Google Earth map, we established the otter distribution map.

Assessment of factors influencing distribution

Studies on otters (Hussain & Chodhury 1997; Ottino & Giller 2004; Anoop & Hussain 2005; Shenoy et al. 2006) show that variables such as river bank type (earthen, sandy, and rocky) river width, water depth, water current (low and high), vegetation density and human disturbance influence the distribution pattern of otters. The human disturbance was rated as low for areas with infrequent disturbance by local people due to fuel wood and MFP collection, bathing and cattle grazing, medium for areas with frequent disturbance by local people due to fuel wood, MFP collection, self-fishing, fire for cooking, bathing, cattle grazing and eco-tourism, and high for areas with regular disturbance by local people due to fuel wood collection, self/commercial fishing, MFP collection, bathing, cattle grazing and cattle pen, tourism including seasonal pilgrimage, fire for cooking, and discarded food. These variables were evaluated at each 500-m interval in the survey blocks. At each survey block, the river width, water depth and water current were evaluated at three to five locations and averaged for each block. Within each survey block, vegetation density was assessed at 100-m intervals, placing a 20 m² quadrat for trees, 5 m² quadrat shrubs, and 1 m² quadrat for grass species and averaged for each block.

The difference in otter abundance observed among (like river bank type: earthen, sandy, rocky) and between categories in different variables (like water current: low and high) were tested for statistical significance, respectively, employing, Kruskal-Wallis H test and Mann-Whitney U-test in SPSS Version 16.0.

The influence of ecological factors on the distribution of otters was explored using multiple regression analysis after testing for normality. In the multiple regression framework, the dependent variable was the otter abundance, arrived based on both direct sighting of otter and their indirect evidences, while the independent variables were the river bank type (earthen, sandy, and rocky), river width, water depth, water current, vegetation density and human disturbance. At first the relationship between the dependent variable and independent variables were tested using scatter plots. Based on the relationship of independent variables, the variable was entered either in linear form or non-linear form with quadratic term. When the relationship was quadratic, both independent variable and its square term were entered into the multiple regression models. If the quadratic term turned out to be insignificant, it was dropped. At the end, only significant independent variables were retained in the equation.

Evaluation of population and group size

Although the presence or absence of otters could be assessed through direct sighting of otters and their evidence, no simple foolproof method is available for censusing river otters (Melquist & Dronkert 1987). A number of factors influence marking intensity and hence this measure cannot be used as a direct indicator of population size (Jefferies 1966; Krqsuuk & Conroy 1987). The Smooth-coated Otter lives in social groups that vary in size and change with seasons (Hussain 1996; Anoop & Hussain 2005). The population size was estimated based on the spatial distribution of various groups, differentiated based on group size and their movement pattern observed during the study period. In total, seven different groups were differentiated based on group size and movement pattern and the total number of individuals recorded within each group was taken into account to estimate the population size in the study area. Data on group size were recorded on each sighting of the identified groups. Mean group size was estimated for the seven groups we identified by averaging the groups size recorded in the multiple sightings of the respective groups. Similarly, the mean group size for overall population was arrived averaging the group size of all the seven groups.

DIET COMPOSITION

Spraint collection: To study the diet composition of Smooth-coater Otters, spraint analysis was used following Anoop & Hussain (2005), as direct observation was not possible due to anthropogenic disturbance. Spraints of the otter were collected visiting the riparian habitat on fortnight interval. Spraints were collected in self-lock polythene covers and labeled with different variables such as status of the spraint, microhabitat, date, and location. The collected samples were air-dried at room temperature and stored separately for laboratory analysis.

Reference sample of fish collection: To identify the fish species from the spraint, a checklist of fish presents in the Cauvery River was prepared. Different fish species were caught from each survey block-using a gas net. The fish species were identified using standard reference books (Jayaram 1994) with the help of experts from the Indian Institute of Science, Bengaluru. From each species, a set of scales were collected and permanent reference slides prepared by mounting with a drop of glycerin and seal with adhesive.

Spraint analysis: The air-dried spraints were weighed to nearest 0.01 g using a physical balance. From each spraint, mucus was removed soaking it in a solution of oxidizing agent (Webb 1976). The spraint was washed with a sieve of 0.5 mm mesh and dried again. All prey remains were segregated under a binocular microscope, assigned to food categories and weighed. Species level identification of the fish were done using reference slides. Other species like insects, mussels, crabs, amphibians, reptiles, and birds were broadly segregated into order level using feathers, teeth and other bones, insect remains, shells, etc. The buff white colour of the bone was used to identify the frogs eaten by otters, while in the case of crab and mussel, general shape, colour and shape exoskeleton were used as key (Anoop & Hussain 2005). The segregated food categories were air-dried and weighed using a physical balance.

Data are presented for each food category using three different methods: (i) Percent frequency $F = \frac{\text{number of spraints containing a given prey category}}{\text{total number of spraints}} \times 100$ (Jenkins et al. 1979), (ii) Relative percentage frequency $R = \frac{\text{number of occurrences of a food category}}{\text{total number of occurrences of all prey categories}} \times 100$ (Rowe-Rowe 1977), and (iii) Dry weight $Dw = \frac{\text{dry weight of a given food category}}{\text{total dry weight of all prey categories}} \times 100$.

RESULTS

Distribution

58 direct sightings and 31 indirect indications were recorded across 125 survey blocks in the Cauvery River. Direct sightings and indirect evidence showed that otter distribution was restricted to the stretch from Dubguli (Yellolapatti) to Biligundlu (Musulumaduvu) downstream (Image 3). The total length of this stretch is 31 km within this study area, no sighting or evidence of otters was found between Anchetty stream to Uganium (around 6 km). Further, there was no direct sighting or indirect evidence of otters in the rest of 31.5 km from Musulumaduvu to Palar indicating restricted distribution of otter in the Hosur and Dharmapuri Forest Divisions.

Factors influencing distribution

Otter were observed to be significantly concentrated in river stretches with higher water depth (K-W $\chi^2=11.358$, $df=2$, $P<0.01$), in islands with shrub/grass cover (K-W $\chi^2=40.595$, $df=2$, $P<0.001$), and in areas with lower water current (M-W $U=1098$, $P<0.05$) and human disturbance (K-W $\chi^2=33.379$, $df=2$, $P<0.001$) (Table 1). Further comparison of otter abundance recorded in the five blocks with the ecological factors prevailed in the respective block revealed that water

depth (Coefficient \pm SE= 0.133 ± 0.034 , $P<0.001$) and vegetation cover (Coefficient \pm SE= 0.031 ± 0.005 , $P<0.001$) influenced the otter abundance positively, while the human disturbance influenced negatively (Coefficient \pm SE= -0.664 ± 0.190 , $P<0.01$) and these three variables explained 54% of the variations in distribution (Table 2).

Population and group size

The study, based on the group size and spatial locations recorded from the 47 direct sightings, differentiated seven different groups of otters. From these seven groups, the study recorded a minimum of 36 individuals during the survey (Table 3). Out of 47 direct sightings of otters, the study estimated the mean group size of 3.8 ± 0.16 . The minimum and maximum group size recorded was two and seven individuals, respectively.

Diet composition

The analysis of 21 otter spraints revealed that otters feed on prey items which include insects, molluscs, crabs, fish, frogs, reptiles, and birds. Fish appeared most frequently in the diet of otters (Table 4). The fish species *Labeo callbasu* occurred in 15 out of 21 scats, and also contributed 90% of dry weight of all the food

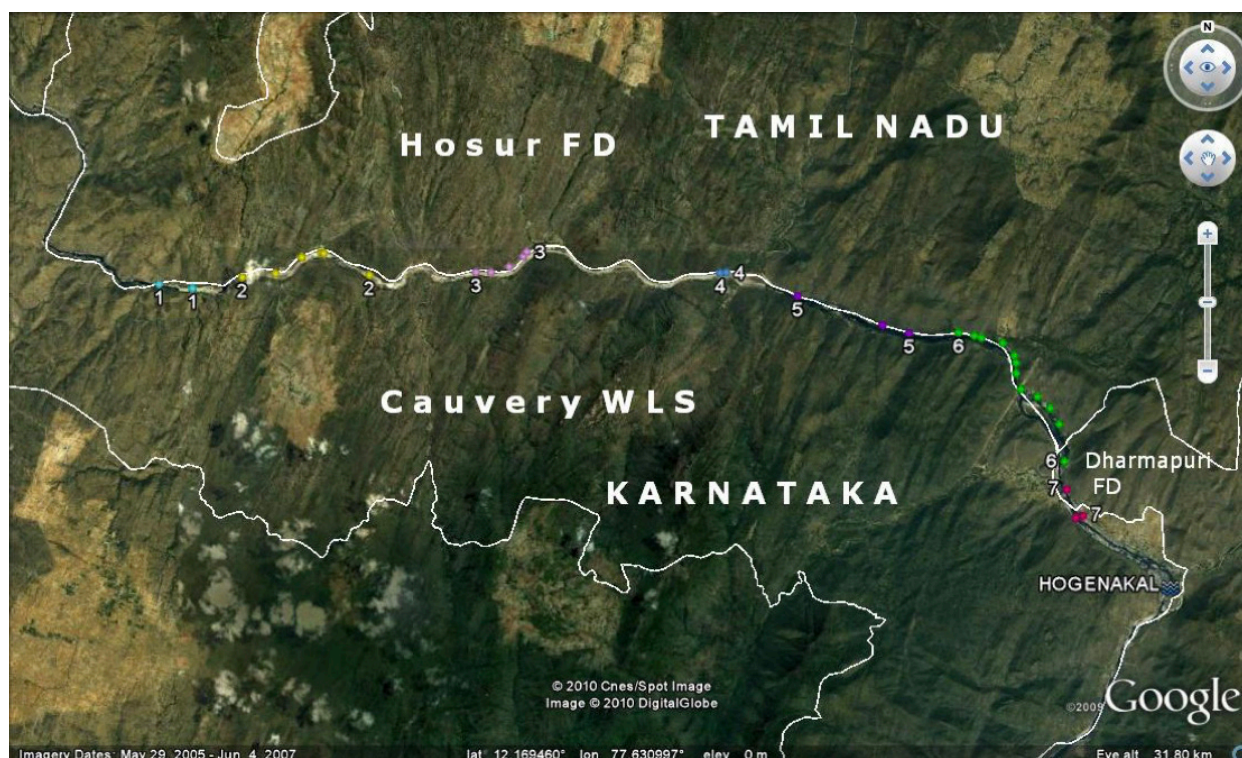


Image 3. Map of study area showing seven otter groups' distribution area along Cauvery River.

Table 1. Distribution pattern of smooth-coated otter in relation to ecological factors along Cauvery River in Hosur and Dharmapuri Forest Divisions, Eastern Ghats.

Factor	Category (n)	Otter abundance mean \pm se	Kruskal–Wallis (χ^2) / *Mann–Whitney U	df	P
Bank type	Earthen (37)	0.41 \pm 0.180	1.36	2	0.507
	Sandy (45)	0.84 \pm 0.270			
	Stony (43)	0.51 \pm 0.271			
Water depth	Low (26)	0.12 \pm 0.085	11.358	2	0.003
	Medium (58)	0.40 \pm 0.165			
	High (41)	1.20 \pm 0.355			
River width	Low (30)	0.93 \pm 0.437	0.715	2	0.699
	Medium (65)	0.58 \pm 0.178			
	High (30)	0.30 \pm 0.153			
Vegetation	Low (17)	0.0	40.595	2	0.000
	Medium (59)	0.0			
	High (49)	1.53 \pm 0.329			
Water current	Low (29)	1.10 \pm 0.410	*10.98		0.01
	High (96)	0.45 \pm 0.140			
Human disturbance	Low (28)	2.32 \pm 0.520	33.379	2	0.000
	Medium (57)	0.18 \pm 0.062			
	High (40)	0.0			

Table 2. Regression equation model to explore the influence of ecological factors on the distribution pattern of Smooth-coated Otter along Cauvery River in Hosur and Dharmapuri Forest Divisions, Eastern Ghats.

Variable	Coefficient \pm Std. error	P	model (R^2)	F	model (p)
Constant	0.348 \pm 0.523	0.507	0.545	33.616	0.000
Water depth	0.133 \pm 0.034	0.000			
Human disturbance	-0.664 \pm 0.190	0.001			
Vegetation cover	0.031 \pm 0.005	0.000			

items, indicating importance of *Labeo* in the otter diet in the study area. It is interesting to note that higher vertebrates such as reptiles and birds seldom feature in the otter diet. In terms of dry weight, fish accounted for 90% of otter diets (Table 4), followed by birds (5%), frogs (2%), molluscs (1%), and crabs (1%). Prey items such as insect and reptiles formed less than one percent of the overall diet of otters.

DISCUSSION

Distribution of otter

This study identified 31 km of otter habitat in the study area. The distribution of otter habitat was mapped during the dry season, and it is likely that during the wet season otters may expand their distribution

area. Also, absence of otter signs in a particular place does not necessarily mean otters are absent from the area, as occasionally they may inhabit an area without depositing spraints (Jenkins & Burrows 1980; Melquist & Hornocker 1983; Kruuk et al. 1987), although this is infrequent (Chehebar 1985). Nevertheless, the findings on the otter distribution area, mapped by the present study, based on dry season observations, have vital management implications, as it is a pinch period in which animals restrict themselves to smaller areas due to resource limitations, which need to be protected from human disturbance for the long-term conservation of the species.

Factors influencing distribution

The multiple regression analysis revealed among the five ecological correlates tested, water depth, vegetation

Table 3. Population size and group size of Smooth-coated Otter estimated based on seven different groups occupying the study area during December 2009–March 2010.

Group ID	Survey blocks used	Total number of individuals	Group size mean \pm SE
1	12 to 15	5	4.0 \pm 0.45
2	18 to 25	4	3.3 \pm 0.18
3	33 to 37	5	4.2 \pm 0.37
4	45 to 49	5	3.7 \pm 0.67
5	52 to 57	7	5.5 \pm 0.96
6	62 to 68	5	3.5 \pm 0.21
7	71 to 74	5	3.7 \pm 0.33
Total	12 to 74	36	3.8 \pm 0.16

cover influenced otter distribution positively, on the other hand, human disturbance influenced negatively. The positive influence of vegetation cover in the form of dense shrub/grass cover along river banks and islands on otter distribution is likely due to the preference of such areas by otters for excavating their holts, most of which were recorded in river stretches associated with dense undergrowth. This has also been reported in earlier findings (Shenoy 2002, 2005; Annob & Hussain 2005; Shenoy et al. 2006). Similarly, water depth also showed a positive influence on otter distribution. Since the study period (December 2009–February 2010) was largely confined to the dry season, it is likely that during that season otters in the study area preferred stretches with deep water to avoid high temperatures. Also, Paterson & Whitfield (2000) reported that fish distribution is closely correlated to water depth. It is important to note the decrease in otter abundance with human disturbance through fishing, bathing, cattle grazing, and forest product collection, which could affect the otter distribution adversely. Direct observations of otters suggest bank edges with sandy soil and islands of rocky outcrops and boulders provide ideal microhabitats for feeding (Burton 1968; Channin 1985), sleeping (Channin 1985; Nolet et al. 1993), grooming (Nolet et al. 1993), playing (Shariff 1984), and territory marking (Green et al. 1984; Kruuk 1992). Islands and rocky outcrops in the middle of the river are safer for aquatic species like otter to escape from threats as compared to river banks, where anthropogenic disturbances are more and such islands are ideal if they contain vegetation undergrowth to provide cover (Shenoy 2002). Prey availability is probably a crucial factor influencing the distribution of the otters follow their food abundance gradient and alter their home ranges accordingly (Mason & Macdonald 1986). Our attempt to estimate the prey abundance

Table 4. Frequency of occurrence of various prey items identified from Smooth-coated Otter spraints in the study area December 2009–March 2010.

Prey items	Occurrence		Dry weight (%)
	Percent frequency	Relative percent frequency	
Insects	9.5	4.5	0.10
Molluscs	9.5	4.5	1.12
Crab	4.8	2.3	1.40
Pisces			
<i>Labeo callbasu</i>	71.4	34.1	89.80
<i>Channa argus</i>	9.5	4.5	
<i>Masatcembalus</i> sp.	14.3	6.8	
<i>Tor khudree</i>	9.5	4.5	
<i>Notopterus notopterus</i>	4.8	2.3	
Unidentified fish	33.3	15.9	
Frog	28.6	13.6	2.20
Reptile	9.5	4.5	0.40
Birds	4.8	2.3	4.70

did not yield adequate data due to the reason that much of the river stretches in the study area are with low water depth, which could not be sampled using gill net. However, fish being the major prey of the Smooth-coated Otters, fish must be available all the year round, if otters are to remain as permanent residents in an area (Melquist & Hornocker 1983). Although, water depth, ground vegetation and human disturbance explained 54% of the otter distribution in the study area, the rest 46% could be a function of fish abundance, which is not addressed adequately in this study.

Population and group size

Although no data is available from southern region for comparison, a detailed survey on population conducted along a 425-km stretch of the Chambal River in a sanctuary reports 29 otters during 1988 and 14 in 1992 (Hussain & Choudhury 1997). The present report of 36 otters for the entire stretch of 62 km surveyed (from Ichiebara on the upstream of Cauvery River to the junction of Palar in the downstream) represents a healthy population. Since the study covered the Cauvery River stretch in the upstream only from Tamil Nadu boundary, it is likely the same river further up in Karnataka region could also be supporting Smooth-coated Otters and thus actual population may be larger than reported here. Overall, the study estimates a mean group size of 3.9 individuals based on 47 sightings. The mean group size was marginally higher during February

(4.3 individuals) compared to January (3.4 individuals). In National Chambal Sanctuary, India, Hussain (1996) estimated a mean group size of 4.6 individuals based on larger sample size ($n = 422$). The present finding of 3.9 individuals per group is comparable to those from Hussain (1996). The smaller group size in the present study could be attributed to the short-term nature representing only the dry season and the absence of wet season data in which the group size reported to be larger (Hussain 1993).

Diet composition

Fish constituted the major prey items during the study, both in terms of frequency of occurrence and dry weight. When occurrence of a food item is high, that food is important for the dependent species (Knudsen & Hale 1968). Similar to the present study, fish were identified as the stable food of Smooth-coated Otters elsewhere in southern India (Balasubramanian 1989; Anoop & Hussain 2005). Although the otters are mainly piscivorous animals, in the present study area they also feed on a variety of other prey items like insects, molluscs, crabs, reptiles, frogs, and birds as reported elsewhere (Anoop & Hussain 2005). Similar to the present study, Norris (1974) found the occurrence of freshwater mussels as part of the otter diet. Otters rarely preyed on birds, although reported elsewhere from other parts of India (Anoop & Hussain 2005). A similar trend in diet composition has been reported for the Eurasian Otter *Lutra lutra* L. (Ottino & Giller 2004).

CONCLUSIONS AND RECOMMENDATIONS

The study shows that Smooth-coated Otters are distributed along the Cauvery River from Dubguli (Yellolapatti) upstream, to Biligundlu (Musulumaduvu) downstream. While water depth and vegetation cover influenced the otter distribution positively, human disturbance influenced it negatively. The study estimated 36 individuals as the minimum population of otter in the area and showed that otters feed on insects, molluscs, crabs, fishes, frogs, reptiles, and birds with fish as the principal component. As the survival of otters depend on the fish population in the area, protection of fish fauna of Cauvery River and the riverine system are essential for the long-term conservation of the otters. Unfortunately, there is tremendous pressure on fish fauna in the study area from local people due to commercial fishing, which needs to be reduced to a sustainable level as the first step for conservation of otters. Apart from fishing,

the riparian habitats also experience other kinds of anthropogenic pressure, including over grazing by scrub cattle, cattle-pen and non-timber forest produce collections and disturbances. Pollution from seasonal pilgrimage and regular tourism as reported in Baskaran et al. (2010), which should be regulated/ stopped for the conservation of riparian habitats of the Cauvery River and its dependent species like smooth-coated otters. Increased awareness of sustainable fishing by the community and long-term monitoring will also benefit the otters' survival.

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