Ecology of otters in Corbett Tiger Reserve

THESIS

SUBMITTED TO THE

FOREST RESEARCH INSTITUTE UNIVERSITY

DEHRA DUN

UTTARAKHAND

For

THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY IN WILDLIFE BIOLOGY

By

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Wildlife Institute of India

Dehra Dun

2007

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

DECLARATION

I hereby declare that the thesis entitled **"Ecology of otters in Corbett Tiger Reserve"** submitted for the award of Doctor of Philosophy in Wildlife Biology to Forest Research Institute University, Dehra Dun is a record of original research work done by me under the supervision of Dr. S. A. Hussain, Scientist E, Wildlife Institute of India, Dehra Dun, and it has not formed the basis for the award of any other degree or diploma. I also declare that the thesis embodies the result of my own work and observations and in that respect the investigation appears to advance knowledge in the subject.

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Place: Dehra Dun

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CERTIFICATE

This is to certify that the thesis entitled **"Ecology of otters in Corbett Tiger Reserve"** submitted for the award of Doctor of Philosophy in Wildlife Biology to Forest Research Institute University, Dehra Dun is a record of original research work done by **ASGHAR NAWAB** at Wildlife Institute of India, Dehra Dun under my guidance and supervision. I further certify that this research work has not previously formed the basis for the award of any other degree or diploma and it fulfils all the requirements laid down in the Ordinance governing award of Ph.D. degree of Forest Research Institute University.

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APPENDIX-3

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This is to certify that Shri. **ASGHAR NAWAB** enrolment no. 0109/Wildlife Bio/620/7-757 carried out the research work under Dr. S. A. Hussain, Scientist E, Wildlife Institute of India, Dehra Dun. The topic of the research registered with Forest Research Institute University was **"Ecology of otters in Corbett Tiger Reserve".** The scholar presented his work in the pre-thesis submission seminar held on March, 10th. 2007 and the RAC found the work to be satisfactory and recommends the work to be presented in the form of thesis for evaluation by examiners for the "Award of Ph.D. Degree" by Forest Research Institute University, Dehra Dun.

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To,

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Sub: - Registration for Doctor of Philosophy Degree.

Dear Sir/Madam,

In response to your application dated 14-8-2001 for enrolment as Research Scholar for the Degree of Doctor of Philosophy in this Institute, it is to inform you that the following decisions have been taken: -

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ii. Your registration number is: - 0109/Wildlife Bio/620/7-757.

iii. The Topic for research approved by the Deemed University "Ecology of otters in Corbett Tiger Reserve."

iv. Name of Supervisor: - Dr. S.A. Hussain.

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ii.	Library Caution Money (Refundable)	Rs. 2000/-
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Yours faithfully,

Registrar
F.R.I., Deemed University

Copy to : -

1. Dr. Syed Ainul Hussain, Reader, Wildlife Institute of india, P.O. No. 18, Chandrabani, Dehra Dun.
2. The Nodal Officer, Wild Life Institute of India, P.B. No. 18, Chandrabani Dehra Dun – 248 001.
3. P.A. to Registrar, F.R.I., Deemed University for information and necessary action please.

With the request to send six monthly progress report of the Scholar to the undersigned regularly as per clause 6.4 and 6.5 of the Ph.D. Ordinance.

Yours faithfully,

Registrar
F.R.I., Deemed University

Contents

ACKNOWLEDGEMENT

I take this opportunity to express my gratitude to all who have made this thesis possible, in particular to Dr. S. A. Hussain, my mentor for giving me this prospect to work in his project and for his continuous support and encouragement. Funding for this project was from the Grant-in-aid of Wildlife Institute of India. Additional fund was raised through IUCN SSC Otter Specialist Group. Research Fellowship from Council of Scientific and Industrial Research (HRD Group, New Delhi) is highly acknowledged.

I am indebted to Shri P. R. Sinha, Director and Dr. V. B. Mathur, Dean FWS, Wildlife Institute of India for providing technical and infrastructural support during the study. I am grateful to Shri S. K. Mukherjee, Shri V. B. Sawarkar and Shri S. Singsit, former Directors, Wildlife Institute of India for extending technical support at various stages of this study. I would like to thank Dr. A.J.T Johnsingh (former Dean, FWS, WII) and Dr. P. K. Mathur for their continuous support and guidance. I earnestly appreciate encouragement and supervision in facilitating this research work from Dr. K. Shankar (Research Co-ordinator, WII). I remain obliged to Shri Qamar Qureshi Sir, Dr. Y.V. Jhala, for helping me with statistical analysis and the refinement of the study design. I sincerely thank Dr. Ruchi Badola (Head, Ecodevelopment Planning & Participatory Management Dept.), Smt. Bitapi Sinha, (Nodal Officer Audio-visual & Wildlife extension Cell), Dr. B. K. Mishra, Shri B. C. Choudhury, Dr. Kartikvasudevan and Dr. K. Sivakumar for their continuous encouragement and support throughout this research work. I would like to thank Shri Rajesh Thapa, (System Manager Computer & GIS Cell), Dr. M.S. Rana (Librarian, WII) and Shri. S.S Lamba (Finance Officer) for their help. The contributions from the Staff of the *various Departments - Administration, Finance, Library, Computer & GIS Cell, Laboratory (Teaching & Research), Audio-visual & Wildlife extension Cell and the Reprographic Centre are highly commendable. I remain indebted to my Alma-maters, La Martiniere College, Lucknow and the Aligarh Muslim University; particularly the Department of Wildlife Sciences. I am grateful to Dr. A. H. Musavi (Founder Chairman, Centre for Wildlife & Ornithology), Dr. H. S. A. Yahya, Dr. Jamal A. Khan, Dr. Afifullah Khan, Dr. S. Kumar and Dr. S Javed for encouraging me to take up wildlife sciences as a career.*

I am extremely thankful to Shri. Srikant Chandola, Chief Wildlife Warden, Governmnet of Uttaranchal and Shri A. S. Negi former Chief Wildlife Warden and Wildlife Adviser to Government of Uttaranchal for permission and extending support during the study period in the Corbett Tiger Reserve. I am indebted to Shri D. V. S. Khati (former Field Director, Corbett Tiger Reserve) and Shri Samir Sinha and Shri Vivek Pandey (former Deputy Directors, Corbett Tiger Reserve) for taking keen interest in this study. Gratitude is expressed to Shri Rajeev Bhartari (Field Director, Corbett Tiger Reserve) and Dr. Parag Madhukar Dhakate (Deputy Director, Corbett Tiger Reserve) for providing logistic support, guidance and their valuable suggestions for improving the quality of this research work. Help rendered by different forest personnel (particularly Shri Harish Dhyani and (Late) Shri Shubratri Ahmed is highly commendable.

I feel privileged to thank all my dear ones at this precious moment of my career – Dr. Orus Ilyas for her untiring support and encouragement in improving this thesis. I will always remember the help and support extended to me by Dr. K. Ramesh and Dr. R.

Jayapal. I thank Amit Srivastava for extending help and continuous encouragement. I thank Reena Bhabhi and Anil Bhai for their support. The cordial support from Poonam, Parichay, Fouzia, Meena, Shivani, Ambica, Neha, Chandrima, Devendra Singh Chauhan, Basudev Tripathy, Sarat Chandra Tripathy, Harendra Bargali, Pankaj Kumar Sahani, Chitranjan Dave, Ashok Verma, Jeevan Singh Jalal, Rajapandian, Anil Kumar, Anupam Srivastava, Hitendra Padalia, Sabyasachi Dasgupta, Bhaskar, Shantanu, Uppamanyu, Bopanna, Kamlesh, Vinay, Meraj Anwar, Aishwarya Maheshwari, Rishi Kumar Sharma, Abhishek, Hari, Anoop K. R........the list is endless.......I thank everyone who cared for me!

Finally, I express my indebtness and gratitude to my parent, family members and relatives, who helped me in many ways in completing this research work and most of all for having trust in me and cheering me all the way to this beautiful success.

LIST OF FIGURES

LIST OF TABLES

Executive Summary

Otters are obligately tied to aquatic environments and are recognized as one of the top predators in the freshwater systems. The three species found in India have been accorded protection under the Wildlife (Protection) Act, 1972. Major threats to otter survival are the loss of wetland habitats, reduction in prey biomass and pollution. Developmental projects such as dams and barrages, and aquaculture activities have taken their toll on wetlands and consequently on the otters. Poaching, however, remains a major threat to their survival.

The study was envisaged to appraise the impacts of making of dams on the ecology of otters in Corbett Tiger Reserve, since it is believed that the habitat of otters got fragmented due to the creation of a dam on the Ramganga River under the Kalagarh Multipurpose Hydroelectric Project. It is generally believed that dams affect otter populations due to the reduction of water flow downstream, denying access to prey, and den sites. In India, it has never been quantified to what extent this affects the habitat use by resident otter populations and hence the findings of this study can be used to formulate a model for similar studies elsewhere in the country. In the Corbett Tiger reserve both smooth-coated and Eurasian otter have been reported. Our preliminary survey revealed that at the low lying areas such as the Ramganga, Mandal and Palain rivers, smooth-coated otter occurs. This study complies with smooth-coated otter limited to the above mentioned areas only and data were collected for winter and summer seasons respectively between 2001 and 2004.

The study was conducted with the following objectives:

(a) To study the status and distribution pattern of otters in the Corbett Tiger Reserve and the adjacent aquatic ecosystems.

(b) To examine the Resource use pattern of otters in relation to habitat and food availability.

(c) To study the potential threats to otter populations in the study area.

Major water bodies were categorized based on their types (Perennial/Seasonal) and presence of disturbance factors (Disturbed/Undisturbed). These water bodies were divided into 5 km segments. Information about habitat, marking places, and signs was recorded for each 500 m section. Searches covered a 100 m x15 m strip along the river edge. A team of 4 trained surveyors with comparable experience conducted the surveys by walking along both the banks and searching for the signs. Along the reservoir, some part was walked or surveyed by boat, whichever was convenient. In each study section a *positive site* was defined as a 'used site' where holts/shelters and other signs of otter presence were found. All coordinates of locations were recorded using a global positioning system unit (Magellan Trail Master hand held GPS unit). Data on eighteen variables were collected. Food and feeding habits of otters was studied by analyzing spraints collected from three different River stretches *viz;* Ramganga, Mandal and Palain covering 100 km stretch of the study area. Collections were made from the entrance of dens, communal sprainting sites and feeding areas. Only fresh scats were collected and every scat was considered a single entity if separated 5 m apart. Fish availability was estimated along 10 km stretches in the buffer zone, using cast nets. For every site thirty samplings (efforts) were done for both winter and summer respectively. Number of species, frequency of catches and length were recorded for each catch. For spraint analysis standard reference material were made for which trapping of fish was carried out using cast nets. The vertebrae, scales and eyeballs were retrieved and weights measured and were kept labeled in a polythene cover for reference.

The presence or absence of otter signs was used as a response to habitat parameters quantified in each plot. To understand the habitat use by otters and to discriminate between the different groups' i.e. otters and the associated fauna, according to their habitat characterization, data were subjected to Multivariate statistics. One Way Analysis of Variance was used to test for significant differences in spraint density *viz-a-viz* water current, water quality, shoreline vegetation, prey availability, associated fauna and disturbance. Relative abundance estimates for otters (number of otter signs/km); crocodiles and gharials (number of individuals/km) were calculated. Difference in otter occurrence across the two sampling years and seasons (winter and summer), mean density of otter signs (spraints, tracks, grooming sites and den sites) were calculated and compared using t-test. Home range of each group was estimated using Kernel Home Range Method and were developed using GIS software Arc View 3.2. Different food categories were identified and data are presented for each food category as relative frequency (F%) and Percentage bulk (Sc%). Catch per unit effort (CPUE) was calculated to determine the fish availability for two different seasons i.e. winter and summer. Preference for major fish species was determined by calculating 95% Bonferroni Confidence intervals following Byers *et al.* (1984). The 95% confidence intervals were constructed by following the formulae: P_{ie}-$Z_{\alpha/2k}\sqrt{}P_{ie}(1-P_{ie})/n$ [P_{ie}[P_{ie}+ $Z_{\alpha/2k}\sqrt{}P_{ie}(1-P_{ie})/n$ .Based on the extent of severity (1-6) six variables were recorded as presence/absence in respective plots. For analysis a qualitative score index for disturbance variables were developed and are expressed as percentage of disturbance intensity.

This research, although, corroborates the findings of previous distributional records of otters along the River Ramganga in Corbett National Park, also confirms the distribution of otters from Rivers Mandal and Palain, hitherto unreported. Of the total 380 plots sampled 15.5% (n = 31) proved positive, with maximum being recorded from River Ramganga (17.5%, n = 14) followed by Mandal (15%, n = 6) and Palain (13.75%, n = 11). Although intensive search were made (n = 180), no sign of otter activity was recorded from Rivers Sonanadi, Kosi and the Reservoir area. This is attributed to high levels of anthropogenic disturbance (sand mining, extraction of bank side vegetation and livestock grazing) along Rivers Sonanadi and Kosi, while the reservoir with steep shore lines (47.38 ± 1.69, range 5°- 90°) and because of deep water (6.99 m ± 30.46, range 1–23.14 m) is unsuitable for otters. Availability of habitat features such as; rocky and sandy stretches with gentle bank slopes, bank side vegetation serving as escape cover, slow water current and prey availability govern the distribution of otters in Corbett Tiger Reserve. The home ranges recorded for different otter groups were small, though they provide favourable habitat conditions for otters.

Relative abundance of otters was estimated as 0.35 per km for River Ramganga, 0.34 per km for River Mandal and 0.26 per km for River Palain. The surveys led to a detection of four otter groups identified in the study area. During the course of the study, a total of 11 sightings were potentially possible and an estimate of 41 individuals (35 adults and 6 juveniles) with a mean of 5.1±1.55 was recorded. The basic group structure consisted of the resident adult male with female and her offsprings. During winter 2003-2004, the two otter groups recorded from River Ramganga showed increase in group size with the addition of 1 and 4 juveniles respectively, while the otter groups recorded from Rivers Mandal and Palain remained stable with 6 and 16 individuals respectively. During the study period 129 (9.92 ± 2.75) mugger and 42 (5.25 ± 1.67) gharial were recorded. Otters share similar habitats with associated wetland fauna, maintaining mutually agreeable strategy to avoid conflicts in sharing resources for foraging, grooming and basking.

The food habits of otters were studied by analyzing 499 spraints collected over the study period. Diet was represented by four prey categories in which fish (84%) was the most frequently occurring item and also formed the bulk (97.27%). There were no significant difference in overall proportions of different prey categories used between winter and summer (Wilcoxon Signed Ranks Test; $Z = 0.0$, $p = 1.0$). Also, there were no significant difference between the sites (Friedman Test; chi square 0.61, $p = 0.74$) and between seasons (Wilcoxon Signed Rank Test; $Z = 0.0$, $p = 1.0$) (Fig. 5.1). Total eight fish species were identified from the spraints, which belonged to two families i.e. Cyprinidae and Sisoridae; although members of the family Cyprinidae were taken more frequently. *Glyptothorax pectinopterus* formed the most favourable diet item during summer while *Labeo dyocheilus* was favoured most in winter. Size class (cm) of fish species caught ranged between 3.9 ± 0.9 (*Puntius* spp) and 53 ± 2.08 (*Labeo dyocheilus*). The selection of prey depend on the availability (abundance) of prey species and catching efficiency of otters, slower moving species being apparently favored.

In the light of the results of the study following conservation management recommendations are suggested, highlighting need for habitat management, control of illegal activities and long term monitoring programmes:

- The available habitat suitable to otters in the Reserve is limited, confining them to middle reaches of the rivers. Other aquatic fauna such as gharial and mugger live within and around the otter habitat and hence dietary overlap and large-scale interspecific competition is obvious, further constraining the availability of the resources for foraging, grooming and basking. These habitats need special attention in terms of management and protection of identified otter den sites and river stretches which are more frequently used.

- Along the peripheral areas of the Reserve locals use destructive methods of fishing such as dynamiting, gill nets and Ichthyotoxic plants to poison fish. This leads to indiscriminate killing of large number of juvenile as well as brood fish which adversely affects the prey abundance of otters. Therefore it is imperative to regulate fishing practices in the Rivers.

- During the study period, poaching of otters was recorded from the peripheral areas of the National Park. This poses a threat to otter population in recolonisation. Effective protection measures should be strengthen at vulnerable points, *viz*; From Domunda to Marchula along the River Ramganga, From Domunda to Maidavan along the River Mandal and From Vatanbasa to Ramesera along the River Palain.

- As the presence of shoreline vegetation is a prerequisite for otter habitat, this should be maintained or wherever necessary restored. Control burning along the riverine stretches, though a well adopted practice by the forest department deteriorates the habitat and growth of riparian vegetation which otherwise serves as escape cover to small mammals such as otters. Hence, it is recommended that a buffer of about 25 m of riparian vegetation should be left unburnt while carrying out routine practices such as control burning.

- Sand and boulder extraction were the major commercial activities associated with River Kosi, however within the reserve area sand and boulder extraction were recorded along River Mandal near *Bhakuan* village, which is for domestic use. Since locals have civil rights to extract such resources, participatory programmes can be initiated to create awareness among locals about the ecological importance of otters in the surrounding water bodies.

- The comparison of historical information with present data suggests fluctuation in otter population over time. This could be because of intrinsic factors in the population or due to anthropogenic pressures such as poaching or due to intra-specific competition from reintroduced gharial and mugger. This necessitates development and implementation of long term monitoring programmes for otters and associated aquatic fauna in the Reserve. This may include searches for habituated and non-habituated (deserted) den sites, presence of otter signs per km stretch (for computing relative abundance) and recording of presence of sufficient riparian cover. The methods used need not be rigorous but should be simple, less time consuming and cost effective. Otter sighting *logbooks* can be maintained at respective rest houses and visitors should be encouraged to record their sightings as, date, place and numbers seen. Such information collated can eventually be used for comparisons either seasonally or annually and later can be verified through rigorous field work and other statistical procedures.

CHAPTER 1

INTRODUCTION

1.1. Otters: A brief

Otters are obligately tied to aquatic environments and occupy littoral areas of both freshwater and marine habitats throughout much of the world (Estes 1989). They are classified in the Lutrinae, one of the subfamilies that belong to the Mustelidae, which also includes the Mustelinae (weasels and minks), Melinae (badgers), Mellivorinae (honey-badger), Taxidiinae (American badger) and Mephitinae (skunks) (Wozencraft 1993). The subfamily comprises 13 extant species for which four to eight different genera have been recognized and variously divided into two or three tribes (Table 1.1). Though otters are widely distributed and play a major role in the wetland ecosystem as a top carnivore species (Sivasothi 1995), not much attention has been given to understand their ecology. They are suitable indicators of the health of a wetland ecosystem as they are sensitive to degradation along the food chain (Erlinge 1972). Of the 5 species found in Asia, three are found in India – Smooth coated otter (*Lutra perspicillata*), Eurasian otter (*Lutra lutra*) and Oriental small-clawed otter (*Aonyx cinereus*) (Foster-Turley and Santiapillai 1990; Hussain 1993; Prater 1998). Major threats to otter survival are the loss of wetland habitats, reduction in prey biomass and pollution and poaching. Developmental projects such as dams and barrages, and aquaculture activities have taken their toll on wetlands and consequently on the otters. Otters are hunted for their pelts, meat, fat and other body parts (Nagulu *et al.* 1999a; Meena 2002).

1.2. Classification and systematics

Past systematic studies on otters have been based primarily on the overall similarity of cranial and dental characters to infer relationships (Koepfli and Wayne 1998). Despite using similar morphological characters however, different methods of systematic analysis have led to a number of taxonomic revisions of the Lutrinae during this century (van Zyll de Jong 1991). Studies based on classical systematic approaches (Pocock 1921), evolutionary systematics (Simpson 1945; Sokolov 1973; Davis 1978 and Willemsen 1992), phenetics (van Zyll de Jong 1972, 1987) and cladistics (van Zyll de Jong 1987) have reached different conclusions regarding relationships. Current classifications (e.g. Wozencraft 1993) have adopted the recent revision of the Lutrinae presented by van Zyll de Jong (1987, Fig. 1.1a). His study was based on canonical variate and Wagner analyses of morphological data from the 13 extant taxa. Relationship trees based on these two approaches showed a high degree of concordance in defining taxon groupings. van Zyll de Jong (1987, 1991) emphasized that the proposed relationships be considered tentative however, until corroborated by cladistic analysis of additional character sets, including DNA sequences. More recently, Willemsen (1992) provided a different hypothesis of relationships among genera of otters through analysis of morphological characters (mostly dental) from both extant and fossil taxa (Fig. 1.1b); however, the methodology adopted for defining relationships was not explicitly stated but resembles an evolutionary systematic approach. There has also been a lack of agreement among studies as to which mustelid subfamily is the sister group to the otters, and should be employed for out-group comparison. Systematic analyses using fossil, molecular, and morphological characters have alternatively concluded that the Melinae, Mustelinae, and Mephitinae were the sister group to the lutrines (Simpson 1945; Wozencraft

1989; Willemsen 1992; Bryant *et al.* 1993; Masuda and Yoshida 1994; Vrana *et al.* 1994 and Dragoo and Honeycutt 1997). Using fossil records, Willemsen (1992) concluded that otters shared a common ancestary with badgers because the earliest lutrine genus, *Mionictis*, of lower Miocene age, shared a number of meline dental characteristics. Molecular data provided evidence for a sister-group relationship between the Mustelinae and Lutrinae (Masuda and Yoshida 1994; Vrana *et al.* 1994 and Dragoo and Honeycutt 1997). Both associations were compacted, however, by the possibility that neither the Melinae nor the Mustelinae may be monophyletic (Petter 1971; Bryant *et al.* 1993 and Dragoo and Honeycutt 1997). Morphological analyses of extant carnivores have united the skunks and the otters as sister groups (Wozencraft 1989 and Bryant *et. al.* 1993). Molecular data did not support an association of skunks and otters; rather the skunks appeared to be the basal lineage of the superfamily Arctoidea (Wurster and Benirschke 1968; Ledoux and Kenyon 1975; Wayne *et al.* 1989; Vrana *et al.* 1994; Ledje and Arnason 1996*a,b* and Dragoo and Honeycutt 1997). In general, the classification of the Mustelidae stands in need of revision, and understanding the relationships between fossil and recent forms is an important prerequisite for this (Schmidt-Kittler 1981; Bryant *et al.* 1993 and Wolsan 1993).

Koepfli and Wayne (1998) distinguished three monophyletic groups of otters using maximum parsimony (MP) and maximum likelihood (ML) methods as suggested by Felsenstein (1981). These groupings did not support the tribal divisions of the subfamily as proposed by van Zyll de Jong (1991) or Willemsen (1992) (Fig. 1.1).

Table 1.1. Otter species of the world.

Scientific name	Common name	Distribution
Aonyx cinerea	Small-clawed otter	Asia
A. capensis	Cape clawless otter	Africa
A. congica	Congo clawless otter	Africa
Enhydra lutris	Sea otter	North America, Asia
Lontra canadensis	North American river otter	North America
L. felina	Marine otter	Latin America
L. longicaudis	Neotropical otter	Latin America
L. provocax	Southern river otter	Latin America
Lutra lutra	Eurasian otter	Africa, Asia, Europe
L. maculicollis	Spotted-necked otter	Africa
L. perspicillata	Smooth-coated otter	Asia
L. sumatranà	Hairy-nosed otter	Asia
Pteroneura brasiliensis	Giant otter	Latin America

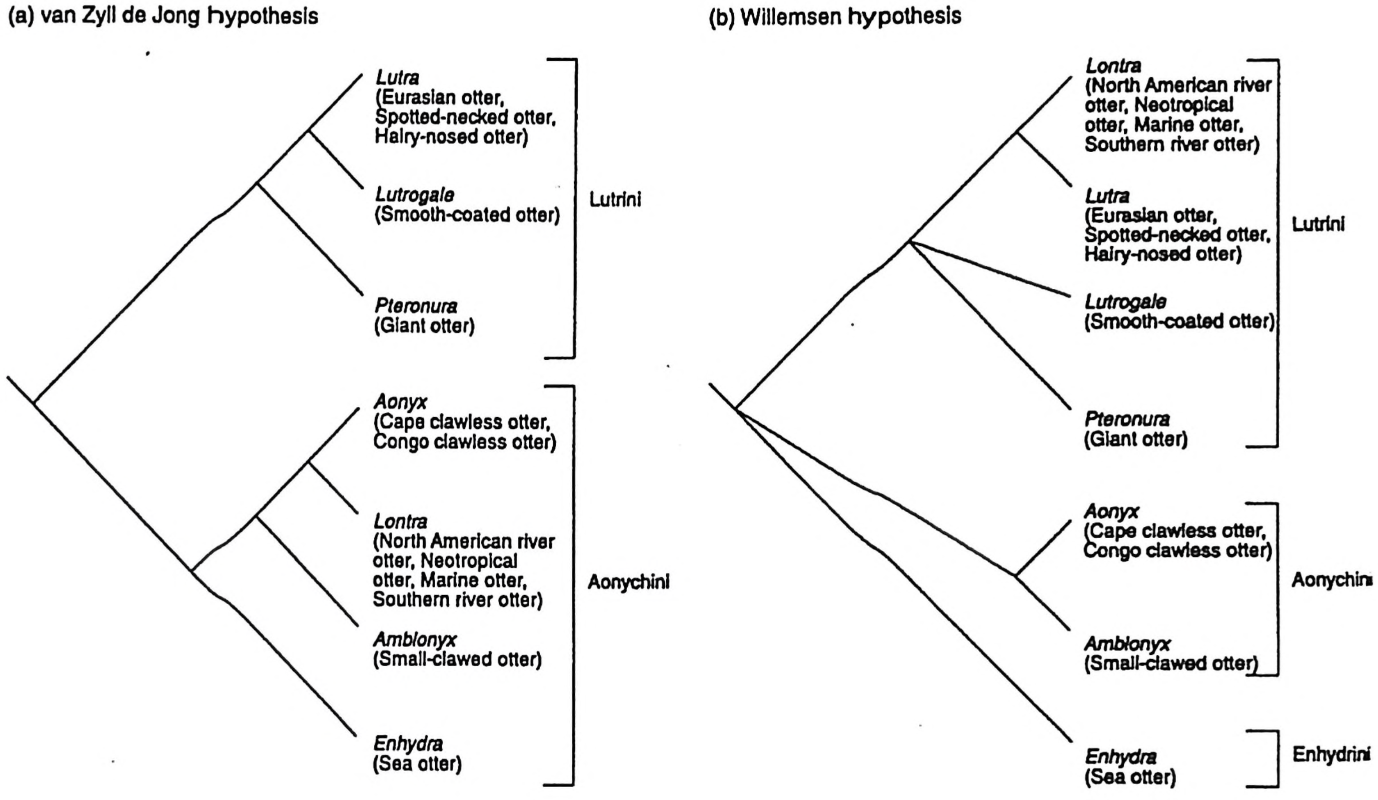


Fig. 1.1. Two recent hypotheses of phylogenetic relationships among genera of the Lutrinae.

(a). Phylogenetic relationships based on van Zyll de Jong (1987, 1991).

(b). Phylogenetic relationships based on Willemsen's evaluation of morphological characters from extant and extinct otter taxa (1992).

Source K. P. Koepfli and Wayne, R. K. (1998).

Koepfli and Wayne (1998) further suggest that among the non-lutrine mustelids, the ermine-polecat-mink clade (clade 4, Figs 1.2 and 1.3) is topologically closest to the otters, although the relationships among these clades could not be confidently resolved with the cyst *b* sequences.The hierarchical relationships among clades are not well resolved, particularly the monophyly of otters, largely because a pattern of short internal branches combined with long terminal branches suggests a rapid evolutionary radiation. Estimates of divergence time calibrated by the fossil record suggest that the lineages leading to the North American river, neotropical and marine otters, and the giant otter diverged before the end of the Miocene (Koepfli and Wayne 1998), much earlier than predicted from the fossil record (Willemsen 1992).

1.3. Conservation issues

The otters and their wetland habitats have received considerable attention in the western hemisphere, both from the scientific community and the general public. However, their status in the wetlands of Asia has remained largely unnoticed in many of the range states, despite the presence of five species of otters in the region (Foster-Turley 1992). Otters have a poor image in Asia, and natural populations have been extirpated through the exploitation of both the animal and its habitat. In some Asian countries, some otter species have even become extinct (de Silva 2000).

A number of threats to worldwide otter populations have been identified (Macdonald and Mason 1990a). In some places otters are still hunted for their fur, or sometimes, meat and organs. They are often killed by fishermen who view them as competitors. Direct persecution of otters, however, is a minor threat to their survival (Foster-Turley 1992). The most important threats to the survival of otter populations are degradation of aquatic ecosystems that they inhabit. At a high trophic level, otters are early victims to poisoning of the food chain with pollutants such as chlorinated hydrocarbon pesticides, heavy metals and organochlorines such as PCBs (Macdonald and Mason 1990a).

Any factors that reduce fish populations also have a deleterious effect on otters. Such factors include siltation from mining and logging operations, discharges of organic wastes into rivers and acidification of water systems from acid rain. Otters also require undisturbed bank side cover for their survival. Logging along riverbanks, channelizing rivers through agricultural lands and "reclaiming" wetlands for agricultural and aquacultural projects also reduce usable otter habitats (Mason and Macdonald 1986).

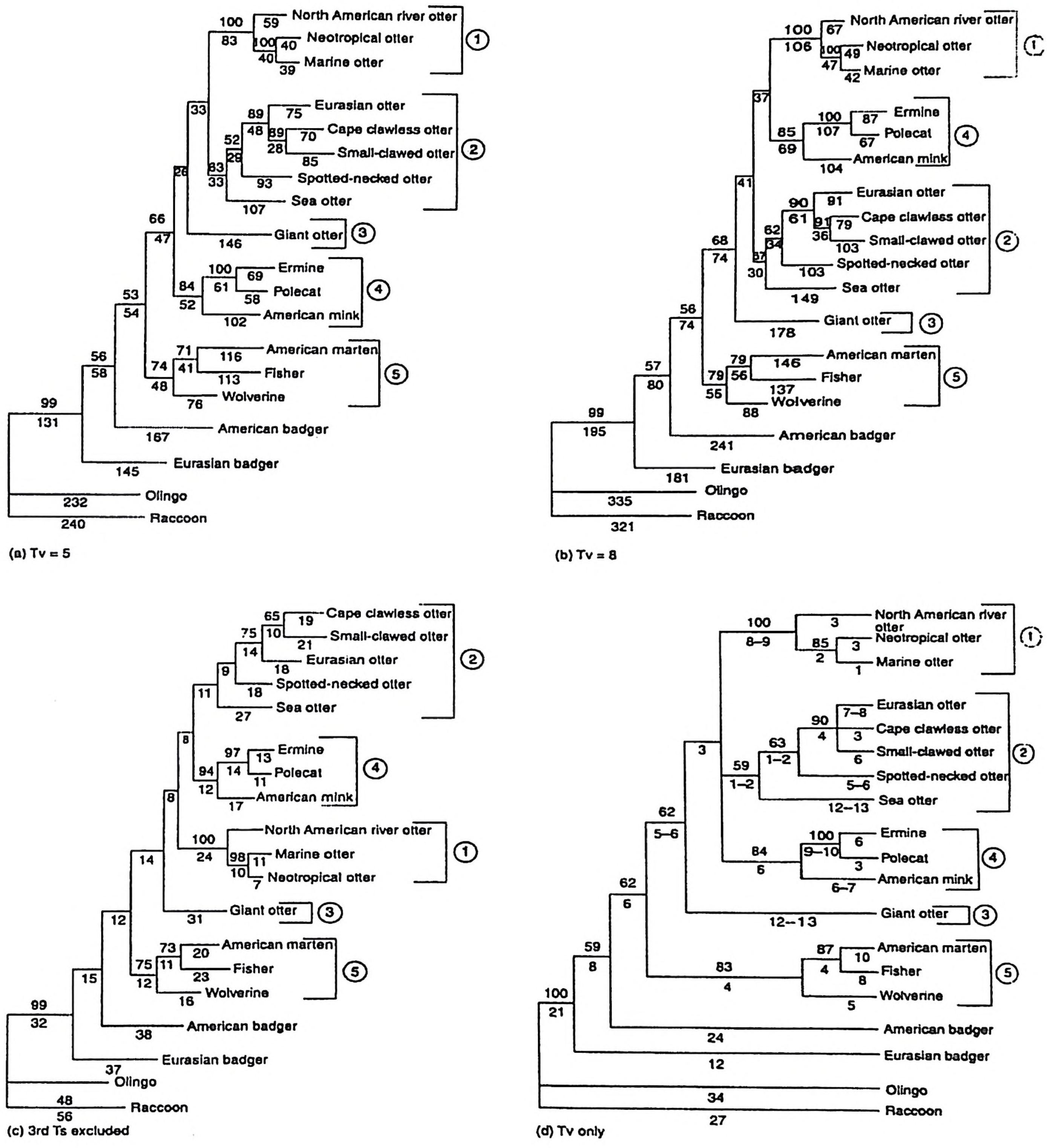


Fig. 1.2. Phylogenetic relationships among 17 species of Mustelidae based on maximum parsimony analysis of cyst *b* sequences.

Source: K. P. Koepfli and Wayne, R. K. (1998).

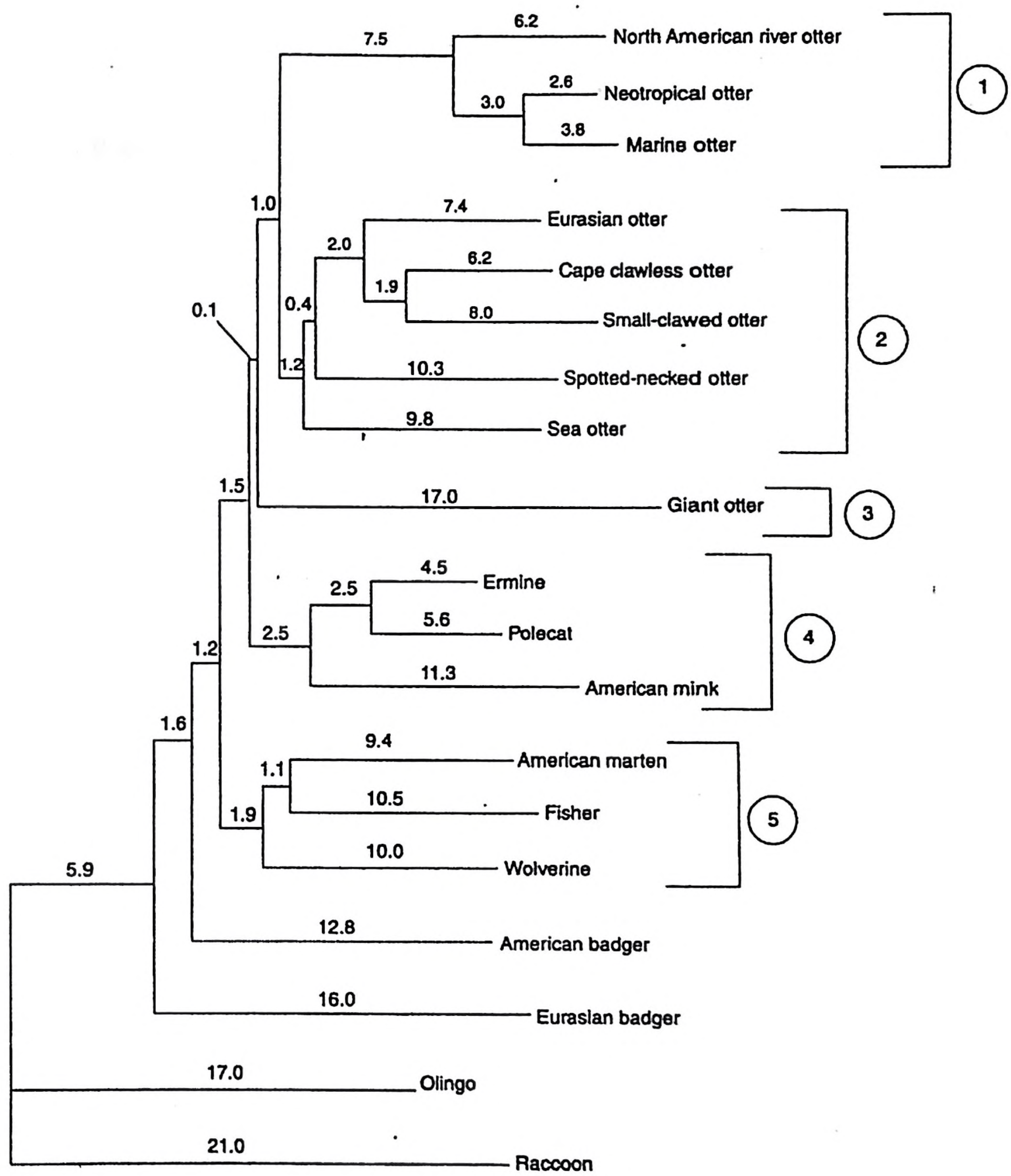


Fig. 1.3. Phylogenetic relationships among 17 species of the Mustelidae based on maximum likelihood analysis of complete cyst b sequence (-InL = 8112.39).

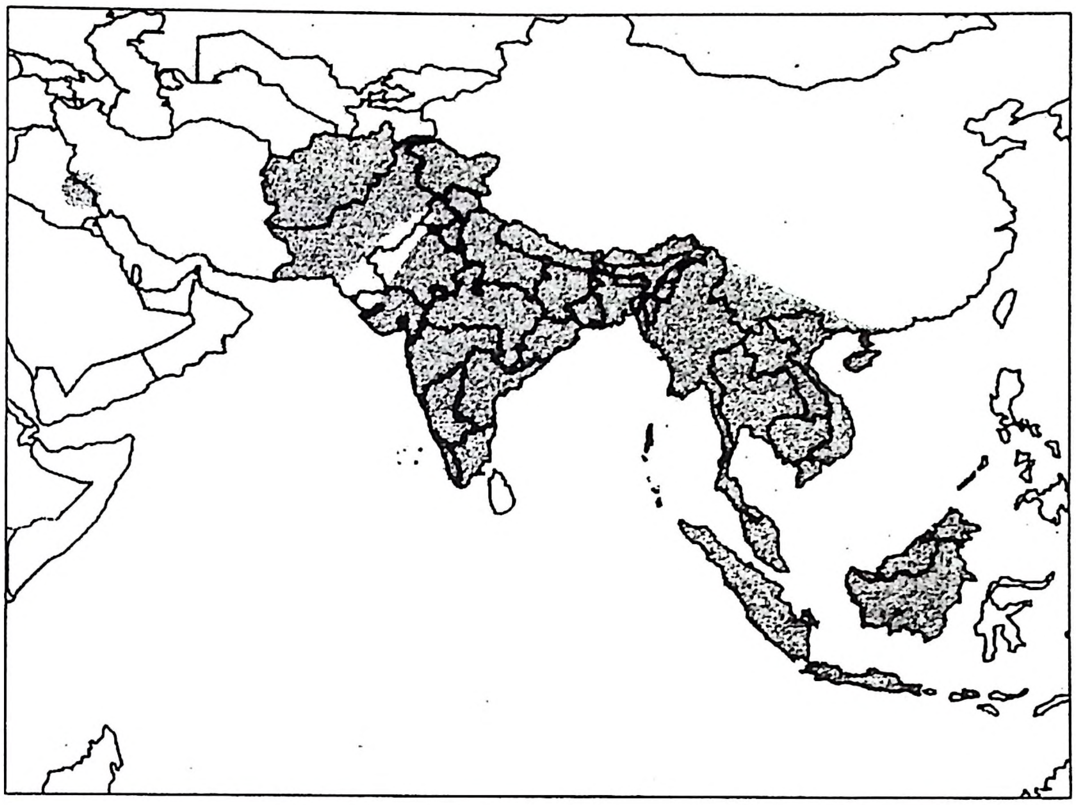
Source: K. P. Koepfli and Wayne, R. K. (1998).

1.4. The Indian otter species: A Profile

1.4.1. The smooth-coated otter *Lutra perspicillata*, Geoffroy, 1826

Smooth otters, the largest otters in Asia except for sea otters, may weigh up to 11.4 kg and the total length ranges between 1067-1300 mm; head to body 655-790 mm, tail length 406-505 mm (Foster-Turley 1992). They are distinctive in their genus for their flattened tails, exceptionally large and heavily webbed front paws, smooth-coat and flat upper border of the rhinarium (Pocock 1941 and Prater 1971). In most of their range they are sympatric with the diminutive small-clawed otter *Aonyx cinerea*, and sometimes also with *L. lutra* and *L. sumatrana*. The smooth-coated otter is distributed throughout south and Southeast Asia (Pocock 1941 and Hussain 1999) (Fig. 1.4). Two subspecies are reported by Pocock (1941), (1) *L. p. perspicillata* – in northeast and southern India, Myanmar and Sumatra (2) *L. p. sindica* – in north and northwestern India and Pakistan (Sindh province). Another sub-species *L. p. maxwelli* whose current status is uncertain, is reported from the marshes of southern Iraq (Mason and Macdonald 1986).

The dorsal part of the body colour varies from deep, nearly blackish-brown to lighter brown with a rufous tinge to much paler tawny or sandy brown. The underside is always lighter than the dorsal part, and the paws paler than the back. The upper lip to the edge of the rhinarium, the cheek to the eye and ear, the sides of the neck, the chin and throat is whitish (Pocock 1941). In its external characters the smooth-coated otter differs from Eurasian otter by its very smooth, sleek coat, *i.e.* hair texture is velvety. Muzzle is not spotted and the rhinarium is bare, dusky with peaked upper margin (inverted V shaped) (Fig 1.5a, b.). The terminal half of the tail is more flattened than the Eurasian otter with a tapered end. Both the fore and the hind paws are large, well webbed, but the third phalanges are free of webbing. The smooth-coated otter occurs along the large rivers and lakes, in mangrove forests along the coast and estuaries, and in Southeast Asia it even uses the rice fields for foraging (Foster-Turley 1992 and Sivasothi and Nor 1994). In the wild, Smooth otters have been observed generally at daytime either singly or in small groups that are thought to be family groups fishing co-operatively (Shariff 1984). Along the large rivers in India, it shows greater preference for rocky stretches in all the seasons, since these stretches provide sites for den and resting (Hussain 1993). It is predominantly a fish eater, but supplements its diet with shrimp/crayfish, crab and insects and other invertebrates such as frogs, mudskippers, birds and rats (Prater 1998; Foster-Turley 1992; Hussain 1993 and Hussain and Choudhury 1997). A typical group of smooth-coated otter consists of male, female, and up to three to five young ones (Hussain 1996). During a radio-tracking study in the National Chambal Sanctuary, India the home ranges of all the otters tracked overlapped intensively. Among the radio-implanted otters, the maximum home range was observed in a sub adult male and the minimum in a juvenile female and male. Among the non-tagged otters, the home range of female with cubs was estimated as 5.5 km while in case of the adult male it was estimated as approximately 17 km (Hussain 1993). The smooth-coated otter attains sexual maturity at 22 months in captivity (Desai 1974). Yadav (1967) observed first litter at 4 years of age. In captivity it mates during August to November (Desai 1974 and Naidu and Malhotra 1989). The gestation period varies from 60 to 62 days (Yadav 1967; Desai 1974 and Naidu and Malhotra 1989). The longest recorded lifespan in captivity is around 20 years 5 months (Acharjyo and Mishra 1983).



Source: Hussain, S.A (1999).

Fig. 1.4. Range Map of Smooth-coated otter *Lutra perspicillata*

Fig. 1.5a. Face of Smooth-coated otter *Lutra perspicillata*

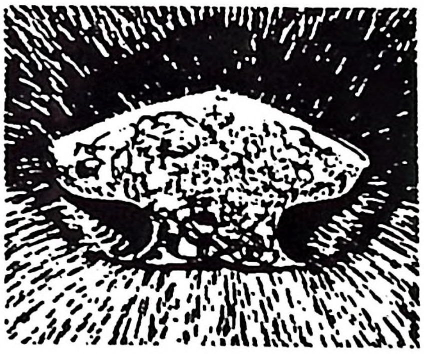


Fig. 1.5b. Rhinarium of Smooth-coated otter *Lutra perspicillata*

Pakistani fishermen along the Indus River historically used trained smooth otters to chase fish into their nets (Foster-Turley 1992). This practice may once have been more widespread. In Bangladesh, villagers in the Sunderbans marshes still raise smooth otters in their homes and train them to wear harnesses and chase fish (Foster-Turley 1990b). Smooth otters are also used in Nepal as decoys for catching the Gangetic dolphin (*Platanista gangetica*) (Shrestha 1988). Smooth otters are maintained in 12 Indian zoos (Naidu and Malhotra 1989) and in a handful of other zoos throughout Asia.

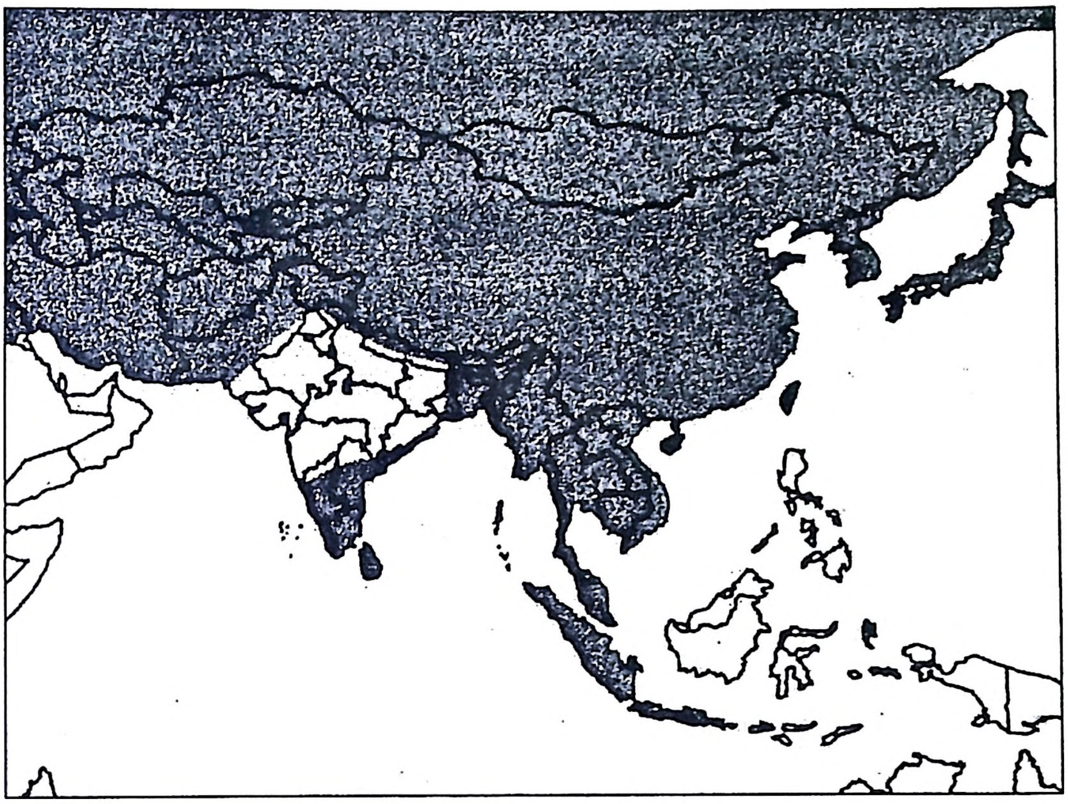
1.4.2. The Eurasian otter *Lutra lutra*, Linnaeus, 1758

The size and proportion of the Eurasian otter is almost similar to the smooth-coated otter but the Eurasian otter can be distinguished by its dense coat with grizzled guard hairs, the "W" shape of the upper margin of its rhinarium (Fig 1.7a, b) and its thicker tail in cross-section (Foster-Turley 1992). It has the widest distribution range of all the otter species, extending from Europe through northern Africa to Asia as far as Korea, Taiwan and Philippines (Mason and Macdonald 1986). In south Asia its occurrence has been confirmed from Afghanistan, Pakistan, India, Sri Lanka, Bangladesh, Nepal, Bhutan and Myanmar (Fig. 1.6). Seven sub-species are reported by Pocock (1941) (1) *L. l. lutra* in Europe and northern Africa (2) *L. l. nair* in southern India and Sri Lanka (3) *L. l. monticola* in northern India (Himachal Pradesh, Sikkim and Assam) Nepal, Bhutan and Myanmar (4) *L. l. kutab* in northern India – Kashmir (5) *L. l. aurobrunnea* in Garhwal Himalayas in northern India and higher altitudes in Nepal (6) *L. l. barang* in southeast Asia (Thailand, Indonesia and Malaysia) and (7) *L. l. chiensis* in southern China and Formosa. The total length ranges between 920-1200 mm, head to body 550-570 mm, tail length 35-375 mm (Foster-Turley 1992). The weight ranges from 4-

12 kg in females and 7-12 kg in male (Reuther 1991). The colour of the dorsal part in the Eurasian otters vary from rusty to dusky-brown, where as ventral side is lighter – sometimes up to grey or whitish. The lips and the throat show individual yellow, grey, or white spots. All four feet have five toes with strong claws and webs between the toes, which extend at least to the last bone of each digit (Pocock 1941).

This species has been well-studied in the European portion of its range (reviews by Chanin 1985 and Mason and Macdonald 1986) but very little is known about its habits in tropical Asia (Foster-Turley 1992). Unlike the smooth otter, the Eurasian otter is said to be found in high altitude habitats. In the Himalayas, Eurasian otters are reported to travel up to 3500 m altitudes in search of spawning trout during the summer, but return in winter to low altitude pools in the valleys of Kashmir (Foster-Turley 1992).

The Eurasian otter is primarily nocturnal, largely solitary and lives in wide variety of aquatic habitats, including highland and lowland lakes, rivers, streams, marshes, and coastal areas. Like most *Lutra* species fish is the major prey of the otters sometimes exceeding more than 80% of the diet (Erlinge 1968; Webb 1975 and Ruiz-Olmo and Palazon 1997). In addition to fish a whole range of other prey items have been recorded in the diet in variable proportions. These include aquatic insects, reptiles, amphibians, birds, small mammals, and crustaceans (Jenkins *et al.* 1979; Adrian and Delibes 1987; Skaren 1993 and de Silva 1996). Age at sexual maturity is around 18 months in male and 24 months in the case of female, but in captivity it is usually 3 to 4 years (Reuther 1991). The gestation period is approximately 65 days, the litter size varies from 1 to 5, and the life expectancy is around 17 years (Acharjyo and Mishra 1983).



Source: Hussain, S.A (1999).

Fig. 1.6. Range Map of Eurasian otter *Lutra lutra* covering Asia

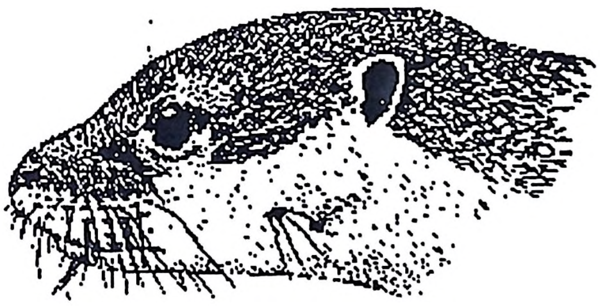


Fig 1.7a. Face of Eurasian otter *Lutra lutra*

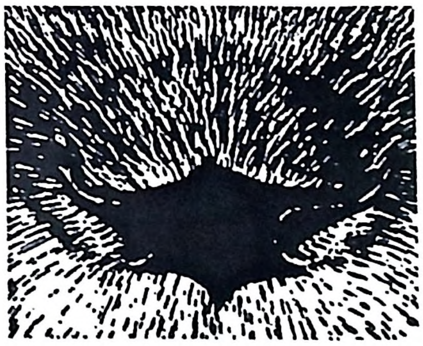


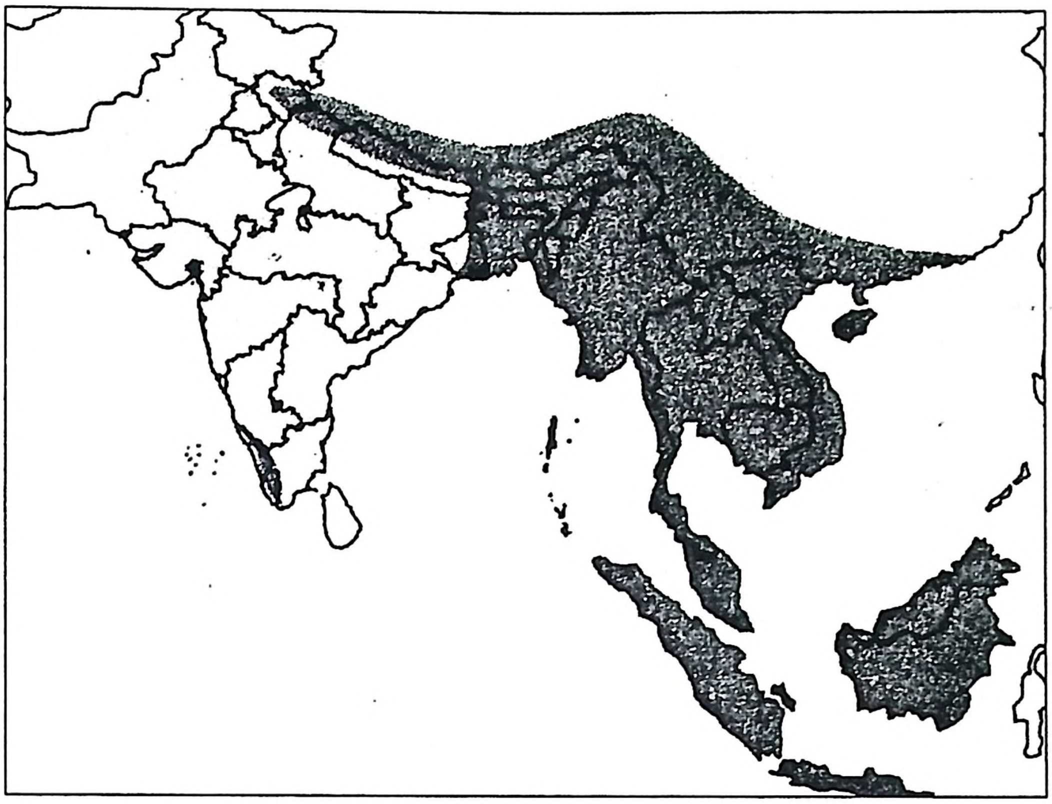
Fig. 1.7b. Rhinarium of Eurasian otter *Lutra lutra*

1.4.3. Small-clawed otter *Aonyx cinerea* Illiger, 1889

The Asian small-clawed otter is the smallest otter in the world, occasionally reaching weights of 5 kg (Foster-Turley 1992). These otters have unique hand-like front paws with reduced nails which are well-adapted for catching small vertebrate and invertebrate prey in shallow, murky water (Foster-Turley and Markowitz 1982). This adaptation is also reflected in the expanded tactile areas of their brain (Radinsky 1968). In most of their range they are sympatric with smooth otters (*Lutra perspicillata*) and often with hairy-nosed otters (*L. sumatrana*) or Eurasian otters *(L. lutra*) as well. The island of Palawan is the only location where small-clawed otters have not co-existed with another otter species (Foster-Turley 1992). The small-clawed otter has a large distribution range, from India in the west through Indonesia in Southeast Asia to Palawan (Philippines) and Taiwan in the east and southern China in the north (Pocock 1941 and Hussain 1999) (Fig. 1.8). Its presence has been confirmed from India, Nepal, Bhutan, Bangladesh, Myanmar, south China, Hainan Islands, Thailand, Laos PDR, Brunei, Malaysia, Vietnam, Indonesia (Sumatra, Java, Borneo), Taiwan and Philippines (Wozencraft 1993). Two sub-species are reported by Pocock (1941). (1) *A. c. concolor* in northeast India and Myanmar extending up to Sumatra (2) *A. c. nirnai* in the hill ranges of southern India.

The Asian small-clawed otter is small in size as compared to all other otter species, head and body measuring 406-635 mm, tail length 246-304 mm, total length 652-939 mm and weight ranging between 2.7-5.4 kg. The females are on an average only a little smaller than the males. It has distinctive webbed feet with the third and fourth digits markedly longer than second and fifth on each foot and all claws reduced to small rudiments, which do not project beyond the tips of the digits (Foster-Turley 1992).

In the wild, Asian small-clawed otters have been observed both singly and in groups and generally at night (Wayre 1978). Little is known about the wild behavior and ecology of this species, they are somewhat better known in captivity. In captivity these animals display a strong pair bond and both parents share the duties of rearing their offspring. As many as seven cubs can be born in a litter following a gestation period of approximately 60 days (Foster-Turley 1992). The interbirth interval can be as short as 10 months, with older siblings staying with the parents and helping to wean the next litter (Wilson *et al.* 1991). Females can begin breeding when only 15 months of age, but only the alpha female in the group breeds. Family groups can easily build up in this way to 15 or more animals, before the groups become too unwieldy for even the largest exhibits. To manage the captive population in United States zoos, same-sexed sibling groups are sometimes housed together. Introducing new, unrelated animals to established groups is generally impossible due to the high levels of aggression displayed. Introducing individual males to females, however, usually goes smoothly. Based on the information gleaned from captive management of this species, it is likely that the social groups observed in the wild (Furuyu 1976) are family groups. These otters have a fairly long history in zoos around the world and by the early 1970s had successfully reproduced in zoos in the United Kingdom (Leslie 1970; 1971 and Timmis 1971) and Australia (Lancaster 1975).



Source: Hussain, S.A (1999).

Fig. 1.8. Range Map of Small-clawed otter *Aonyx cinerea*

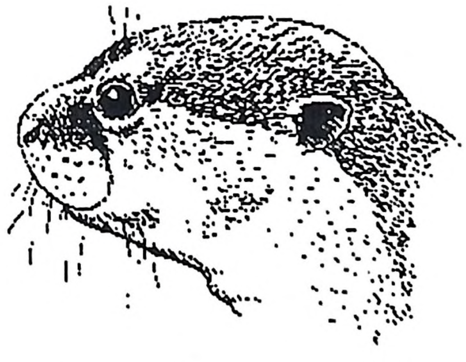


Fig. 1.9a. Face of Small-clawed otter *Aonyx cinerea*

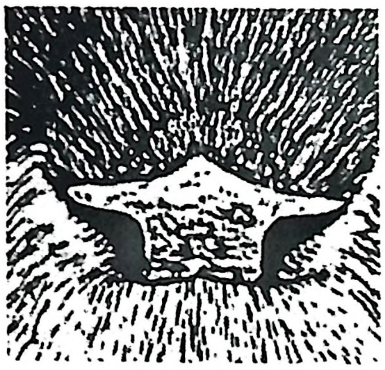


Fig. 1.9b. Rhinarium of Small-clawed otter *Aonyx cinerea*

1.5. Conservation efforts

Increasingly, otters are being used as the symbol for the survival of healthy aquatic environments, and programmes to conserve otters have gained momentum (Foster-Turley 1990a). Surveys to determine where otter populations still exist and where greater habitat protection measures are necessary are a first step. Parallel efforts involve research into such areas as the ecological requirements of otters, their reproductive biology, and the effects of deleterious pollutants in the food chain. Conferences and education efforts are needed to disseminate information on otter biology and to ensure the public's support of otter and wetland conservation endeavors (Foster-Turley 1992).

Otter conservation efforts in India lag far behind those in Europe and the rest of the world. Developing a practical and comprehensive programme for conserving otters for a developing country like India is a daunting task. The status of otters in India is feebly documented albeit there exists a specific wetland conservation policy that provides technical inputs for the conservation management of wetlands since 1988 (Hussain 1999). No national level co-coordinated research programme exists to assess the present status and related conservation shortcomings pertaining to otter conservation.

This study which forms a part of the major project initiated by the wildlife Institute of India in November 2000, attempts to appraise the impacts of making of dams on otter populations so as to assess the differences between canalized and non-canalized rivers and streams, their riparian vegetation, river bank morphology and woody debris, and the otter's utilization of these habitats. It is generally believed that dams affect otter populations due to the reduction of water flow downstream, denying access to prey and den sites. In India, it has never been quantified to what extent this affects the habitat use by resident otter populations (Hussain 1999) and hence the findings of this study can be used to formulate a model for similar studies elsewhere in the country.

Research on otters in Asia, date backs to 1988 when the first International Symposium on Asian otters was planned (Foster-Turley *et al.* 1990 and Hussain 1999). Since then two doctoral works have been carried out on smooth-coated otter, the first in National Chambal Sanctuary (Hussain 1993) and the other being on the ecology of the same species in two different habitats in south India by Satyanarayana (1997). A few short-term studies have also been conducted (e.g. Umapathy and Durairaj 1995; Nagulu *et al.* 1997; Haque and Vijayan 1995; Anoop 2001 and Shenoy 2003).

Practical habitat management activities ranging from basic field research programmes, to planning and advising Government in undertaking large-scale development projects on species specific habitat management with the active participation of local people is essential if otter conservation attempts are to succeed.

1.6. Legal and conservation status

All the three species of otters are protected in India under the Wildlife (Protection) Act, 1972 and are listed as endangered. Eurasian and smooth-coated otter are listed under Schedule II while small-clawed otter is listed under Schedule I, which provides complete protection from hunting. Also, Eurasian otter is listed in Appendix I and smooth-coated and small-clawed otter are listed in Appendix II of CITES (Hussain 1999).

1.7. Literature review

1.7.1. Distribution and status of otters

The Eurasian otter has the widest distribution range of all the otter species extending from Europe through northern Africa to Asia as far as Korea, Taiwan and Philippines (Mason and Macdonald 1986). In south Asia its occurrence has been confirmed from Afghanistan, Pakistan, India, Sri Lanka, Bangladesh, Nepal and Bhutan. In east Asia the otter seems to be extinct in Japan and there is no report of its occurrence from the eastern parts of Pakistan and the central and western parts of India. Besides, it seems that the Eurasian otter reached the island of Sumatra but did not reach the island of Java (Reuther 1991). Israel, Jordan, Iraq and Iran form the southern border of the Eurasian otter's range in the near and middle East. As is shown by reports from Morocco, Algeria and Tunisia in Africa, the Eurasian otter is found north of the Sahara only (Reuther 1991). Seven sub-species were reported by Pocock (1941); (1) *L. l. lutra* – occur in Europe and northern Africa (2) *L. l. nair* – in southern India and Sri Lanka (3) *L. l. monticola* - in northern India (Himachal Pradesh, Sikkim and Assam) Nepal, Bhutan and Myanmar (4) *L. l. Kutab* – in northern India (Kashmir) (5) *L. l. aurobrunnea* – Garhwal Himalayas in northern India and higher altitudes in Nepal (6) *L. l. barang* - South-east Asia (Thailand, Indonesia and Malaysia) and (7) *L. l. chiensis* – Southern China and Formosa.

The smooth-coated otter is distributed throughout southern Asia from Indonesia, through Southeast Asia, and westwards through southern China, India and Pakistan, with an isolated population in Iraq (Pocock 1941; Hussain 1993 and Hussain and Choudhury 1997). Though its current status in the middle east including Iraq is not known, its presence has been confirmed from Nepal, India, Bangladesh, Bhutan, Southwest China, Mynamar, Thailand, Vietnam, Malaysia, Sumatra, Java and Borneo (Mason and Macdonald 1986). Three sub-species existed (Pocock 1941). Two are reported from British India including Pakistan and Mynamar, and from Malay Peninsula including Sumatra (Pocock 1941). (1) *L. p. perspicillata* – occurs in Northeast and in southern India, locality type Nepal Tarai and Madras, Mynamar (Burma) and Sumatra (2) *L. p. sindica* – occurs in north and north-western India, locality type Chak in the Sukkur district of Sindh (now in Pakistan). Another sub-species, *L. p. maxwelli* reported from the marshes of southern Iraq (Mason and Macdonald 1986) whose current status is uncertain.

The Asian small-clawed otter has a large distribution range, from India in west Asia through Indonesia in Southeast Asia to Palawan (Philippines) and Taiwan in the east and southern China in the north (Pocock 1941). Its presence has been confirmed from India, Nepal, Bhutan, Bangladesh, south China and Hainan Islands, Thailand, Laos PDR, Brunei, Malaysia, Vietnam, Indonesia (Sumatra, Java, Borneo) Taiwan and Philippines (Wozencraft 1993). Pocock (1941) reported two subspecies from India. *A. cinerea concolor,* Rafinesque, 1832 which occurs in Himalayas from Kulu eastwards from entire northeast India, locality type – Garo hills, Assam. *A. cinerea nimai* Pocock, 1939 occurs in southern India, locality type – Virajpet in south Coorg.

The distribution and status of the otter was long a matter of guesswork in the past and largely depended on information gathered through questioners, until standardized field surveys were initiated. In most of the studies, the methodology of the survey involving a search for signs of otter activity has been adapted from Macdonald (1983). Indirect evidences such as; spraints, footprints and holts are the obvious signs looked for in the field. The studies have been conducted by laying a linear transect along the shoreline, often dividing the area into different zones using landmarks (Hussain and Choudhury 1997). Some notable studies that have been attempted to assess the status and distribution pattern of otters include works by Macdonald and Mason (1985) in northeast Greece.

Information on the status of otter population in India is still scanty. There seems to be a rapid decline in otter population due to loss of habitat and intensive trapping (Hussain and Choudhury 1997). The earliest authentic report of the occurrence of otters in the Tarai, Garhwal and Kumaun areas (lower Himalayas) have been given by Hinton and Fry (1923). Lamba (1980) reported sightings of *L. lutra* in groups of 5-15 along the Ramganga River and the Reservoir. A preliminary study by Hussain (1998) revealed a small population of otters living in a 14 km stretch of the Ramganga River. Recent surveys (*e.g.* Hussain and Choudhury 1997; Nagulu *et al.* 1997 and Hussain 1998) have confirmed that the otters have declined in numbers and now occur as isolated populations restricted mostly to Protected Areas. Lack of baseline data on the ecology of otters is one of the major constraints facing otter conservation thus necessitating status survey of otters in India.

1.7.2. Factors affecting distribution

Otters in different regions may depend upon differing features of habitat and their choice of resting sites appears catholic (Mason and Macdonald 1986). Holes in the riverbank, cavities amongst tree roots, piles of rock, wood or debris may all be used. Initial studies on the River Teme catchment in western England (Macdonald *et al.* 1978) suggested that otter distribution related to the availability of possible resting sites, to the density of bankside vegetation and to the density of mature ash (*Fraxinus excelsior*) and sycamore (*Acer pseudoplatanus*) trees. Fish stocks can also be affected by a lack of bankside trees. Shading helps to maintain water temperatures and oxygen levels that are suitable for salmonids (Meehan *et al.* 1977 and Karr and Schlosser 1978). Under water, roots provide hiding and feeding places for fish. In a situation where instream cover of this sort had been removed during management of an English river, Swales (1982) found that the mean standing crop of the fish population fell by 76%. Jenkins and Burrows (1980) and Bas *et al.* (1984) working in north – east Scotland, also found that sprainting activity by otters correlated with the presence of riparian tree roots and with bankside woodland.

A lack of trees is not; however, always detrimental to otters, so long as other forms of shelter are readily available. On the coast of Scotland, Norway and Portugal, holts were found amongst rock falls (Kruuk and Hewson 1978 and Macdonald and Mason 1980). Similar sites were found on Portuguese and Spanish rivers (Macdonald and Mason 1982 and Elliot 1983). Dense scrub also provides cover. While radio-tracking otters, Green *et al.* (1984) found many resting sites situated above ground. Some of these were simply depressions in vegetation no more than 30 cm high, but most were associated with *Salix* scrub, *Rhododendron* or *Polygonum cuspidatum*. In the absence of trees or scrub, marshland with Phragmites or tussock sedge provides ideal cover for otters. Jenkins *et al.* (1979) when surveying the catchment of the western Cleddau in west Wales recorded all signs of otters from the wild marshes in upper reaches. Thus, it is important that the riparian vegetation be dense and that an otter, once disturbed can slip away unseen to find another refuge (Mason and Macdonald 1986).

1.7.3. Habitat Use

Otters habitat appears to be extremely variable, however, more accurately it can be characterised as a narrow strip on either side of the interface between water and land by being to some extent one-dimensional, linear (Kruuk 1995). Stumpf and Mohr (1962) asserted that the expression of home range in terms of linear units is justifiable for a number of species, including otters, and home ranges of otters living in riverine habitat are often estimated in linear units (Erlinge 1967 and Melquist and Hornecker 1983). Similarly, the length of coastal shoreline has often been used to quantify the home range of otters living in marine habitats (Kruuk and Hewson 1978 and Arden-Clarke 1986) and Lacustrine habitats (Erlinge 1968). The linearity of the habitat also makes confrontation more inevitable that could affect competition for resources. In such case, Kruuk (1995) has suggested random dispersion, with tolerance between individuals by some kind of group territorial system among otters. It is possible that otter's general pattern of a group territorial system is not adaptive but merely, or partly, a consequence of phylogenetic inertia (Kruuk 1995). Moreover, there appear to be differences in the spatial organization in different areas, and there is variation in group size and range size, which can be, explained in terms of adaptation to environmental characteristics in which resource dispersion hypothesis (Macdonald 1983 and Carr and Macdonald 1986) plays an important role.

The Eurasian otter is found in a wide variety of aquatic habitats, including highland and lowland lakes, rivers, streams, marshes, swamp forests and coastal areas independent of their size, origin or latitude (Mason and Macdonald 1986). In the Indian sub-continent Eurasian otter occur in cold hill and mountain streams. In summer (April-June) in the Himalayas they may ascend up to 3,660 m. These upward movements probably coincide with the upward migration of the carp and other fish for spawning. With the advent of winter the otter come down to lower altitude (Prater 1971). In a study conducted in Thailand in Hui Kha Khaeng where Eurasian, smooth-coated and small-clawed otter live sympatrically, Kruuk *et al.* (1994) found that the Eurasian otter used rapidly – flowing upper parts of the river. In Sri Lanka the Eurasian otter was found in the headwaters of all five river systems but not in the estuary (de Silva 1997). In Europe the Eurasian otter is found in the brackish waters below sea level in the Netherlands as well as up to 1,000 m and more in the Alps or the Pyrenees (Ruiz-Olmo *et al.* 1989) and above 3,500 m in the Himalayas (Prater 1971) or 4,120m in Tibet (Mason and Macdonald 1986). The Eurasian otter seems to be very adaptable, using saltwater as well as freshwater habitats, sewerage systems in urban areas or rivers in Asia. In most parts of its distribution ranges otter distribution is correlated with bank side vegetation showing importance of vegetation to otters (Mason and Macdonald 1986). Otters in different regions may depend upon differing features of the habitat, but to breed they need holes in the river bank, cavities among tree roots, piles of rock, wood or debris. The Eurasian otter avoids deep water from a negative energetic balance. Otter distribution in coastal areas especially the location of holts, is strongly correlated with the presence of freshwater (Kruuk and Balharry 1990 and Beja 1992).

Hussain (1993) and Hussain and Choudhury (1997) have found that along the large rivers in India, the smooth-coated otter shows greater preference for rocky stretches in all the seasons, since these stretches provided sites for den and resting. Stretches with bankside vegetation and marsh were used in proportion to their availability especially in summer as they provide ample cover while travelling or foraging. Open clayey and sandy banks were largely avoided as they lack escape cover. The habitat is sub-optimal since these rocky stretches are found in patches and are under pressure (Hussain 1993). In the Tarai areas of the Upper Gangetic plains the seasonally flooded swamps dominated by *Phragmites karka, Arundo donax, Sclerostachya fusca, Carex obuscuriceps* and *Cynodon dactylon* communities interspersed with *Syzigium* spp. were extensively used by smooth-coated otters during monsoon (July-September) and in early winter (October-February).

In most of their range the Asian small-clawed otter are sympatric with smooth-coated and Eurasian otters. In India all the three species occur in Southwest India particularly from Western Ghats and possibly in the hills of Uttar Pradesh and Assam. In south India they are mostly found along the hill streams. They were once common in the mangroves of east Calcutta and Sunderbans (Sanyal 1991). In Malaysia and Indonesia including Java they occur in coastal wetlands, and along the banks of paddy fields. Comparable data from Java, Mynamar and India reveals that the Asian small-clawed otters have a high climatic and trophic adaptability in south and Southeast Asian tropics, occurring from coastal wetlands up to mountain streams (Melisch *et al.* 1996).

Studies on habitat use by otters are few and this is true especially for Asian otter species where there is little information available on their ecology (Foster-Turley 1992). Distribution of field signs has been used to study habitat use by otters (*e.g.* Jenkins and Burrows 1980; Mason and Macdonald 1983; Bas *et al.* 1984 and Kruuk *et al.* 1986). However, these methods were criticized because the patterns of field signs are difficult to interpret because there are a number of factors influencing them and hence these measures alone cannot be used as a direct indicator. Later on, radio-tracking studies were initiated; nonetheless minor problems persisted such as; unobtrusive and trap shy behaviour of the animal and nocturnal activity in some of its distribution ranges (Durbin 1993). Published studies on habitat use of otters based on radio telemetry are few. Kruuk *et al.* (1993) studied the niche differentiation between the three species of otter occurring sympatrically in the Huay Kha Khaeng Province (Western Thailand), the habitat use pattern of smooth-coated otter was studied in the National Chambal Sanctuary by Hussain and Choudhury (1997). The most recent of these studies being that of Perrin and Carranza (2000) on the habitat preferences of the spotted necked otter *L. maculicollis* in Kwa Zulu-Natal Drakensberg, South Africa.

1.7.4. Feeding ecology

Diet and feeding habits of otters is one aspect of their ecology that has been studied widely in different parts of the world (summaries in Mason and Macdonald 1986). Of the seven species of river otters in the world, the diet and feeding of the Eurasian otter has been studied most widely: Erlinge (1968) discusses that of captive European otters, Kruuk *et al.* (1994) discuss that of the Eurasian otter in Thailand. The food and feeding of other river otter species studied include; in Africa, the cape claw-less otter *Aonyx capensis* and spotted necked otter *Lutra maculicollis* (Rowe-Rowe 1977); in India, the smooth-coated otter *Lutra perspicillata* (Haque and Vijayan 1995; Hussain and Choudhury 1997 and Anoop and Hussain 2005); in Thailand, the oriental small-clawed otter *Aonyx cinerea* (Kruuk *et al.* 1994) and smooth-coated otter *L. perspicillata* (Kruuk *et al.* 1994). Little information is available on the diet of the south east Asian hairy-nosed otter *Lutra sumatrana* and the Zaire clawless otter *Aonyx congica*. Early studies suggested that otters were opportunistic, foraging on the prey most vulnerable to capture (Erlinge 1968), however, later work has suggested that otters may be more selective than once thought, particularly when a greater number of species are available (*e.g.* Kruuk and Moorhouse 1991). Food preferences, hunting strategies and seasonal changes in the diet can be influenced by latitude, habitat, and available prey biomass and prey activity. Cyprinid fish feature heavily in otter diet from lowland eutrophic lakes, ponds and rivers (Webb 1975 and Brzezinski and Jedrzejewska 1993) whilst salmonid fish are more important in highland or oligotrophic areas (Carss *et al.* 1990 and Ruiz-Olmo and Palazon 1997). In rivers with a low diversity of prey, otters tend to feed on few species only, however, where populations are diverse, the otter's diet may comprise several prey categories, though many of these will be taken in small amounts (Roche 1998). Coastal otters feed mainly on inter-tidal or benthic species (Kruuk and Moorhouse 1990), although they may alternate between marine and freshwater habitats (Kruuk *et al.* 1986). In winter, some fish (*e.g.* eel, *Anguilla anguilla*) become harder to catch as they become torpid and bury themselves in mud, conversely, in summer other species (*e.g.* trout, *Salmo* sp.) may become harder to catch as they are able to move more quickly (Mason and Macdonald 1986). Fish migrations, whether for spawning or overwintering, can temporarily increase the availability or biomass of some species. Pike (*Esox lucius*) or salmonids are often taken in higher numbers following spring spawning runs, when they become weak and easy to catch (Carss *et al.* 1990).

Otters are capable of taking quite large fish; pike of over 9 kg have been recorded (Chanin 1985) and carp of over 60 cm were regularly taken during the winter of 1998 from commercial fish ponds in the Czech Republic (Roche pers. observation), however, in general, large fish tend to be taken infrequently (Anoop 2001). There is some evidence of different size/weight preferences between otters of different sexes and ages (Foster-Turley 1992) showed that males took larger fish than females, with adult males taking the largest, and that mothers ate smaller fish than those she fed to her cubs. Kruuk (1995) recorded that cubs and sub-adult otters in coastal areas had a larger proportion of less profitable crustaceans in the diet compared with adults and related this to low foraging efficiency in younger animals. As well as these general trends, individual otters developed specialisation for particular prey species, *e.g.* rabbits. Captive otters fed on a wide range of species have been seen to develop individual food preferences (Green pers. observation). Different methods have been employed to assess the diet of otters, *i.e.* direct observation, examination of feeding sites, analysis of stomach contents and spraints (Webb 1975). Many of the prey items that the otters feed on can be identified and their size classes can be estimated fairly accurately by direct observation (Kruuk and Moorhouse 1990) but in areas where they are nocturnal in habit this method is of no use. Feeding sites could give clue only about larger prey specimens, which are eaten when the otters are out of water but since most of the fish are eaten in the water itself, this method too is of not much use. Gut content analysis is the best method for dietary studies of otters but this would involve killing of animals (Webb 1975). There is only one published report on food habits of otters by using gut content analysis (Fairley 1972). This was done by analysing the guts of 33 otters, which were drowned to death in fish traps.

Seasonal variations in the composition of the diet of otters have been observed and are often related to the seasonal changes of the ecological factors. For instance, Erlinge (1967); Webb (1975); Kruuk and Moorhouse (1990) and Weber (1990) studied this phenomenon in *L. lutra*. Seasonal variation in food composition is known also in other species of otter, such as; *Aonyx capensis, L. maculicollis* (Rowe-Rowe 1977) and *L. perspicillata* (Haque and Vijayan 1995).

1.8. Rationale

The Tarai Bhabar was once a stronghold of otters. The earliest report of the occurrence of otters in the region comes from (Hinton and Fry 1923). All the three species of Indian otters have been reported from the region. However, increasing development activities and anthropogenic pressures in the region have led to disappearance of otters from many streams and rivers which were once major otter habitats, so much so that otters are now reported only from the protected areas (Hussain 1998). With upcoming developmental projects and increasing levels of human pressures, it is imperative that detailed ecological studies be initiated so as to conserve otters as the key wetland species. This study was initiated with the perspective of conserving otters at landscape level and that similar studies could be repeated elsewhere in the country. In the Corbett Tiger reserve both smooth-coated and Eurasian otter have been reported. Our preliminary survey revealed that at the low lying areas such as the Ramganga, Mandal and Palain rivers, smooth-coated otter occurs. This study complies with smooth-coated otter limited to the above mentioned areas only and data were collected for winter and summer seasons respectively between 2001 and 2004.

1.9. Objectives

The study was conducted with the following objectives:

(a) To study the status and distribution pattern of smooth-coated otters in the Corbett Tiger Reserve and the adjacent aquatic ecosystems.

(b) To examine the Resource use pattern of smooth-coated otters in relation to habitat and food availability.

(c) To study the potential threats to smooth-coated otter populations in the study area.

1.10. Organisation of the thesis

The entire efforts for the thesis work and its outcomes have been synthesized into six chapters *viz.* 1) Introduction, 2) Study Area, 3) Status and distribution, 4) Habitat use, 5) Food and feeding habits and 6) Threats. Chapter 1 discusses the biological, behavioural and conservation attributes of otters in general and the species under study in particular. It essentially provides the background to the research, highlighting the lack of information for conservation of otters in Corbett Tiger Reserve and the necessity to undertake the present ecological study. Chapter 2 describes the study area in terms of both physical and biological characteristics. Chapters 3-6 maintain independent identities in the form of research papers and the research questions addressed in the individual chapters are dealt in separate Introduction followed by detailed Methodology, Results and Discussion. The current status and distribution of otters and their associated fauna in Corbett Tiger Reserve are given in Chapter 3, which also includes the abundance estimates of otters and their associated fauna obtained across the sites, season and years are presented in this chapter. Chapter 4 deals with the otter-habitat association and the factors that influence habitat choice.

Food and feeding habits of otters have been discussed in detail in Chapter 5. Potential threats to otter populations in Corbett Tiger Reserve and adjacent areas are given in Chapter 6. Though these chapters stand independent to a large extend, they certainly maintain a logical order. The literatures that were referred to and cited in all these chapters have together been compiled and listed at the end under References. An appendix on the Icthyofauna of Corbett Tiger Reserve has been appended at the end.

1.11. Summary

Otters are semiaquatic members of the family mustelidae that eveolved 30 million years ago. There are 13 species of otters placed in four genera of which three species are found in India. All the three species of Indian otters have been reported from the Himalayan Tarai region, however; increasing development activities and anthropogenic pressures in the region have led to disappearance of otters from many streams and rivers which were once major otter habitats, so much so that otters are now reported only from the protected areas. With upcoming developmental projects and increasing levels of human pressures, it is imperative that detailed ecological studies be initiated so as to conserve otters as the key wetland species. This research was initiated with the perspective of conserving otters at landscape level and that similar studies could be repeated elsewhere in the country. In the Corbett Tiger reserve both smooth-coated and Eurasian otter have been reported. This study complies with smooth-coated otter limited to the low lying areas such as the Ramganga, Mandal and Palain rivers.

CHAPTER 2

STUDY AREA

2.1. Introduction

The Himalayan region of India has a distinguished status in having premier Corbett Tiger Reserve, lying in the foothill of outer Himalayas within the districts of Nainital and Pauri Garhwal that spreads over an area of 1288.32 km^2. The reserve has aptly been described as the land of roar, trumpet and song and it presents a scene of remarkable beauty. In 1956-57 it got its recognition with the name of Jim Corbett, a renowned hunter turned conservationist; who was instrumental in setting up the reserve. This reserve saw luck when it became part of Project Tiger and was chosen as a venue for inauguration of this project in 1973. Corbett Tiger Reserve forms an important repository of the natural heritage of Uttarakhand and is one of the best-protected areas of the Sal forest in Siwalik ranges, perhaps the last refuge of a number of endemic, depleted and threatened animal species in the Himalayan Terai (Lamba 1980).

2.2. History

The Corbett Tiger Reserve was established as India's First National Park on 8th August 1936, with the date on which the Uttar Pradesh National Parks Act came into force, and christened Hailey's National Park after Sir Malcolm Hailey, the then Governor of Uttar Pradesh, who was influential in its creation. Post independence, its name was changed to Ramganga National Park in 1954 and then in 1957 to its present name Corbett National Park, in memory of Jim Corbett, the legendary hunter and naturalist who had helped in marking out its boundaries and setting it up. With the launching of Project Tiger on 1st April 1973, Corbett National Park was selected as one of the tiger reserves and has the distinction of being chosen as the venue for the inauguration of this project on 1st February 1974. In past, the forests were considered to be the property of the ruling power and formed the source of revenue to the state. These were an exclusive shooting area to erstwhile Viceroys, Governor-Generals and other dignitaries. It was Sir Malcolm Hailey then Governor of U.P, who set aside 257 km^2 of forest as protected area. The area of the National Park was increased from 323. 75 km^2 to its present size of 520.82 km^2 in 1966, to enhance its integrity and to compensate for the land due to the submergence, because of the construction of a hydel dam at kalagarh.

2.3. Physical attributes

2.3.1. Location

Corbett Tiger Reserve is situated at the foothills of the Himalayas in the civil district of Nainital and Pauri Garhwal in Uttarakhand, carved out of former Uttar Pradesh State in 2000. The area lies between Latitudes 29°25'N to 29°40'N and Longitude 78°5'E to 79°5'E. Ramnagar is the Headquarter of Project Tiger and is an obligatory point to go to the Park. It is about 250 km from Delhi and 240 km from Dehradun. Ramnagar is well connected with New Delhi and Dehradun by roads and as well as railways. Pantnagar is the nearest airport, which is about 80 km from Ramnagar.

2.3.2. Biogeographic location

The Reserve falls under the Himalayan Realm as far as the floristic regions of the world are concerned and under the Oriental region of the world's zoogeographical regions (Singh and Pandey 1986).

2.3.3. Area

Corbett Tiger Reserve encompasses a total of 1288.32 km^2. This is represented by 520.82 km^2 of National Park, 301.18 km^2 of Sonanadi Wildlife Sanctuary and the remaining 466.32 km^2 as buffer area. The area is more or less trapezoidal in shape with average length of 35 km and width of about 32 km. To the original area of 323.75 km^2 of National Park, 197.07 km^2 was added later in 1966 and the legal boundaries of the National Park were notified vide Government order No. 4229/XIV-A-867-62, dated August 24, 1966. Sonanadi Wildlife Sanctuary came into existence in 1987 notified vide Government order No. 5434/14-3-139/82, dated January 9, 1987. The reserve forest buffer area of National Park, which together comprises Ramnagar Tiger Reserve Division, was added to the Corbett Tiger Reserve in the year 1991 by incorporating areas from Ramnagar Forest Division and Terai West Forest Division.

2.3.4. Topography

The reserve is confined to the Bhabar tract of Siwalik formation at altitudes of 350-1210 m, with varied topography of many temporary marshy depressions, ravines and plateau land. A series of more or less parallel ridges run from North West to South East decreasing in height, southwards towards the plains. The largest and the longest (though not the highest) runs through the Park in an East-west direction from Sajgadi *Sot* to Ledpani *Sot*. To the south of this median ridge are a number of small ridges lying in North-southwest direction. The two larger ones of these join the median ridge at Tunirokhar *Sot* and Chhotakoti *Sot*. Every aspect and degree of slopes are, therefore, represented but the general aspects are chiefly Northern and Southern and the slopes moderate to steep. An important topographical feature is the Patlidoon, an elevated valley with a fairly wide, almost level floor through which the Ramganga flows in westerly direction before turning south at Buxar to the plains. To the south rising from the plains there is hilly belt of varying width, where the ground is extremely rugged and broken up with steep and precipitous slopes on Siwalik sand rock formation and cut in every direction by rains and streams, many of which are severely dry except during and after the rains.

2.3.5. Geology and edaphic characters

The Geological distribution has a significant influence on the distribution of various forest types because of related differences in drainage, soil depth, fertility and terrain. The soil presents endless variety wherever the sand rock crops out and on all southern aspects of Siwalik conglomerate the soil is almost always sandy and shallow. On *dun* like flats the soil is deep fresh though stony. Northern slopes have well drained sandy to sandy loam soil capable of carrying good forest. The general sequence of Geological formations of the area may typically be represented in ascending order as follows:

1. **Recent Deposits**
   (a) Horizontal river gravel alluvium
   (b) Deposits of Bhabar Zone
2. **Shivalik Series**
   (a) Upper Shivalik Conglomerates
   (b) Middle Shivalik Sand Rock
   (c) Lower Shivalik (Nahan) Sandstone
3. **Great Boundary Fault**
4. **Older Himalayan Rock**
   (a) Upper Tal
   (b) Lower Tal
   (c) Basic Effusives
   (d) Krol

(e) Infra Krol

(f) Naghthat

(g) Chandpur

(h) Metamorphics

The configuration of the terrain presents numerous variations with forests situated at the foothills of the Himalayas. A series of more or less parallel ridges run from North West to South East decreasing in height, southwards towards the plains. To the south rising from the plains there is hilly belt of varying width, where the ground is extremly rugged and broken up with steep and precipitous slopes on Shivalik sand rock formation and cut in every direction by rains and streams, many of which are severally dry except during and after rains.

2.3.6. Drainage pattern

The total drainage system in the area is controlled by lithology and the tectonic features, besides the climatic effects. Rivers flowing along the strike of the litho-units present an overall parallel drainage pattern with dendritic to sub-dendritic trellis (Mithal and Joshi 1982). The system comprises of River Ramganga and its major tributaries i.e. Rivers Sonanadi, Mandal and Palain; with many small tributaries (Sots) of their own, which remain dry for most part of the year. The valleys of the streams are wide along the strikes or the lithologic contacts but form narrow steep gorges while cutting through the rock units. River Ramganga is the first major rain fed tributary on the left side of the River Ganga. It originates in the lower Himalaya at a height of 3110 m above M.S.L; a little north of the village Lohaba in the Pauri Garhwal District, Uttarakhand; and flows over the unstable Himalayan formations for about 168 km from its source to its debouching point at Kalagarh. The catchment encompasses a total area of 3134 km^2 and the rivers and their tributaries make up to six or seven order basins (Mithal and Joshi 1982), the third order basins are three hundred and one while the six and seven orders total to six (Table 2.1). All major tributaries originate in the north-western part of the water divide and flow in a NW-SE to NNW-SSE direction to meet River Ramganga. Ramganga, enters the Park from the north-east near Gairal Forest Rest House, runs a south-westerly course up to Sarapduli Forest Rest House, bends to flow in north-west direction up to its confluence with the reservoir near Dhikala Forest Rest House and changes course to south-west again to emerge out of the Park at Kalagarh (Lamba 1980). Joshi (1994) reported that there is no pollution (organic) load in Ramganga and that the river is biologically productive due to moderate temperature, low current velocity (low gradient) and preponderance of large deep pools and oxbow lakes (Table 2.2). The dam constructed in 1962, at the confluence of Sonanadi and Ramganga River near Kalagarh, about 24 km from Dhikala has created a vast reservoir spreading over an area of about 80 km^2 of which 42 km^2 falls in Corbett National Park, the remaining area being in Sonanadi Wildlife Sanctuary; also provides a perennial source of water to the reserve. River Kosi, flowing along the eastern boundary of the reserve, is another important perennial source of water (Bhartari 1999). During the rainy season, most of these streams are flooded for short periods and waters are heavily laden with silt, sand, boulders etc. and flow with torrential velocities causing damage to the adjoining banks and low lands. The drainage system is having greater conservation implication since distribution and abundance of several wildlife species are known to revolve around these water sources.

Table. 2.1. Number of third order basins in different tributaries. (*Source* - Mithal and Joshi 1982).

Name of tributaries	**No. of IIIrd. Order basins**	**Lower Shivalik sand-shales**	**Middle Shivalik sand-shales**	**Lime-stones**	**Quartzites**	**Phyllites**
Sona Nadi	39	-	39	-	-	-
Mandalti	75	23	-	2	3	7
Mandal	76	-	-	24	19	-
Deota	22	-	-	-	15	-
Other basin	89	22	-	-	19	7
Total	301	45	39	26	56	14

Table. 2.2. Seasonal fluctuations in the limnological characteristics of River Ramganga during 1989-1990. (*Source* – Joshi 1994).

Limnological characteristics	**Winter (Dec – Mar)**	**Summer (Apr – Jun)**	**Monsoon (Jul – Sep)**	**Autumn (Oct – Nov)**
Air temperature (°C)	9.50	31.50	20.5	13.00
Water temperature (°C)	11.20	23.50	18.4	12.70
Water velocity (m/sec)	0.60	0.42	1.20	0.70
Turbidity (%)	0.35	0.48	16.15	2.85
Sediment load (tons/day)	150.35	127.70	7585.20	610.40
pH	7.90	7.52	8.65	8.05
Free CO_2 (mg 1^{-1})	1.60	1.85	7.40	2.40
Dissolved O_2 (mg 1^{-1})	12.80	8.50	7.30	10.00
Chloride (mg 1^{-1})	6.70	9.05	5.80	5.35
Phytoplakton (U ml^{-1})	19.80	8.80	6.20	13.30
Zooplankton (U ml^{-1})	2.85	2.15	0.62	2.10

Fig. 2.1. Map of Study Area (IRS LISS – III Image of Corbett Tiger Reserve).

2.4. Ecological attributes

2.4.1. Climate

The general climate is tropical with three distinct seasons – winter from November to February, summer from March to June and monsoon from mid June to October (Bhartari 1999). These seasons play a crucial role in the ecology of the habitat, distributing advantages and disadvantages so as to maintain a fragile balance between all life-forms. The temperature normally ranges from 3°C in December – January to 42°C in June. The maximum winter temperature rarely exceeds 30°C whereas the minimum summer temperature normally remains below 23°C. The maximum shade temperature seldom exceeds 44°C even in the hot weather. Since the study area is located in the forested foot hills of the outer Himalaya, it remains adequately humid throughout the year. Maximum average relative humidity reaches 98 per cent during monsoon months and during the drier period it has never been recorded below 57 per cent. From November to February the nights can be very cold with much frost and dew, and in low lying localities such as Patli dun a dense fog lingers often till after 10 A.M. From March to the onset of Monsoons, frost and fog are absent, but dew is deposited until April. A valley wind, locally known as *Dadu* blows down the valley beginning about 9 P.M and dying about 8 A.M. This brings down the night temperature. In the hot month from mid March to mid June the *Dadu* is followed by a hot wind blowing up the valley from 10 A.M to 8 P.M, during this period the air becomes very dry with much dust in suspension giving rise to a thick haze, which is only interrupted by thunderstorms. South-West Monsoons are the main source of rainfall. Maximum rainfall occurs from mid June to September, August being the month of maximum rainfall. Premonsoon showers or thunder showers often accompanied by hail occur in the months of April and May (Lamba 1980).

2.4.2. Floral diversity and vegetation types

The area is represented by a large number of forest types, which is influenced by a variety of locality factors such as geology, altitude, aspect, slope, soil depth and texture and biotic disturbances. Three forest types of Champion and Seth (1962) classification are found in the area (Bhartari 1999), Table 2.3.

According to Pant (1986) major area of CNP consists of mixed deciduous tropical and sub-tropical forests which are further grouped into 9 forest types, they are; (i) Moist Siwalik 'SAL' forest (ii) High alluvium 'SAL' forest (iii) Dry Siwalik 'SAL' forest (iv) Northern Tropical Dry Mixed Deciduous forest (v) Moist Savanna forest (vi) North Indian moist deciduous forest (vii) Khair-Sissoo forest (viii) Dry Bamboo brakes (ix) Himalayan Sub-tropical forest. He reported a list of 617 species of flora from CNP. This was represented by 594 species of angiosperms, 1 species of gymnosperms and 22 species of ferns and fern allies. The latest addition to flora of CNP is a list of 69 species of lichens by Upreti and Chatterjee (1999). Purely aquatic vegetation is scarce in the park area, *Potamogeton nodosus* and *P. crispus* are among the typical aquatic plants in the park. However, other herbaceous species characteristic of moist marshy or water logged area include; *Cyanotis cristata, Polygonum glabrum, P. hydropiper, Bacopa monnieri, Ranunculus sceleratus, Veronica anagallis, Lippia nodiflora, Rotala mexicana, R. indica, Limnophila indica, Nasturium officinale, Centella asiatica and Typha angustata*. The only indigenous conifer in the Park is *Pinus roxburghii* (Chir) in the compartment No. 9/10, at Ghilmodya *Sot*. Based on visual interpretation of (IRS 1B/LISS II/ FCC, 1994) remote sensing data, 13 types of vegetation classes have been documented in CNP (Pant and Chauhan 2000), Table 2.4.

Table 2.3. Forest types of Champion and Seth (1962) classification found in Corbett Tiger Reserve.

S.No.	Forest types	Nomenclature
1.	Sub-Group 3C:	North Moist Deciduous
1.1	3C/C2a	Moist Siwalik Sal
1.2	3C/C2b(1)	Moist Bhabar Dun Sal
1.3	3C/C3a	Western Gangetic Moist Mixed Deciduous
2	Sub-Group 5B:	Northern Tropical Dry Deciduous
2.1	5B/C1a	Dry Siwalik Sal
2.2	5B/C2	Northern Dry Mixed Deciduous
2.3	5/IS2	Khair-Sissoo Forest
3.	Sub-Group 9:	Himalayan Sub-Tropical Pine Forest
3.1	9/C1a	Lower Siwalik Chir Pine Forest

Table 2.4. Vegetation classes based on visual interpretation of (IRS 1B/LISS II/ FCC, 1994) remote sensing data.

S.No.	Vegetation class	Area (sq. km)
1.	Sal	109.50
2.	Sal-mixed	64.50
3.	Mixed-sal	111.13
4.	Miscellaneous	120.82
5.	Bamboo mix	13.20
6.	Bamboo mix grasses	15.23
7.	Grassland	12.71
8.	Mixed-grasses	15.26
9.	Plantation	3.51
10.	Scrub	3.48
11.	Riparian	2.60
12.	River sand with grasses	19.02
13.	Water body	25.28
14.	Habitations	4.58
Total		**520.82**

The flat grassy plains sometimes quite extensive, locally termed as *Chaur* occupy a special and significant ecological status in the Park. The important chaurs are Dhikala chaur, Phulai chaur, Khinnanauli chaur, Paterpani chaur, Mohanpani chaur, Bhadhai chaur, Bijrani chaur and many other smaller ones. These are of varying extent. These chaurs are generally a result of man-made clearings, made in the past for cultivation and settlements; subsequently abandoned. These carry rich dense growth of various medium sized to tall grasses, both palatable and unpalatable in varying degree. These are the most favored grazing grounds of the ungulates. The recent man-made reservoir over the Ramganga has engulfed a very large chunk of these chaurs of Buxar and Dhikala with apparent adverse ecological changes (Lamba 1980 and Bhartari 1999).

2.4.3. Faunal diversity

CTR is bestowed with a wide variety of fauna, including several charismatic, endangered and endemic species. Mammalian fauna is represented by 50 species belonging to 9 orders *viz.*, Insectivora, Chiroptera, Carnivora, Proboscidae, Primates, Pholidota, Artiodactyla, Lagomorpha and Rodentia. CTR holds the second largest population of the Tiger (*Panthera tigris*) in the world and the region is one of the last remaining strongholds of a potentially viable population (Sinha 2001). It, along with the Rajaji National Park also represents the North-Western most limits of Tiger distribution in the Indian subcontinent. The Sonanadi sanctuary forms a crucial part of the habitat of the N.W population of the Asian elephant (*Elephas maximus*) since it constitutes a corridor between the Corbett and the Rajaji populations. This is used by the large herds moving to and from CNP, Lansdowne Forest Division, Bijnor Plantation Division and Rajaji National Park. Of the elephant range lying between the Ganga and the Gaula Rivers, Sonanadi still remains one of the relatively undisturbed areas today. Besides being indicators of habitat types and being threatened, Mustelids occupy a prominent place in the mammalian community of the area. 6 species of mustelids are found in CTR. The Gharial (*Gavialis gangeticus*) is the subject of a re-introduction programme, by January 1987, 27 young gharials had been released in the Park (Derek 1989). Hussain (1995) has reported 29 species of fishes from Corbett Tiger Reserve (Appendix I). Birds form a significant constituent of the biodiversity of the study area. Out of the approximate 1300 species of birds found in the Indian subcontinent, more than 40% have been recorded in CTR. 549 species of birds (both resident and migrant) have been reported by Sharma *et al.* (2003). Herpetofauna are represented by 23 species of reptiles (Lamba 1987). Surveys conducted to document the diversity of other life forms have indicated high species richness and abundance of lower invertebrates (Lamba 1987). Given the vast area with diverse habitat types and virtually unexplored, the faunal diversity seemingly will have interesting additions.

2.5. Anthropological attributes

There is no village inside Corbett Tiger Reserve. Three villages (i. e. Dhara, Jhirna and Kothirau) located on the southern boundary of Corbett Tiger Reserve as intrusions were relocated to Village Ampokhra, in Firozpur-Manpur area situated on Ramnagar-Kashipur highway during 1990-1993 (Hussain and Garg 2004). The areas thus vacated were designated as Corbett Tiger Reserve buffer zones and are being developed into grasslands through habitat management. Human inhabitations such as, Aamdanda Khatta and Ringora Khatta are situated within the reserve forest area of Ramnagar Tiger Reserve. The human population of these villages is around 65,982. Livestock population of 92 villages around the reserve is 44,416. People in the villages around the reserve exploit natural resources by way of cutting of trees and grasses. Cattle lifting by tiger and leopard take place. In Corbett Tiger Reserve, Gujjars have been using the forests of the Kalagarh Division for their livelihood since about the 1950s. Initially, they were permitted to settle in Pakhrau, Kalushahid, Nalkatta and Dhara. Gujjars traditionally construct huts called *deras* using poles and grasses from the forests. These are constructed in open patches inside the forest near a water source. They were also permitted to graze a small number of buffaloes in the Sonanadi valley in selected areas of Laldarwaza, Shishamkhatta and Chipalghatti blocks. Of late some have also begun to keep cows, goats and mules. The rapid increase in the human and livestock population of the Gujjars coupled with the near cessation of their seasonal migration is cause for severe stress on the habitat of Sonanadi and its buffer (Sinha 2001). Traditionally, the people have also been using certain parts of Corbett Tiger Reserve for annual pilgrimage, visiting shrines within the reserve area (pers. com).

2.6. Summary

Corbett Tiger Reserve was founded in 1936, and has the distinction of being the first National Park in India. It is situated at the foothills of the Western Himalayas in the civil district of Nainital and Pauri Garhwal in Uttarakhand. The Reserve encompasses an area of 1288.32 km^2. This is represented by 520.82 km^2 of National Park, 301.18 km^2 of Sonanadi Wildlife Sanctuary and the remaining 466.32 km^2 as buffer area. The area lies between Latitudes 29°25'N to 29°40'N and Longitude 78°5'E to 79°5'E. Geologically the park belongs to Shivalik formations that are composed of conglomerates, sand, rocks, stones and boulders. The altitude varies from 350-1200 m with undulating topography. The soil is alluvial and the vegetation consists of mixed deciduous tropical and sub tropical forests with sal *Shorea robusta* as the dominant species. A number of springs flow inside the park, although the Ramganga River remains the main source of perennial water. The river flows for about 40 km along the Northern and Southern boundaries of the Park. In 1962, a 127 m rock filled dam was built near Kalagarh on the south-western border of the Reserve at the confluence of the Sonanadi and Ramganga Rivers. From June 1974, water was stored in the reservoir forming an 84 km^2 lake submerging a land area of 42 km^2 of the Reserve and subsequently affected the ecology of the Reserve in several ways. A number of flora and fauna have been recorded from the Reserve.

CHAPTER 3

STATUS AND DISTRIBUTION

3.1. Introduction

Monitoring abundance and distribution of animals is essential for understanding their population ecology, although monitoring animal populations is often difficult especially when cryptic species are involved and hence, indirect methods of monitoring populations are used to record three facets of the status of a species: its distribution, relative abundance and its absolute abundance (Wilson and Delahay 2001). In general, recording distribution is not nearly as difficult as assessing abundance, particularly absolute abundance (Bonesi and Macdonald 2004). Whether or not signs can be used to estimate abundance has long been debated for otter, a mustelid that uses the same habitats as mink (Bonesi *et al.* 2000). Evidence so far is consistent with the fact that surveys targeting population estimate of otters invariably result in underestimate of their population, largely due to their inconspicuous habits (Ruiz-Olmo *et al.* 2001; Kruuk *et al.* 1986 and Conroy and French 1987); however, surveys are shown to be a reliable indicator of otter distribution (Bonesi *et al.* 2000).

At the end of the 1970s and the beginning of the 1980s, the first standardized method of survey for otters was developed and was rapidly put into practice throughout Europe and North Africa (Green and Green 1980 and Mason and Macdonald 1986). The method was first applied to the Eurasian otter *Lutra lutra,* providing information on the western range of its distribution (Ruiz-Olmo *et al.* 2001) and was soon adopted and expanded to include other species of otter, such as the southern river otter *Lontra provovocax* (Chehebar 1985), *Lutra maculicollis* and *Aonyx capensis* (Rowe-Rowe

1992) and the smooth-coated otter *Lutra perspicillata* (Hussain and Choudhury 1997). The initial enthusiasm led to an attempt at the exhaustive mapping of otter distribution and an estimate of relative abundance and habitat selection (Macdonald and Mason 1983; 1985 and Ruiz-Olmo *et al.* 2001). These surveys were based on the identification of indirect but indisputable signs (mainly tracks and spraints) which otters leave at visible spots (e.g. boulders and dead logs) and in predictable places (e.g. under bridges, at junctions of rivers or streams and exposed sandbanks) which facilitates survey work (Ruiz-Olmo *et al.* 2001). In this way, it is possible to differentiate between positive and negative sites (presence detected or not) and to count the number of signs (Ruiz-Olmo *et al.* 2001 and Hussain and Choudhury 1997). There followed a debate between those who were in favor of using the method in this way (Jefferies 1986 and Mason and Macdonald 1987) and those who questioned the validity and precision of the results obtained (Kruuk *et al.* 1986; Conroy and French 1987, 1991 and Kruuk and Conroy 1987), because of temporal, spatial and individual variation apparent in otter sprainting behavior (Mason and Macdonald 1987; Jahrl 1995; Kruuk 1995; Kranz 1996 and Ruiz-Olmo and Gonsálbez 1997).

Apart from the record of occurrence by chance observations, virtually nothing was known about the ecology and the distribution of otters in Corbett Tiger Reserve. This chapter elucidates on the current status and distribution of otters in the reserve and the questions that were addressed at in this respect were;

(i.) Do otters exhibit any variations in distribution pattern ?

(ii.) How do otters repond to associated fauna in their habitat?

3.2. Methodology

Data collection

The survey methodology was designed after referring to the methods used by various authors (Melquist and Hornocker 1979; Macdonald and Mason 1983; Chehebar 1985; Kruuk *et al.* 1994; Lee 1996 and Hussain and Choudhury 1997). Major water bodies were categorized based on their types (Perennial/Seasonal) and presence of disturbance factors (Disturbed/Undisturbed). These water bodies were divided into 5 km segments. Information about habitat, marking places, and signs was recorded for each 500 m section. Searches covered a 100 x 15 m strip along the river edge. These plot dimensions were used because during the survey it was found that if otters are present in an area, there signs were most likely to be encountered within 15 m perpendicular to the shoreline. This has been substantiated by several studies (e.g. Kruuk and Conroy 1987; Hussain and Choudhury 1997 and Anoop and Hussain 2004). A team of 4 trained surveyors with comparable experience conducted the surveys by walking along both the banks and searching for the signs. Along the reservoir, some part was walked or surveyed by boat, whichever was convenient. All signs were removed so that they were not counted more than once. In each study section a *positive site* was defined as a 'used site' where holts/shelters and other signs of otter presence were found. Each spraint site usually contains several spraints, and usually each spraint originates from a different visit to that site by an otter (Jenkins and Burrows 1980). Only spraints separated by more than 5 m were considered to be different sites (Melquist and Hornocker 1983; Newman and Griffin 1994 and Medina 1996). Otter holts in the area were also mapped. Holts were occupied holes with fresh spraints deposited close to the entrance over several days. Active scent marks were recognized by a strong odour. Measurements of tracks were taken across the foot from the tip of the middle toe to the extremity of the heel (length) and from the extremities of toes 1 cm to 5 cm (width). The median values of the track sizes; both width and length were calculated. Any observations (*Ad-libitum*) on otters during the course of the study were recorded, while special efforts to see otters were made by positioning on vantage points within viewing distance (*ca.* 30-50 m) at the opening of holts at sunrise and sunset. All coordinates of locations were recorded using a global positioning system unit (Magellan Trail Master hand held GPS unit). The variables measured were:

1. River Characteristics

   (i) Width (cm) - distance between the banks.

   (ii) Average depth (cm) - depth at four points from the shore till the middle point.

   (iii) Water current (Slow=1/Fast=0).

2. Shoreline Characteristics

   (i) Approximate percentage of total area (100 m x 15 m) of the plot occupied by Rocky stetch, Sandy stretch, Muddy stretch, Clayey stretch and Alluvial stetch.

   (ii) Gentle or steep bank slope (degrees)

   (iii) Number of dead logs – used as basking sites.

   (iv) Number of streams joining the main course of river.

   (v) Shoreline vegetation - (Presence=1/Absence=0).

   (vi) Escape distance (cm) – Nearest distance from shore to tall and dense vegetation (Grasses and Shrubs).

   (vii) Escape Cover – percentage grass and shrub cover available.

(viii) Average grass height (cm).

3. Prey Availability – (Presence=1/Absence=0).

4. Associated Fauna (mugger, gharial and turtle) - (Presence=1/Absence=0).

5. Disturbance (Presence=1/Absence=0)

Data analysis

In order to determine the difference in otter occurrence across the two sampling years and seasons (winter and summer), mean density of otter signs (spraints, tracks, grooming sites and den sites) were calculated and compared using t-test. The presence or absence of otter signs was used as a response to habitat parameters quantified in each plot. Relative abundance estimates for otters (number of otter signs/km); muggers and gharials (number of individuals/km) were calculated. Discriminant Function Analysis (DFA) was performed to discriminate between the different groups' i.e otters and the associated fauna, according to their habitat characterization. Proportionate and continuous data were suitably transformed (Arcsine and Log transformation respectively) and standardized (Zar 1984). This data was then subjected to calculation of univariate *F* ratio's and *U* statistics (Wilk's Lambda). *U* statistics varies from 0-1, where large values of lambda indicate that group mean do not appear to be different while small values indicate that group mean do appear to be different. To check for auto-correlation Pearson Product Moment Correlation coefficient was performed and auto-correlated variables were dropped (Table 3.1). The stepwise DFA was performed on a 1608 sample-13 habitat variables matrix.

Table 3.1. List of variables used in discriminant function analysis.

S. No	Variable code	Variable	Adjustment and discarded criteria
1	roc	Rocky %	Proportionate data adjusted with arcsine transformation
2	san	Sandy %	Proportionate data adjusted with arcsine transformation
3	mud	Muddy %	Proportionate data adjusted with arcsine transformation
4	Clay	Clayey %	Proportionate data adjusted with Arcsine transformation
5	alluv	Alluvial %	Proportionate data adjusted with arcsine transformation
6	escpcov	Escape cover %	Proportionate data adjusted with arcsine transformation
7	escpdist	Escape distance (cm)	Continuous data adjusted with log transformation
8	dlog	Dead log	Continuous data adjusted with log transformation
9	str	Stream	Continuous data adjusted with log transformation
10	rwidth	River width (cm)	Continuous data adjusted with log transformation
11	wdepth	Average water depth (cm)	Continuous data adjusted with log transformation
12	bsl	Bank slope (degrees)	Continuous data adjusted with log transformation
13	avg.grht	Average grass height (cm)	Continuous data adjusted with log transformation
14	wcur	Water current (Fast=0/Slow=1)	Qualitative data, discarded
15	sveg	Shoreline vegetation (P=1/A=0)	Qualitative data, discarded
16	pavail	Prey availability (P=1/A=0)	Qualitative data, discarded
17	assocfauna	Associated fauna (P=1/A=0)	Qualitative data, discarded
18	distb	Disturbance (P=1/A=0)	Qualitative data, discarded

3.3. Results

3.3.1 Distribution pattern and relative abundance of otter signs in Corbett Tiger Reserve

Observations showed that otters occur in three river stretches *viz,* Ramganga, Mandal and Palain (Fig. 3.1). Of the total 380 plots sampled 15.5% (n = 31) proved positive, with maximum being recorded from River Ramganga (17.5%, n = 14) followed by Mandal (15%, n = 6) and Palain (13.75%, n = 11). Although intensive search were made (n = 180), no sign of otter activity was recorded from Rivers Sonanadi, Kosi and the Reservoir area (Table 3.2). A total of 838 signs were recorded over the whole study period, the most common being spraints, followed by tracks and grooming sites (Table 3.3). A total of 8 den sites were also recorded of which 4 (2 in Ramganga and 1 each in Rivers Palain and Mandal) remained habituated throughout the course of the study (2001-2004). Using all data from the entire study area and period significant positive correlations were found between number of spraints and other otter signs (track, grooming sites and den sites) (Table 3.4). Mean densities of otter signs for both the years were compared using t-test (Table 3.5) and were not found to be significant for spraints ($t = .894$, $P>0.05$), tracks ($t = .818$, $P>0.05$), grooming sites ($t = -.707$, $P>0.05$) and den sites ($t = .158$, $P>0.05$). Signs were also compared seasonally (Table 3.6) and only mean density of spraints were found to be significantly different ($t = 3.23$, $P<0.05$) while that of tracks ($t = .818$, $P>0.05$), grooming sites ($t = -.707$, $P>0.05$) and den sites ($t = .158$, $P>0.05$) were not significant. Relative abundance of otters was estimated as 0.35 per km for River Ramganga, 0.34 per km for River Mandal and 0.26 per km for River Palain (Fig. 3.2). The surveys led to a detection of four otter groups identified in the study area. During the course of the study, a total of 11 sightings were potentially possible and an estimate of 41 individuals (35 adults and 6 juveniles) with a mean of 5.1±1.55 was recorded (Table 3.7).

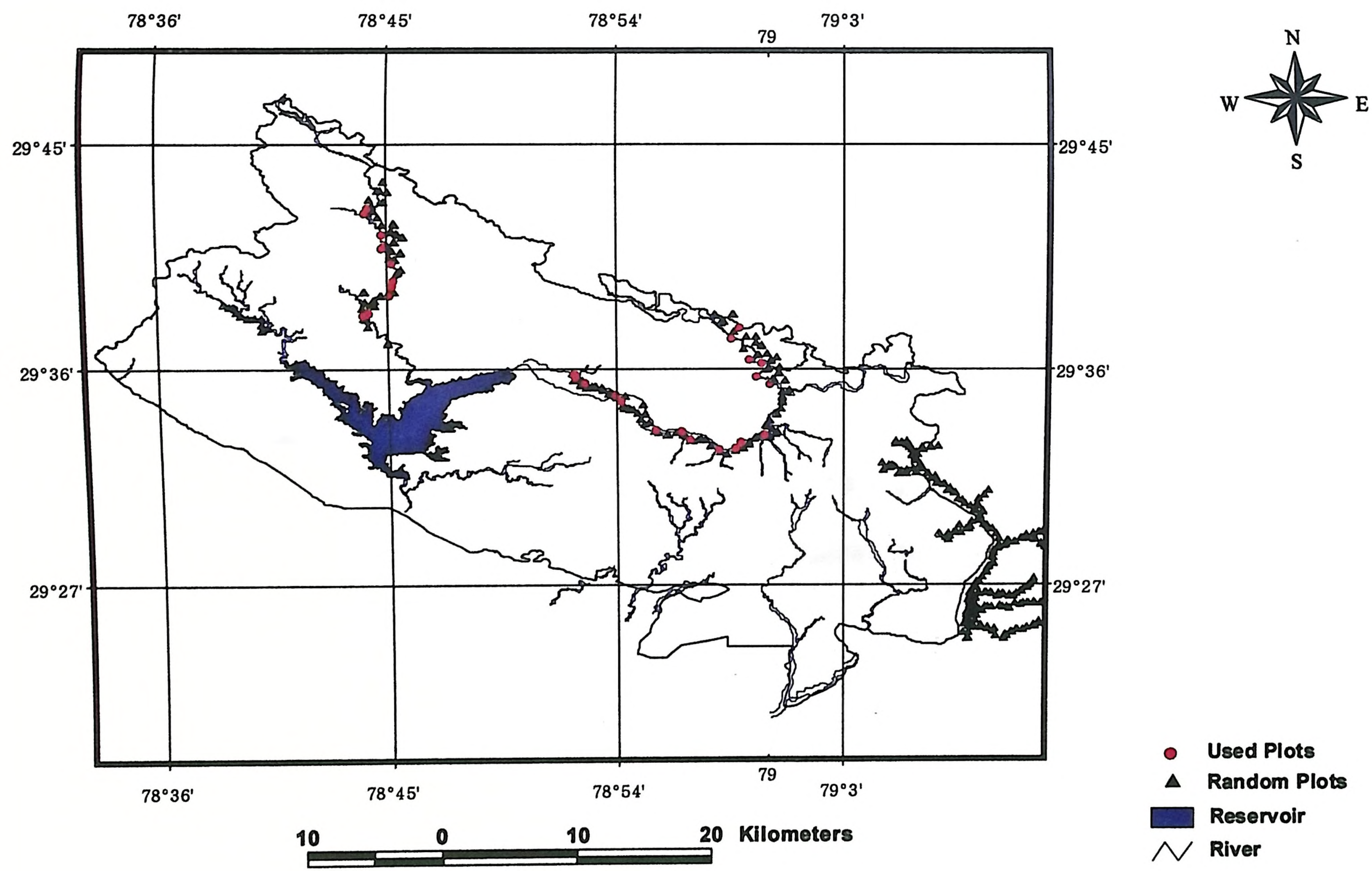


Fig. 3.1. Distribution of otter sign (spraints) across the sampling sites in Corbett Tiger Reserve.

Table. 3.2. Observation of otter evidences in different survey sites in Corbett Tiger Reserve.

Survey site	*Sampling intensity*	*Otter evidence*
Ramganga (*UD*)	40 km (n = 80)	17.5% (n =14)
Mandal (*UD*)	20 km (n = 40)	15% (n = 6)
Palain (*UD*)	40 km (n = 80)	13.75% (n = 11)
Sonanadi (*D*)	10 km (n = 20)	0
Reservoir (*D*)	40 km (n = 80)	0
Kosi (*D*)	40 km (n = 80)	0
Total	190 km (n = 380)	15.5% (n = 31)

UD = Undisturbed Habitat
D = Disturbed Habitat

Table 3.3. Descriptive statistics of the sprainting activity and other otter signs in Corbett Tiger Reserve.

Variables	**n**	**Mean ± SE**	**Min.-max.**
Signs	838	209.5 ± 98.12	70 - 499
Spraints	499	1.01 ± 0.02	0 - 2
Tracks	157	0.35 ± 0.02	0 - 1
Grooming sites	112	0.23 ± 0.02	0 - 1

n = number of occurrences of each sign.
SE = Standard error.

Table 3.4. Correlation between spraints and other signs of otter presence in Corbett Tiger Reserve.

Variables	**Spraints**	**Tracks**	**Grooming sites**	**Den sites**
Spraints	-	0.7 (P<0.01)	0.6 (P<0.01)	0.3 (P<0.01)
Tracks		-	0.7 (P<0.01)	0.2 (P<0.01)
Grooming sites			-	0.03
Den sites				-

Table 3.5. Mean density ± SE of otter signs between years in Corbett Tiger Reserve.

Variable	YEAR I (2002-2003)	YEAR II (2003-2004)	t-value
Spraints	6.04 ± 0.22	6.33 ± 0.25	0.894 (P = .372)
Tracks	2.2 ± 0.19	1.97 ± 0.21	0.818 (P = .415)
Grooming sites	1.49 ± 0.17	1.52 ± 0.19	-0.707 (P = .945)
Den sites	0.94 ± 0.14	0.91 ± 0.15	0.158 (P = .875)

Significance level = p<.05

Table 3.6. Mean density ± SE of otter signs during summer and winter seasons in Corbett Tiger Reserve.

Signs	Summer	Winter	t-value
Spraints	6.69 ± 0.9	5.65 ± 0.26	3.23 (P = .001)
Tracks	2.04 ± 0.19	2.15 ± 0.19	-.386 (P = .700)
Grooming sites	1.42 ± 0.17	1.59 ± 0.18	-.643 (P = .520)
Den sites	0.89 ± 0.14	0.97 ± 0.15	-.389 (P = .698)

Significance level = <.05

Table 3.7. Group size of otters in Corbett Tiger Reserve.

Site	Season					
	Winter (2001-2002)			Summer (2002)		
	Adult	Juvenile	Total	Adult	Juvenile	Total
Ramganga (Group A)	4	0	4	0	0	0
Ramganga (Group B)	10	0	10	0	0	0
Mandal	6	0	6	6	0	6
Palain	15	1	16	0	0	0
Site	Winter (2003-2004)			Summer (2003)		
	Adult	Juvenile	Total	Adult	Juvenile	Total
Ramganga (Group A)	4	1	5	5	0	5
Ramganga (Group B)	10	4	14	14	0	14
Mandal	6	0	6	0	0	0
Palain	16	0	16	0	0	0

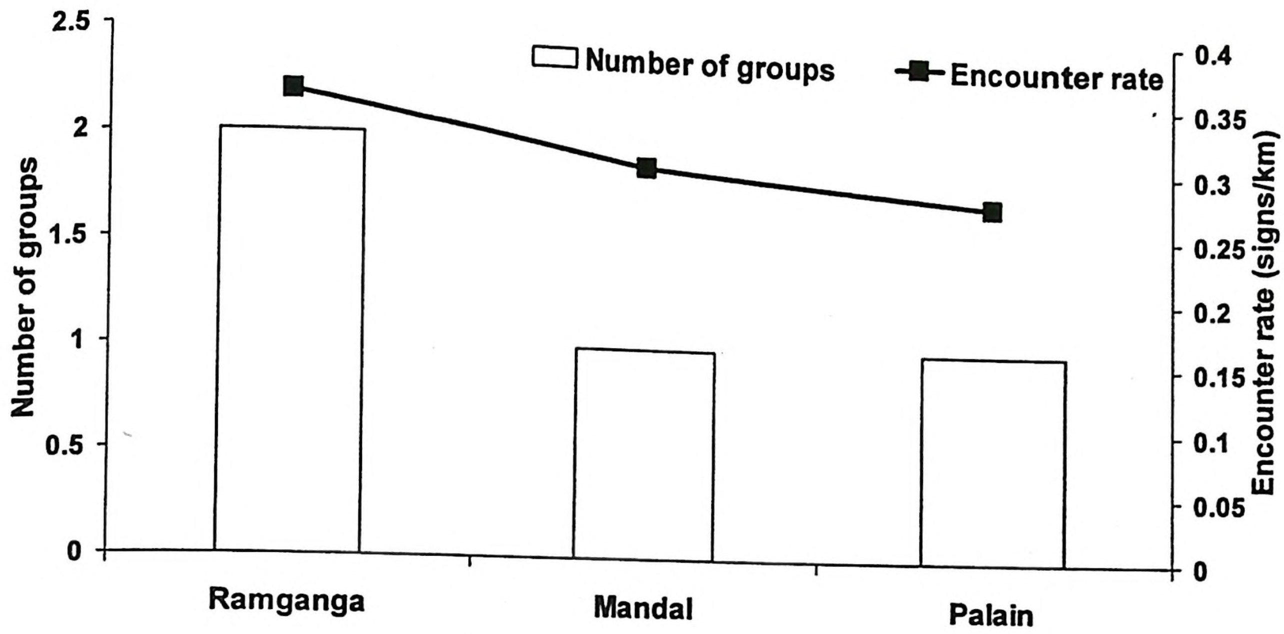


Fig. 3.2. Abundance estimate of otters in Corbett Tiger Reserve

3.3.2. Abundance estimate of associated fauna (Crocodilians) in Corbett Tiger Reserve

Crocodylus palustris (mugger) and *Gavialis gangeticus* (gharial) form the major wetland fauna of Corbett. The records maintained in this study are based on direct sightings of adult gharials and mugger, their sizes ranging from >2m to >4m. During the study period 129 (9.92 ± 2.75) mugger and 42 (5.25 ± 1.67) gharial were recorded. Table 3.8 provides the abundance estimates of crocodilians and Fig. 3.3 presents the distribution of mugger and gharial in CTR.

Table 3.8. Abundance estimates of crocodilians in Corbett Tiger Reserve.

Site	Dist.covered (km)	Individuals recorded / (Encounter rate)*							
		Summer (2002)		Winter (2001-2002)		Summer (2003)		Winter (2003-2004)	
		Mugger	Gharial	Mugger	Gharial	Mugger	Gharial	Mugger	Gharial
Ramganga	40	13 (0.33)	9 (0.23)	9 (0.23)	5 (0.13)	11 (0.28)	14 (0.35)	8 (0.2)	8 (0.2)
Palain	40	1 (0.03)	0	1 (0.03)	0	1 (0.03)	0	1 (0.03)	0
Reservoir	40	31 (0.85)	2 (0.05)	10 (0.25)	2 (0.05)	28 (0.7)	1 (0.03)	13 (0.33)	1 (0.03)
Sonanadi	5	0	0	0	0	2 (0.05)	0	0	0

*Encounter rate = Individuals recorded / Distance covered.

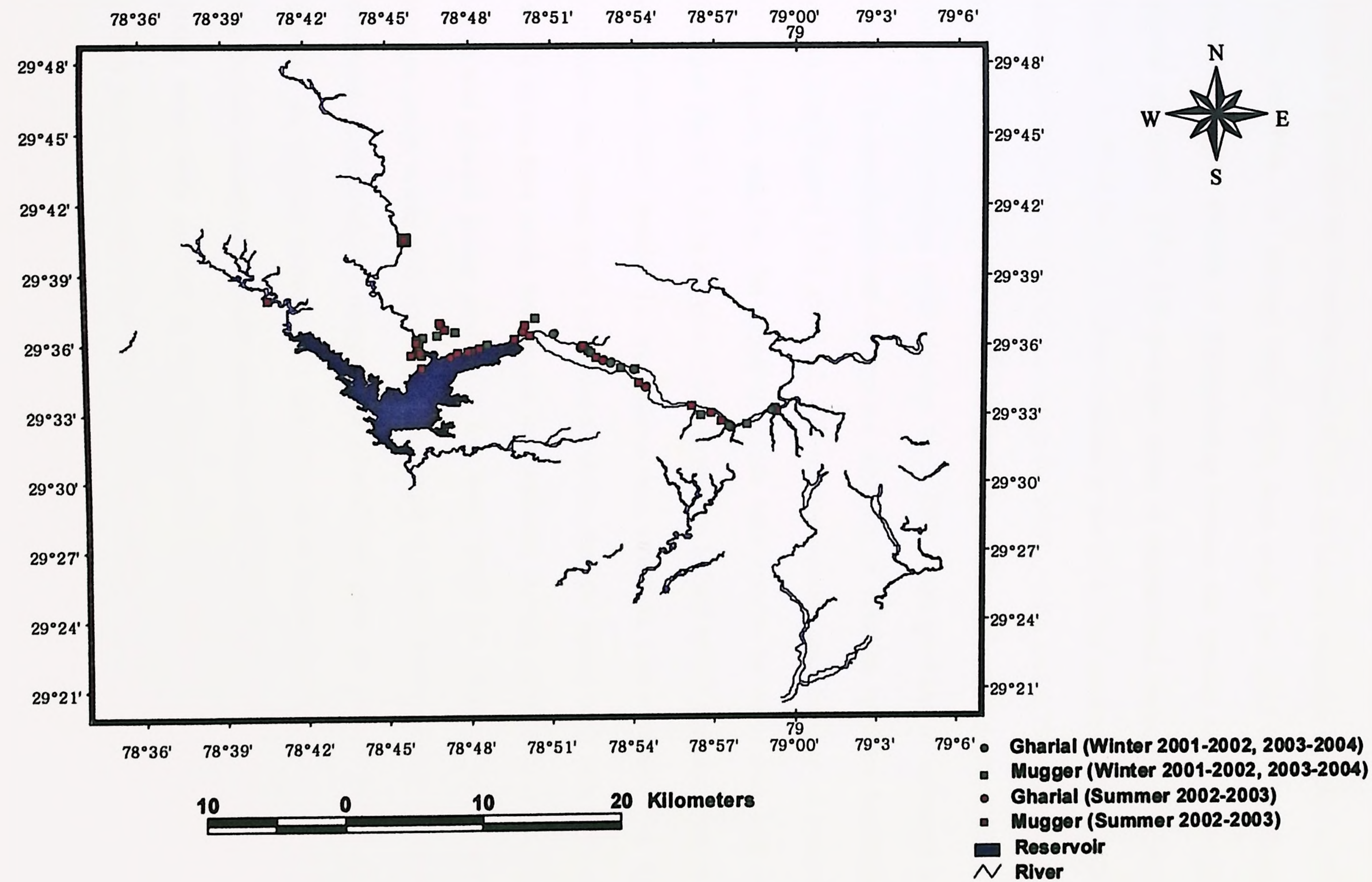


Fig. 3.3. Distribution of mugger and gharial in Corbett Tiger Reserve.

3.3.3. Factors governing distribution of otters and the associated fauna in Corbett Tiger Reserve

Table 3.9 provides the *U* statistics and *F* ratios for habitat variables included in DFA. Three variables, i.e., average water depth, bank slope and sand had significant *F* values and were capable of discriminating between the species i.e. otter, mugger, gharial and turtle. Table 3.10 provides values of standardised canonical discriminant function coefficients for variables included in the DFA. The analysis produced three discriminant functions (DF's) accounting for 94.9%, 4.4% and 0.7% of the variance respectively. The DF1 represents the gradient of average water depth; DF2 is the gradient of increasing sandy stetches while DF3 is the gradient of increased bank slope. The distribution of the species centroids in relation to three functions is provided in Figure 3.3.1 and 3.3.2. The relative position and location of species in these figures exhibits the extent to which each species is associated with each function. Figure 3.3.1a is a plot of DF1 in relation to DF2 which separates otter to the other associated species i.e crocodilians and turtles to some extent. The figure explicates that otters prefer low water depth (i.e. shallow water) on X axis while on Y axis it shows that sandy stetches are less preferred. Among other associated species turtle and gharial favour medium to low water depth (i.e. shallow water) and the mugger prefer areas with very high water depth (i.e deep water). Sandy stetches are preferred moderately by mugger and gharial and least by turtles. Figure 3.3.1b explains the relation between DF1 and DF3, which shows that with low water depth (i.e shallow water) otters prefer areas with gentle bank slope, while turtle and gharial prefer areas with medium to low water depth (i.e. shallow water) and crocodile prefers areas with high water depth (i.e. deep water). On Y axis; otter, mugger and turtle, all, use habitat with moderately steep bank slope while gharial prefer gentle bank slopes. Figure 3.3.1c explains the relation between DF2 and DF3. It explains that on the X axis otter, mugger and gharial moderately use sandy stretches while on

Y axis, otter, mugger and turtle prefer habitat with moderately steep bank slope while gharial favours gentl bank slope. The Figure 5.2 explains the distribution of otter and its associated fauna in three dimensional space.

Table 3.9. Values of Wilks' Lambda and univariate F ratios for variables used in DFA (3 & 222 degree of freedom).

Variables	Wilks' Lambda	F ratio	Significance
Alluvial	0.974	1.971	0.119
Avg. depth	0.634	42.632	0.000
Avg. grass height	0.981	1.453	0.228
Bank slope	0.838	14.356	0.000
Clayey	0.941	4.658	0.004
Deadlog	0.982	1.364	0.255
Escape cover	0.921	6.345	0.000
Escape distance	0.943	4.473	0.005
Muddy	0.960	3.123	0.027
River width	0.793	19.316	0.000
Rocky	0.909	7.412	0.000
Sandy	0.871	11.007	0.000
Stream	0.938	4.922	0.002

Table 3.10. Standardised canonical discriminant function coefficient for 3 variables from a discriminant function analysis of otters and their associated fauna (percentage of variance and percentage of cumulative variance extracted by each DF is noted in each column).

Variables	Function		
	DF1	DF2	DF3
Avg. depth	0.808*	0.520	-0.281
Bank slope	0.439	-0.239	0.869*
Sandy	-0.323	0.825*	0.470
% Variance	94.9	4.4	0.7
% Cumulative variance	94.9	99.3	100

*Variables showing largest absolute correlation with each function.

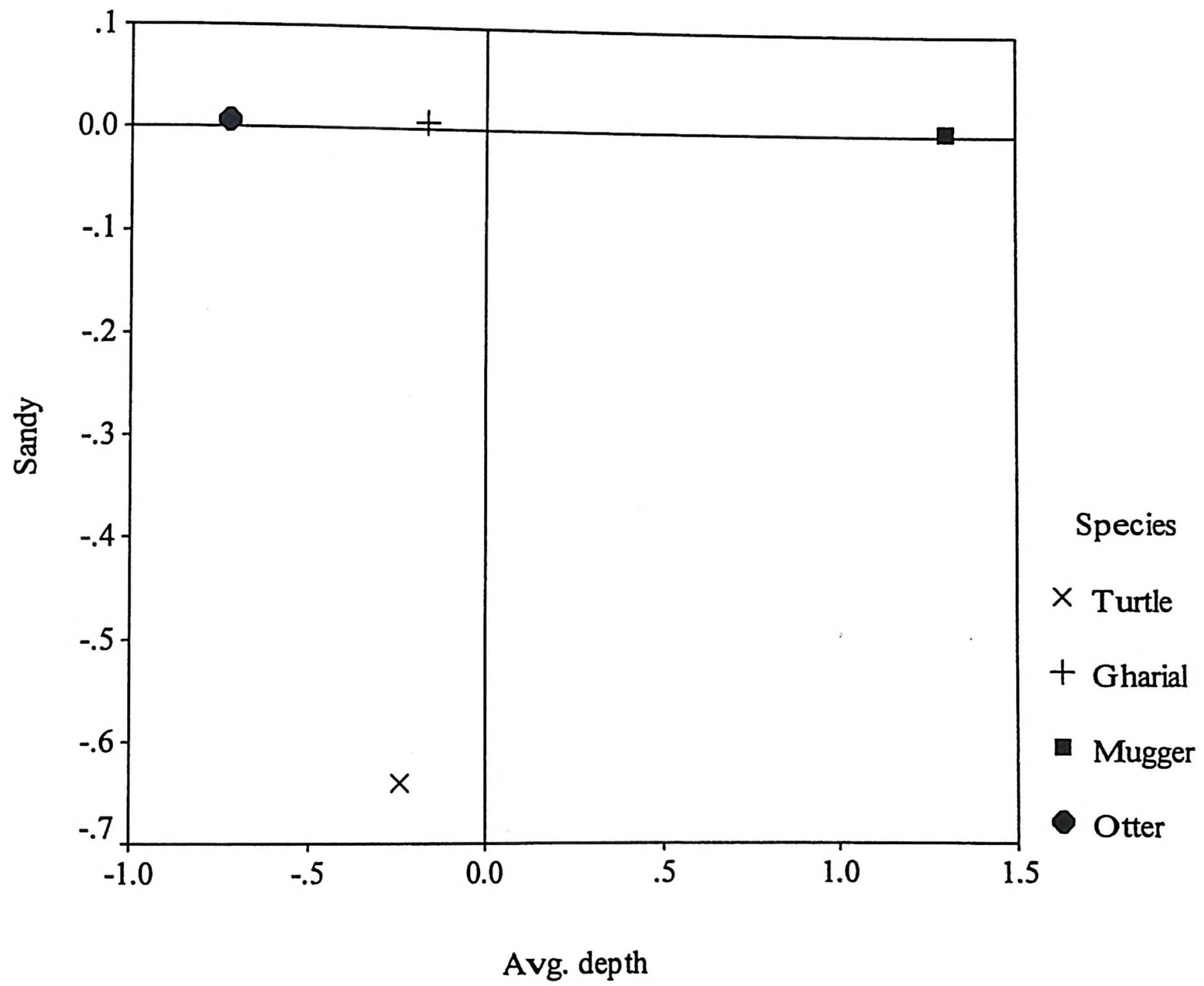


Figure 3.3.1a. Distribution of species centroids in relation to discriminant function 1and 2.

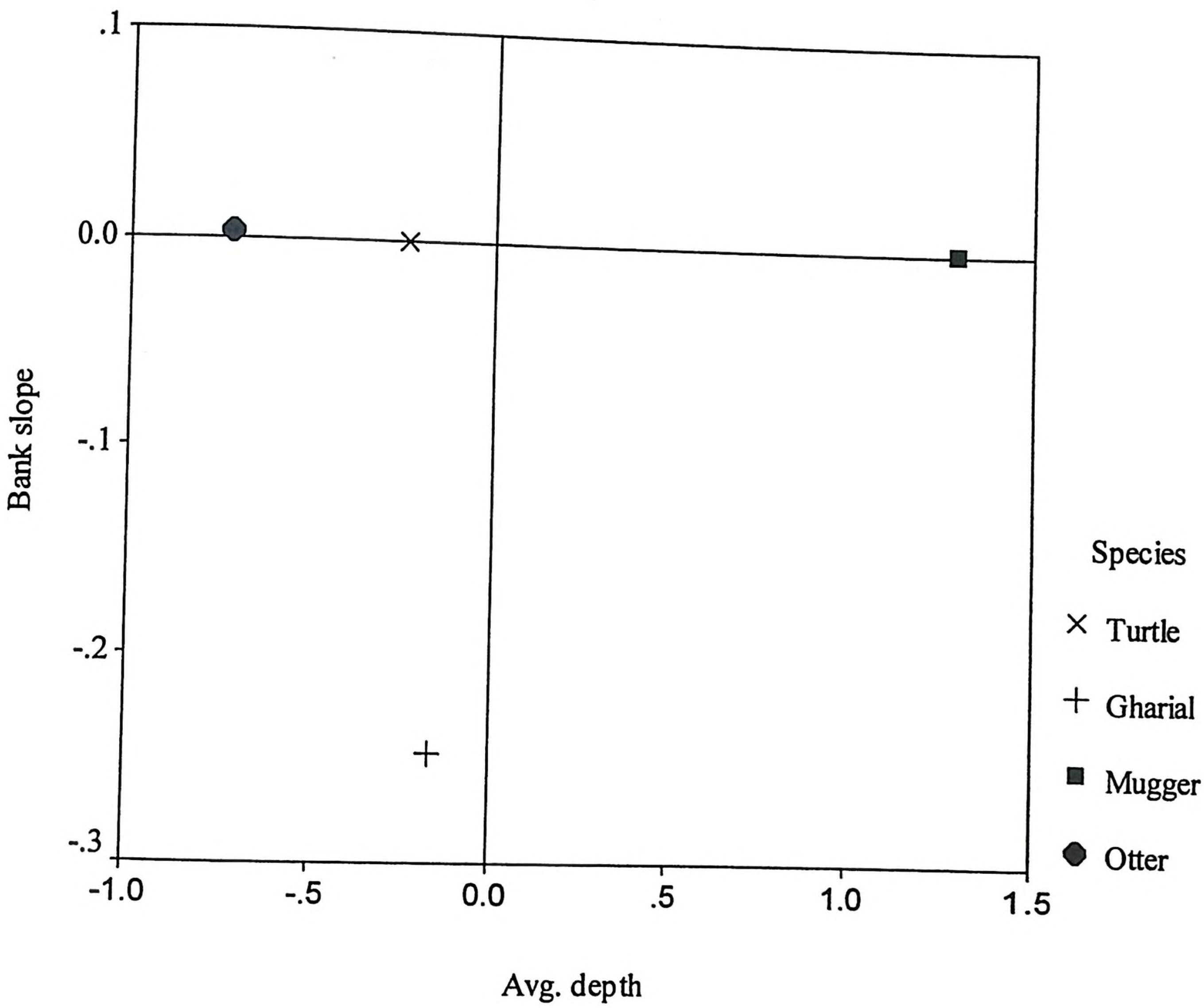


Figure 3.3.1b. Distribution of species centroids in relation to discriminant function 1and 3.

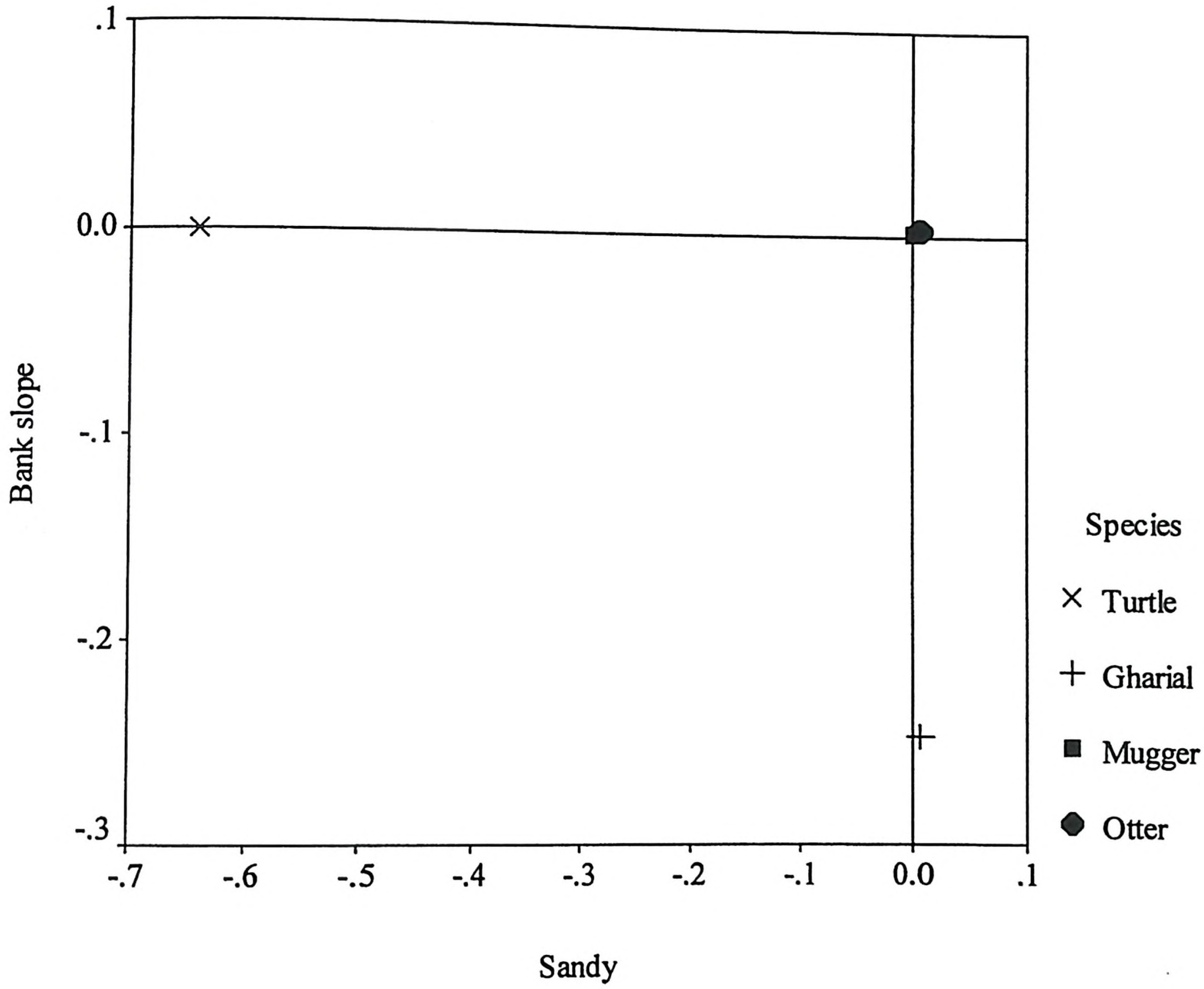


Figure 3.3.1c. Distribution of species centroids in relation to discriminant function 2 and 3.

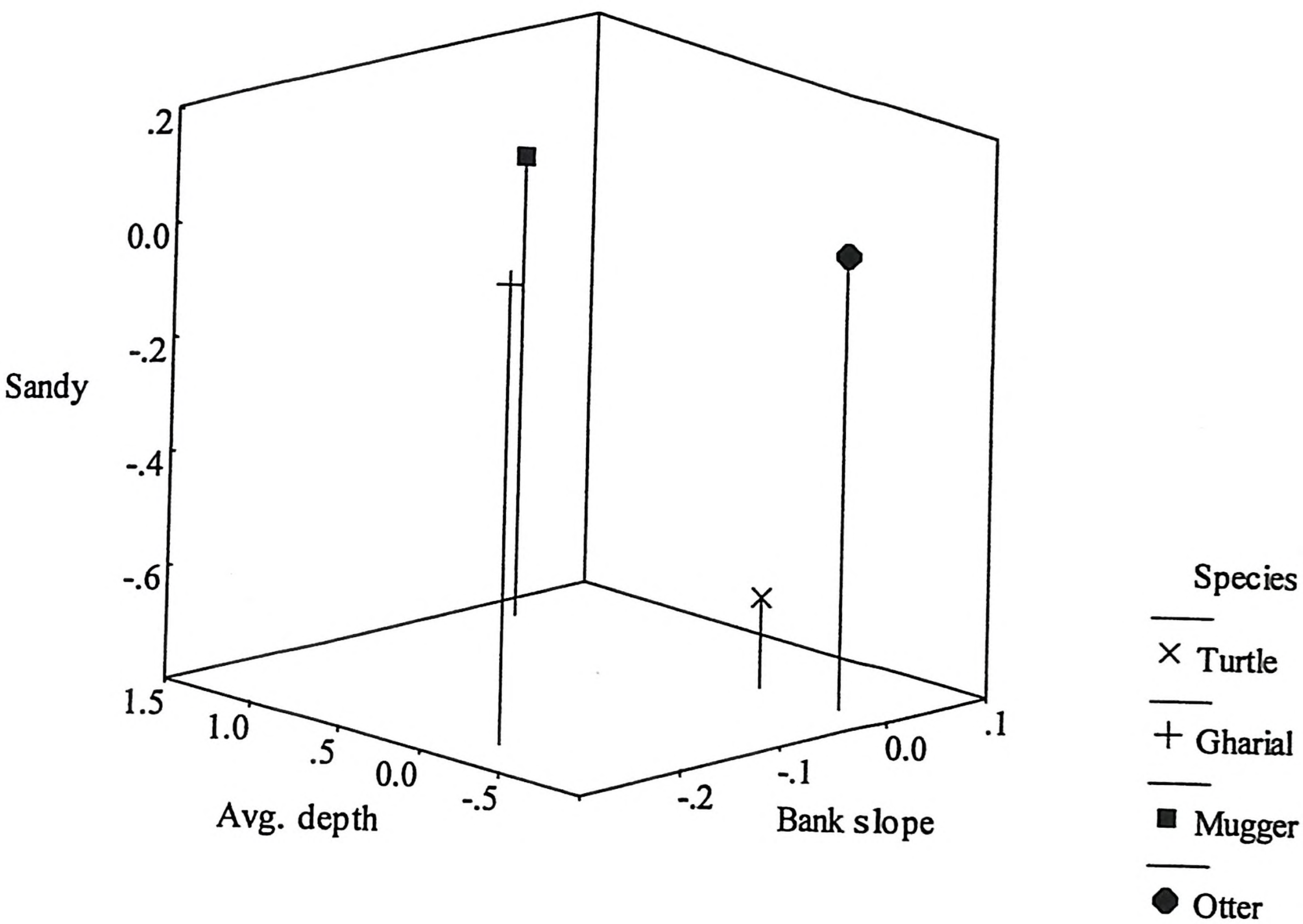


Figure 3.3.2. Distribution of species according to three discriminant functions.

3.4. Discussion

To ensure the successful management and conservation of otters, determining their distribution and abundance is an essential first step in this process. As otters live at low densities and are shy and often nocturnal or crepuscular, they are often diffcult to track and study and therefore making direct estimates of population size and structure is not feasible, hence; the number of sprainting sites and the number of spraints (signs) has been considered as an index of otter activity. If spraints are present, this means that otters are in the area, but if absent, this does not necessarily imply that there are no otters, nor is a stretch of river with many spraints likely to be used by otters more than another with fewer spraints (Kruuk *et al.* 1986). Also, the level of marking by individuals may be influenced by age, sex, social position and seasonality, among other factors, while populations at very low densities may mark their ranges very little (Kruuk 1995). From a practical point of view, spraint sites (n = 31) were generally easier to record than spraints (n = 499) as it was occasionally difficult to distinguish individual spraints when several were present at one site. Spraint sites were by definition separate and therefore potentially independent of each other. In addition, the number of sites remained fairly constant. Spraints deposited along the river margins are at times difficult to locate due to vegetation and changes in the water level. As a consequence, during field work, the observations of these signs are uncertain and depend on weather conditions. Considering that spraints do have a major significance in otter intra and interspecific communication, Yoxon (1998) suggests that the collection of spraints by researchers may influence the deposition of spraints by otters. Nevertheless, the responses of otters to the removal of spraints and the communication function time after spraint deposition is not well documented yet and seems to vary. However, Kruuk (1995) has reported it to vary from 30 days to some hours in the case of the European otter. Moreover, if the monthly removal of spraints had the effect of stopping the otter from using the area as suggested by Yoxon (1998), data collected in the present study would show a continued reduction of collected spraints month after month, which was not observed. A similar observation was also made by Quadros *et al.* (2001) when conducting research on *Lontra longicaudis*, in Southern Brazil. Besides, it is known that female otters may defecate in the water during the perinatal period (Chanin 1993 and Kruuk 1995) and it is also impossible to collect all spraints in the environment (Ruiz-Olmo and Gonsalbez 1997).

Historically, Pockock (1939) has reported the probable occurrence of all three species in freshwater systems along the Himalayan Terai. Bhargava and Prasad (1975) reported occurrence of *L. perspicillata* while Lamba (1980) and Hussain (1998) have reported occurrence of *Lutra lutra* in small groups along River Ramganga within the core zone of Corbett National Park. The preliminary survey revealed that at the low lying areas such as the Ramganga, Mandal and Palain rivers, smooth-coated otter occurs. This was confirmed by the measurements of the footprints (n = 56, median length = 8.57 ± .006 and breadth = 6.37 ± .006) (Kruuk *et al.* 1993) and this was further inveterated by the shape of the rhinarium (Foster-Turley 1990a) and flat underside of the tail (Pocock 1941) when a pair of poached otters were retrieved from along the Ramganga river and consequently being examined. During a Week long survey along River Kolhuchaur in Lansdowne Division abutting the North-western periphery of Corbett Tiger Reserve, evidences of otter presence were collected but the species could not be confirmed. Even though we may have failed to locate some individual animals or very low populations, it is clear that the species is now endangered, with permanent populations confined to a few stretches only such as, Ramganga, Mandal and Palain. Four different otter groups that ranged from 4 to 16 individuals were recorded and the basic group structure consisted of the resident adult male with female and her offsprings. During winter 2003-2004, the two otter groups recorded from River Ramganga showed increase in group size with the addition of 1 and 4 juveniles respectively, while the otter group recorded from Rivers Mandal and Palain remained stable with 6 and 16 individuals respectively.

It can be presumed that otters occurred throughout much of the range of protected area but as no concrete records were maintained it is not possible to determine the precise time of the initial decline. Several factors may have contributed to the loss of the species over large areas and to the present pattern of distribution, the major reason being the construction of dam on the River Ramganga (Hussain 1998). Interchange of otter populations between Ramganga on the east of the reservoir and Palain and Sonanadi on the western side can be validated from radio tagging studies in these areas. This is specially so in light of absence of evidence of otter use of the reservoir areas.

In most of their distribution range in Asia, otters occur along with several aquatic species such as gharial *Givalis gangeticus*, Indian marsh crocodile *Crocodylus palustris*, saltwater crocodile *C. porosus*, Siamese crocodile *C. siamensis*, Ganges river dolphin *Platanista gangetica* and several species of turtles. In CTR, interaction between gharial and *Lutra lutra* and *L. perspicillata* has been recorded by Patridge films (2000). This study in CTR reveals that otters along with the associated fauna i.e mugger (*Crocodilus palustris*), gharial (*Gavialis gangeticus*) and several species of turtles tend to share similar habitats with moderate preference for sandy areas with shallow water and gentle bank slopes. They seem to maintain mutually agreeable strategy to avoid conflicts in sharing resources for foraging, grooming and basking.

Hussain (1993) had observed that the smooth-coated otters generally avoided sites that were used by mugger for basking and defecation, and often confronted gharial in the National Chambal Sanctuary, India. Studies on the dietary habits of mugger in Andhra Pradesh have revealed the presence of otter furs in the scats of Indian marsh crocodile (Kumar *et. al.* 1995) and alternately the hatchlings of crocodile can also be potential prey for otters (Kumar 1993). The attraction of predators to otter scats has been documented by Chanin (1993), who also mentions that female otters stop defecating at holts when they contain small cubs, defecating elsewhere and in the water. This strategy avoids predators being attracted by the strong smell of otter spraints.

3.5. Summary

This research, although, corroborates the findings of previous distributional records of otters along the River Ramganga in Corbett National Park, also confirms the distribution of otters from Rivers Mandal and Palain, hitherto unreported. Of the total 380 plots sampled 15.5% (n = 31) proved positive, with maximum being recorded from River Ramganga (17.5%, n = 14) followed by Mandal (15%, n = 6) and Palain (13.75%, n = 11). Although intensive search were made (n = 180), no sign of otter activity was recorded from Rivers Sonanadi, Kosi and the Reservoir area. Relative abundance of otters was estimated as 0.35 per km for River Ramganga, 0.34 per km for River Mandal and 0.26 per km for River Palain. The surveys led to a detection of four otter groups identified in the study area. During the course of the study, a total of 11 sightings were potentially possible and an estimate of 41 individuals (35 adults and 6 juveniles) with a mean of 5.1±1.55 was recorded. The basic group structure consisted of the resident adult male with female and her offsprings. During winter 2003-2004, the two otter groups recorded from River Ramganga showed increase in group size with the addition of 1 and 4 juveniles respectively, while the otter groups recorded from Rivers Mandal and Palain remained stable with 6 and 16 individuals respectively. During the study period 129 (9.92 ± 2.75) mugger and 42 (5.25 ± 1.67) gharial were recorded. Otters share similar habitats with associated aquatic fauna and seem to maintain mutually agreeable strategy to avoid conflicts in sharing resources for foraging, grooming and basking.

CHAPTER 4

HABITAT USE

4.1. Introduction

The extinction of endangered species and the consequent loss of biodiversity is one of the most challenging consequences of human-induced habitat destruction. Human activities such as agricultural development, commercial afforestation and urbanization have led to habitat fragmentation, namely loss of the original habitat, reduction in habitat patch size and increasing isolation of habitat patches. The process of landscape change as a result of habitat fragmentation has far-reaching consequences for species survival. In particular, for area-sensitive species, the patches of suitable habitat may be too small to support a breeding pair or a functional social group (Lambeck 1997), whereas species with low dispersal capacity are unable to recolonize the habitat patches following the extinction of their local population (Collinge 1996).

Sine long, Rivers have been subdued and transformed due to construction of large dams and barrages, mainly serving for hydropower production, controlling floods and facilitating irrigation with little regard for dire environmental consequences. Vast areas of wildlife habitat and sensitive ecosystems have thus been lost and unfortunately, untill recently, there has been little effort to assess the impact of flora and fauna on non-forest ecosystems and even, where studies were conducted; there was a tendency to consider only large mammals as wildlife. It is generally believed that dams adversely affect otter populations due to the reduction of water flow down stream, denying access to prey and den sites. The construction of dams, which causes a seasonal, or all year round loss of water in the lower parts of rivers is seen as a major threat to otters (Jimenez and Lacomba 1991). In India, however, it has never been quantified to what extent this affects the habitat use by resident otter populations.

Knowledge of the habitat preference of sympatric Asian otters remains fragmentary, whereas in Europe and North America many studies on *Lutra lutra* and *L. canadensis* have led to an increasing understanding of otter habitat preferences in temperate regions (Melisch *et al.* 1996). Different studies have identified food availability, fresh water and shelter suitable for resting and breeding as the key factors in habitat selection (Melquist and Hornocker 1983; Mason and Macdonald 1986; Dubuc *et al.* 1990; Kruuk 1995 and Anoop and Hussain 2004). Habitat of otters can be characterized as a narrow strip on either side of the interface between water and land, where food is acquired in the cold, watery environment on one side, and recovery from the costs borne from this exposure takes place on the other *i.e.* land (Kruuk 1995). Otters are fairly clumsy on land and therefore are vulnerable to predators whereas in water they can move fast but loose body temperature very rapidly (Kruuk 1995). These inherent limitations are countered by high intake of food to replenish the greater energy burnt to keep themselves warm and by frequent grooming on land to dry the fur and heating up of the body. So otters are able to sustain themselves only when food is available in plenty and that it can be extracted with least effort. The other essential requirements for otters, like shelter and grooming places are only selected from what is available. This chapter aims at contributing to the knowledge about the habitat use pattern of *L. perspicillata* along the major perennial water bodies in Corbett Tiger Reserve and the questions addressed were;

(i.) What are the structural and functional attributes of the habitats that influence the habitat choice of otter populations?

(ii.) How do man-made reservoirs affect the habitat selection in otters?

4.2. Methodology

Data collection

Data were collected from thirty-eight 5 km segments of water bodies surveyed in the study area. Sampling points were laid at 500 m intervals and searches were made in 100 m x 15 m plots along the river edge. For the estimation of habitat availability each plot were categorised as rocky stretch, sandy stretch, muddy stretch, clayey stretch and alluvial stretch. A detailed account of survey methodology has been provided in Chapter three. Home range boundaries were identified and delineated by the occurrence of intensively used areas from the presence of dens, through high levels of sprainting sites (Erlinge 1967, 1968).

Data analysis

To understand the habitat use by otters, data were subjected to Principal Component Analysis (PCA). The data collected for available and utilized plots were organized in sample-habitat parameter matrix for summer and winter seasons respectively. The raw data matrix was arranged into proportionate data and continuous data which had to be suitably transformed into Arcsine and Log transformation and standardized following Zar (1984). Factor analysis was used to reduce the dimensionality of the habitat variables (Table 4.1). The first three factors (predictors) were used for interpretation as these explained maximum variations in the data set. Pearson product moment correlation was performed on all the habitat variables and auto correlated variables were dropped. PCA was performed using *Varimax* rotation and factor scores were saved. Extracted factors were subjected to Pearson Product Moment correlation analysis with habitat variables to find out significant correlations between habitat variables and factors. Availability and utilized plots were plotted in two dimensional space defined by PCI, PCII and PCIII. All the extracted factors with *eigen* values of more than one were saved and used for the logistic regression analysis. To strengthen the results obtained through PCA Logistic regression was performed with animal presence/absence as the dependant variable and the habitat variables as the covariates. The One Way Analysis of Variance was used to test for significant differences in Spraint density *viz-a-viz* water current, water quality, shoreline vegetation, prey availability, associated fauna and disturbance. All statistical tests were carried out following Zar (1984) using computer statistical package SPSS. Home range of each group was estimated using Kernell Home Range Method (Worton 1989) and were developed using GIS software Arc View 3.2.

Table 4.1. List of variables used in Principal Component Analysis.

S. No	Variable code	Variable	Adjustment and discarded criteria
1	roc	Rocky %	Proportionate data adjusted with arcsine transformation
2	san	Sandy %	Proportionate data adjusted with arcsine transformation
3	mud	Muddy %	Proportionate data adjusted with arcsine transformation
4	Clay	Clayey %	Proportionate data adjusted with Arcsine transformation
5	alluv	Alluvial %	Proportionate data adjusted with arcsine transformation
6	escpcov	Escape cover %	Proportionate data adjusted with arcsine transformation
7	escpdist	Escape distance (cm)	Continuous data adjusted with log transformation
8	dlog	Dead log	Continuous data adjusted with log transformation
9	str	Stream	Continuous data adjusted with log transformation
10	rwidth	River width (cm)	Continuous data adjusted with log transformation
11	wdepth	Average water depth (cm)	Continuous data adjusted with log transformation
12	bsl	Bank slope (degrees)	Continuous data adjusted with log transformation
13	avg.grht	Average grass height (cm)	Continuous data adjusted with log transformation
14	wcur	Water current (Fast=0/Slow=1)	Qualitative data, discarded
15	sveg	Shoreline vegetation (P=1/A=0)	Qualitative data, discarded
16	pavail	Prey availability (P=1/A=0)	Qualitative data, discarded
17	assocfauna	Associated fauna (P=1/A=0)	Qualitative data, discarded
18	distb	Disturbance (P=1/A=0)	Qualitative data, discarded

4.3. Results

4.3.1. Habitat availability

Five categories of habitats were available in the study area (Fig. 4.1). At the landscape level, rocky stretches composed of boulders and sandrocks that constituted (47.94%), followed by (25.96%) alluvial stretches while muddy stetches constituted the least (3.59%). River Mandal represented a maximum (63.61%) rocky stretches while River Sonanadi recorded nil. River Sonanadi recorded a maximum of (47.95%) muddy stretches while Rivers Ramganga and Palain recorded nil, the overall availability recorded was (3.59%). River Sonanadi recorded (41.09%) while River Mandal recorded the least (0.37%) clayey stretches composed of mixture of sand and mud, while the overall availability recorded (13.66%). Alluvial stretches composed of gravely deposits mixed with sand, clay or mud constituted 25.96% of which River Ramganga recorded a maximum of 54.25%.

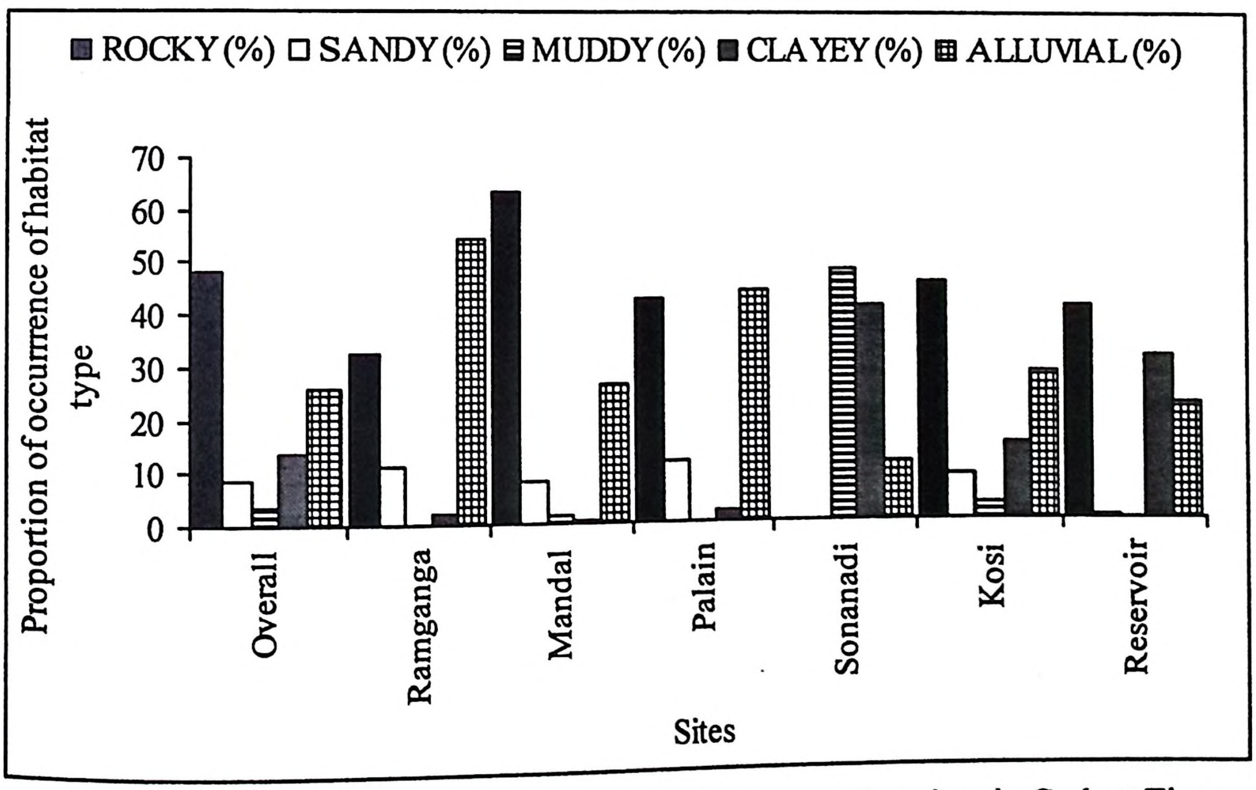


Figure. 4.1. Habitat avaialability across different sampling sites in Corbett Tiger Reserve and adjacent aquatic ecosystems.

4.3.2. Factors influencing habitat use by otters in winter in Corbett Tiger Reserve

The first three principal components accounted for 40.23% of variance in otter habitat data (Table 4.2). The first factor was positively correlated with rocky stretches ($r = 0.843$ $p < .01$) and bank slope ($r = 0.633$, $p < .01$) but was negatively correlated with alluvial stretches ($r = -0.809$ $p < .01$). The second factor was positively correlated with river width ($r = 0.906$, $p < .01$) and average depth ($r = 0.894$, $p < .01$). The third factor was positively correlated with escape cover ($r = 0.818$, $p < .01$) and average grass height ($r = 0.800$, $p < .01$).

Figure (4.2) explains the distribution of utilised and available plots in relation to first, second and third component. Figure (4.2a) is a plot of PCI in relation to PCII which illustrates that otters prefer areas with moderate to steep bank slopes with rocky stretches but moderate to low alluvial stretches, while on Y axis it shows that otters prefer moderate to high river width and average depth. Figure (4.2b) is a plot between PC I and PC III and shows the preference of otters to moderate to steep bank slopes with rocky stretches but moderate to low alluvial stretches and moderate to high escape cover and average grass height. Figure (4.2c) is the plot of PCII and PCIII that depicts the preference of otters to areas with moderate to high river width and average depth in relation to moderate to high rocky stretches and moderately steep bank slope but low alluvial stretches. The logistic regression model ($R^2 = 0.40$) had an efficiency of 93.41% correct classification of available and utilized plots. The model suggests that the otters prefer sandy stretches with moderately steep bank slopes and presence of more number of deadlogs and tall average grass height. Relatively narrower river width is favoured with several streams joining the main course. They avoid longer escape distances (Table 4.3). Table 4.4.1 presents the association of mean otter spraint numbers to different speeds of water current i.e. fast and slow. No spraints were recorded at sites with fast current while (0.89 ± 0.004) spraints were recorded at sites with slow current and the results were found to be significant ($F_{1\ 802}$ = 128.173, P<.000). Table 4.4.2 depicts the association of mean otter spraint numbers present at different shoreline vegetation categories i.e. presence/absence. Spraints were recorded maximum at sites with presence of shoreline vegetation (0.40 ± 0.005) and results were found to be significant ($F_{1\ 802}$ = 6.293, P<.002). Table 4.4.3 presents the association of mean otter spraint numbers to the presence/absence of prey availability. Spraints were recorded only at sites with prey availability (0.39 ± 0.004) and results were found to be significant ($F_{1\ 802}$ = 14.517, P<.000). Table 4.4.4 shows the association of mean otter spraint numbers to sites with associated fauna. Although more spraints (0.57 ± 0.21) were recorded from sites which showed presence of associated fauna, however, the results were not found to be significant ($F_{1\ 802}$ = 2.738, P<.098). Table 4.4.5 shows that high mean otter spraint numbers (0.37 ± 0.004) were recorded from sites that had no disturbance and the results were found to be significant ($F_{1\ 802}$ = 6.790, P<.01).

Table 4.2. Principal Component Analysis of the habitat variables showing component loading on three principal components for winter in Corbett Tiger Reserve.

Variables	**Component**		
	PC I	**PC II**	**PC III**
Escape distance	-0.115	-0.001	-0.325
Deadlog	0.135	0.116	0.172
Sream	0.002	-0.229	-0.279
River width	0.002	0.906	-0.004
Avg. depth	0.176	0.894	-0.003
Bank slope	0.630	0.260	0.135
Avg. grass height	0.007	-0.002	0.800
Rocky	0.843	0.003	-0.007
Sandy	-0.005	-0.002	0.179
Muddy	0.003	-0.006	-0.138
Clayey	-0.002	0.151	0.003
Alluvial	-0.809	0.003	0.003
Escape cover	-0.005	-0.004	0.818
% Variance	**14.16**	**13.74**	**12.32**
%Cumulative variance	**14.16**	**27.9**	**40.23**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 14 iterations.

Table 4.3. Summary of logistic regression model for predicting suitability of a sample plot for otters in winter in Corbett Tiger Reserve.

Variable	B	S.E	Wald	df	Sig.	R	Exp (B)
Sandy	0.6246	0.0965	41.9182	1	0.0000	0.3023	1.8675
Escape distance	-0.6633	0.2152	9.5006	1	0.0021	-0.1310	0.5151
Dead log	0.5075	0.1269	15.9969	1	0.0001	0.1790	1.6611
Stream	0.5289	0.1051	25.3304	1	0.0000	0.2311	1.6970
River width	-0.5690	0.2513	5.1268	1	0.0236	0.2311	0.5661
Bank slope	-0.4169	0.1809	5.3089	1	0.0212	-0.0846	0.6591
Avg. grass height	0.6967	0.2220	9.8485	1	0.0017	-0.0870	2.0071
Constant	-3.4103	0.2409	200.3348	1	0.0000	0.1340	

Table 4.4.1. Association of mean otter spraint numbers to water current in winter in Corbett Tiger Reserve.

Water current	Spraint Mean ± S.E
Fast current	0.00 ± 0.00
Slow current	0.89 ± 0.004

Table 4.4.2. Association of mean otter spraint numbers to shoreline vegetation in winter in Corbett Tiger Reserve.

Shoreline vegetation	Spraint Mean ± S.E
Presence	0.40 ± 0.005
Absence	0.008 ± 0.003

Table 4.4.3. Association of mean otter spraint numbers to prey availability in winter in Corbett Tiger Reserve.

Prey availability	Spraint Mean ± S.E
Presence	0.39 ± 0.004
Absence	0.00 ± 0.00

Table 4.4.4. Association of mean otter spraint numbers to associated fauna in winter in Corbett Tiger Reserve.

Associated fauna	Spraint Mean ± S.E
Presence	0.57 ± 0.21
Absence	0.29 ± 0.004

Table 4.4.5. Association of mean otter spraint numbers to disturbance in winter in Corbett Tiger Reserve.

Disturbance	Spraint Mean ± S.E
Presence	0.13 ± 0.004
Absence	0.37 ± 0.004

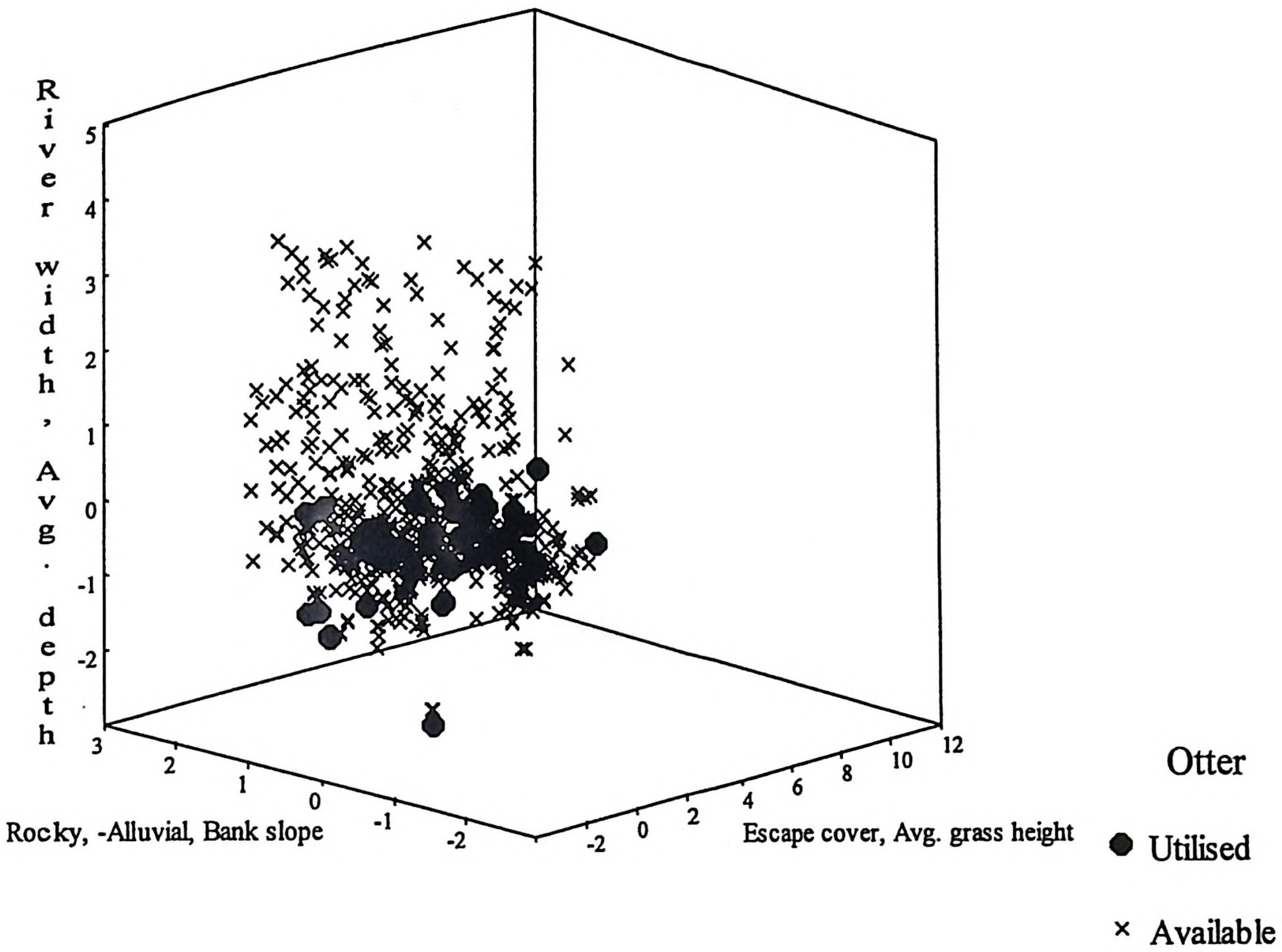


Fig. 4.2. Ordination of available and utilized plots of otters during the winter season in Corbett Tiger Reserve.

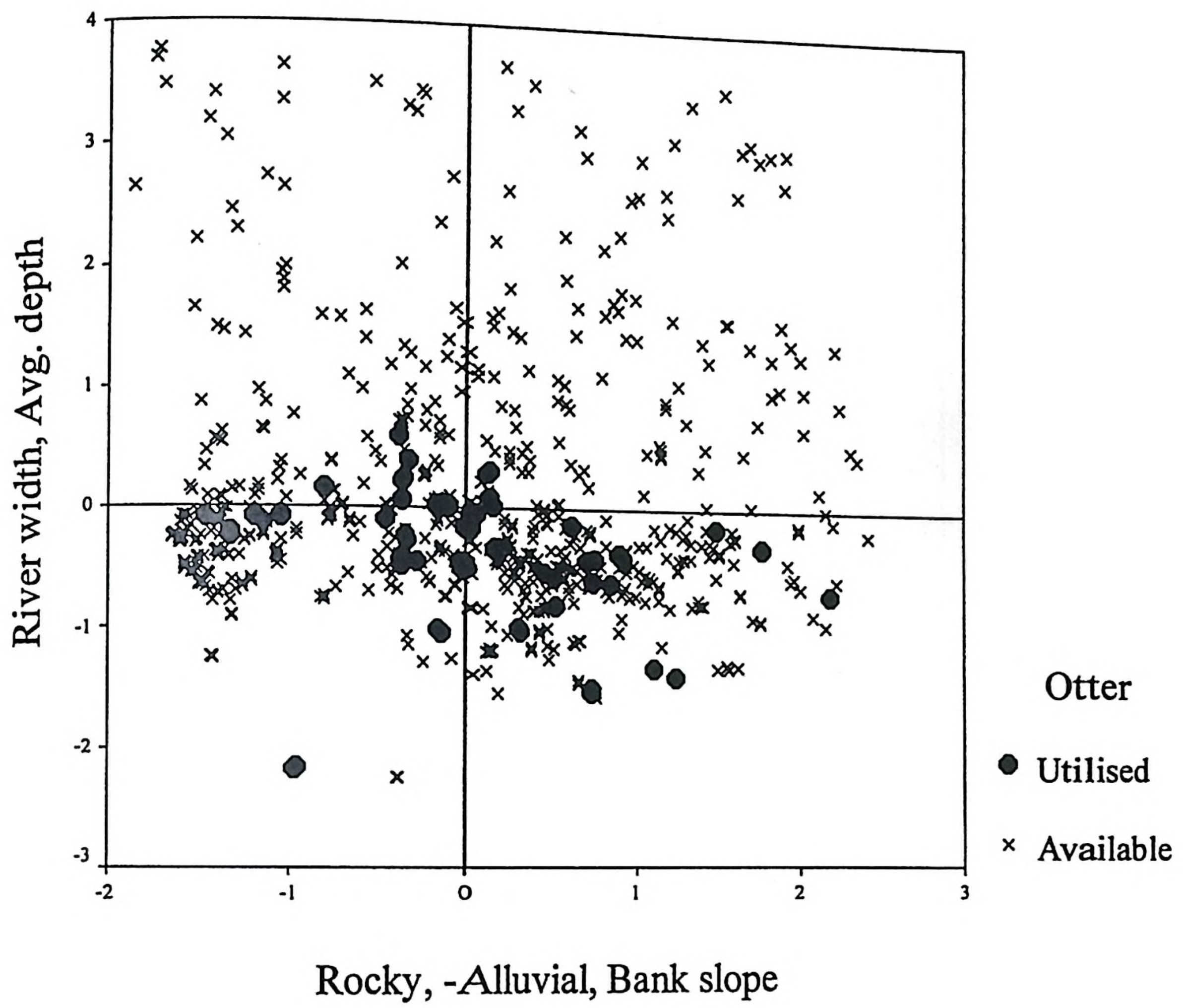


Fig. 4.2a. Distribution of available and utilized plots in relation to PC1 and PC2 during winter season in Corbett Tiger Reserve.

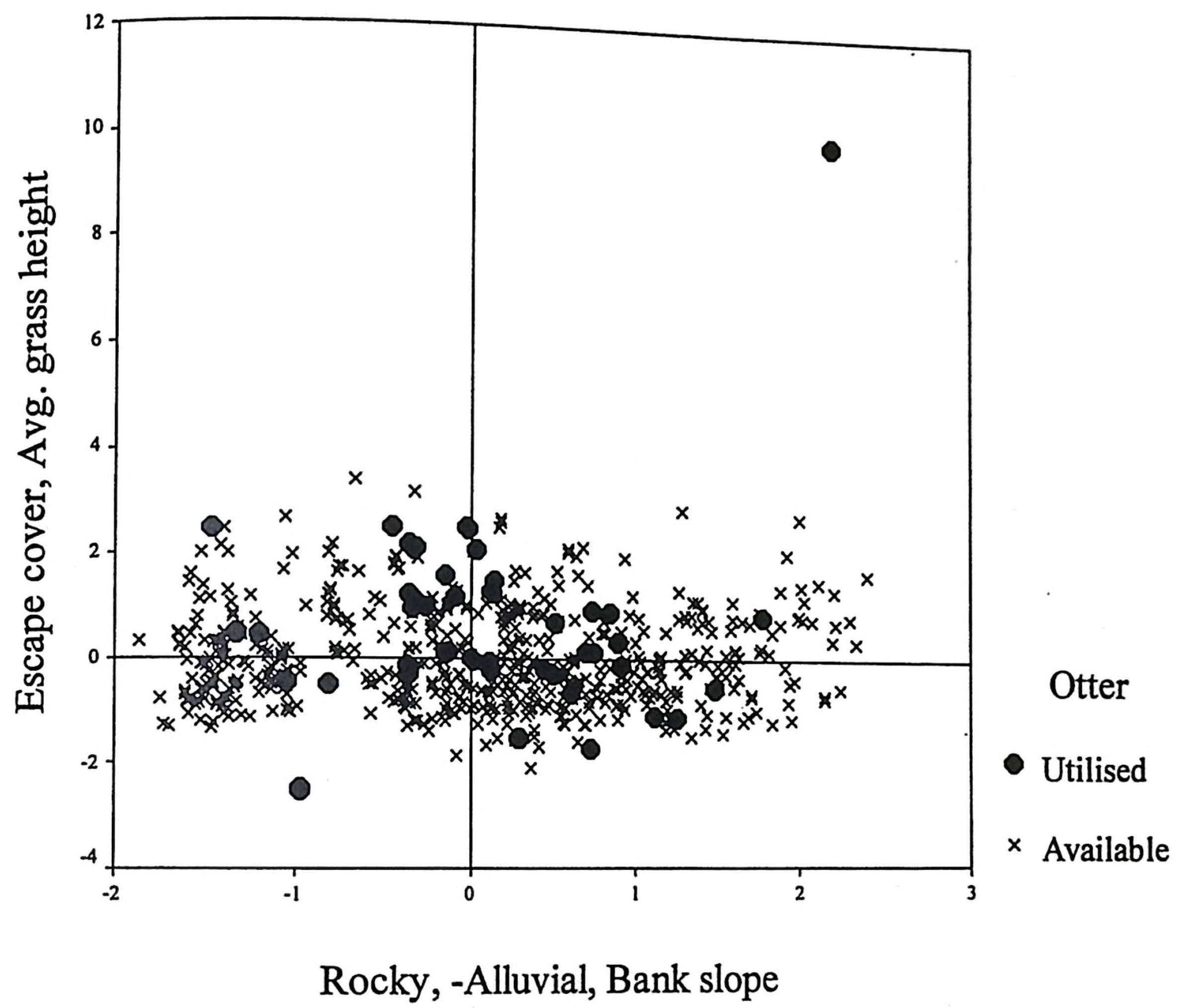


Fig. 4.2b. Distribution of available and utilized plots in relation to PC1 and PC3 during winter season in Corbett Tiger Reserve.

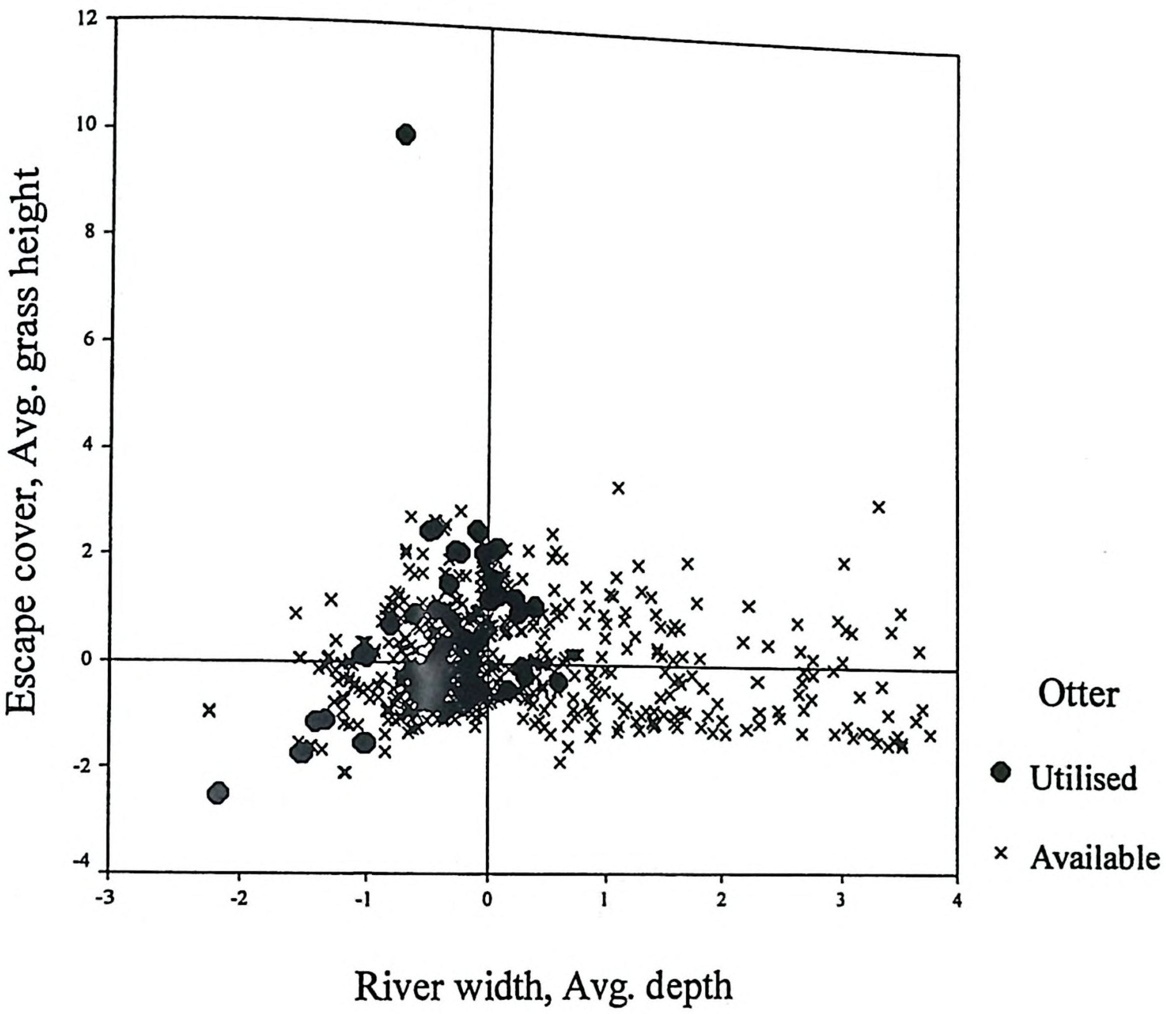


Fig. 4.2c. Distribution of available and utilized plots in relation to PC2 and PC3 during winter season in Corbett Tiger Reserve.

4.3.3. Factors influencing habitat use by otters in summer in Corbett Tiger Reserve

The first three principal components accounted for 42.92% of variance in otter habitat data (Table 4.5). The first factor was positively correlated with average grass height ($r= 0.886$, $p<.01$) and escape cover ($r= 0.826$, $p<.01$) but was negatively correlated with escape distance ($r= -0.514$, $p<.01$). The second factor was positively correlated with rocky stretches ($r= 0.899$, $p<.01$) and bank slope ($r= 0.666$, $p<.01$) but negatively correlated with alluvial stretches ($r=.-0.776$, $p<.01$). The third factor was positively correlated with river width ($r= 0.921$, $p<.01$) and average depth ($r= 0.905$, $p<.01$).

Figure 4.3 explains the distribution of utilised and available plots in relation to first, second and third component. Figure 4.3a is a plot of PC I in relation to PC II which shows that otters prefer areas with moderate to high grass height and escape cover but short escape distance, while on Y axis it shows the preference of moderate to high rocky stretches with moderately steep bank slopes and moderate to low alluvial stretches. Figure 4.3b is a plot between PC I and PC III that shows the presence of otters in areas with moderate to high grass height and escape cover but short escape distance with narrow river width and low average depth. Figure 4.3c shows the plots between PC II and PC III, otters prefer areas with moderate to high rocky stretches and moderately steep bank slope but low alluvial stretches and narrow river width and low average depth. The logistic regression model ($R^2= 0.48$) had an efficiency of 93.66% correct classification of available and utilized plots. The model suggests that the otters prefer sandy and rocky stretches with gentle bank slopes and average grass height. Areas with several streams joining the main course are favoured and longer escape distances are avoided (Table 4.6). Table 4.7.1 presents the association of mean otter spraint numbers to different speeds of water current i.e. fast and slow. No spraints were recorded at sites with fast current while (0.85± 0.10) spraint were recorded at sites with slow current and the results were found to be significant ($F_{1\ 802}$ = 115.402, P<.000). Table 4.7.2 depicts the association of mean otter spraint numbers present at different shoreline vegetation categories i.e. presence/absence. Spraints were recorded maximum at sites with presence of shoreline vegetation (0.39 ± 0.005) and results were found to be significant ($F_{1\ 802}$ = 10.771, P<.001). Table 4.7.3 presents the association of mean otter spraint numbers to the presence/absence of prey availability. Spraints were recorded only at sites with prey availability (0.38 ± 0.004) and the results were found to be significant ($F_{1\ 802}$ = 12.741, P<.000). Table 4.7.4 shows the association of mean otter spraint numbers to sites with associated fauna. Although spraints were recorded from both presence/absence sites (0.31± 0.004), however, the results were not found to be significant ($F_{1\ 802}$ = 0.000, P<.983). Table 4.7.5 shows that high mean otter spraint numbers (0.37 ± 0.004) were recorded from sites that had no disturbance and the results were found to be significant ($F_{1\ 802}$ = 21.075, P<.000).

Table 4.5. Principal Component Analysis of the habitat variables showing component loading on three principal components for summer in Corbett Tiger Reserve.

Variables	Component		
	PC I	PC II	PC III
Rocky	-0.106	0.849	0.002
Sandy	0.142	-0.008	0.001
Muddy	-0.313	-0.0003	-0.112
Clayey	0.132	-0.003	0.145
Alluvial	0.0005	-0.776	0.003
Escape cover	0.826	-0.142	-0.008
Escape distance	-0.514	-0.161	-0.001
Deadlog	0.004	0.160	0.113
Stream	-0.148	-0.0009	-0.129
River width	-0.001	-0.001	0.912
Avg. depth	-0.005	0.187	0.905
Bank slope	-0.006	0.666	0.243
Avg. grass height	0.886	-0.003	-0.0007
%of Variation	**14.69**	**14.49**	**13.72**
%Cumulative variance	**14.69**	**29.196**	**42.92**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation covered in 12 iterations.

Table 4.6. Summary of logistic regression model for predicting suitability of a sample plot for otters in summer in Corbett Tiger Reserve.

Variable	B	S.E	Wald	df	Sig.	R	Exp (B)
Escape distance	-0.6085	0.2203	7.6318	1	0.0057	-0.1135	0.5442
Deadlog	0.4448	0.1252	12.6232	1	0.0004	0.1559	1.5601
Stream	0.5712	0.1025	31.0843	1	0.0000	0.2580	1.7705
Bank slope	-0.5380	0.1982	7.3714	1	0.0066	-0.1109	0.5839
Average grass height	0.3660	0.1539	5.6578	1	0.0174	0.0915	1.4420
Rocky	0.6187	0.1884	10.7804	1	0.0010	0.1418	1.8564
Sandy	0.8852	0.1188	55.5327	1	0.0000	0.3501	2.4235
Constant	-3.3984	0.2353	208.5300	1	0.0000		

Table 4.7.1. Association of mean otter spraint numbers to water current in summer in Corbett Tiger Reserve.

Water current	**Spraint Mean ± S.E**
Fast current	0.00 ± 0.00
Slow current	0.85 ± 0.10

Table 4.7.2. Association of mean otter spraint numbers to shoreline vegetation in summer in Corbett Tiger Reserve.

Shoreline vegetation	**Spraint Mean ± S.E**
Presence	0.39 ± 0.005
Absence	0.008 ± 0.003

Table 4.7.3. Association of mean otter spraint numbers to prey availability in summer in Corbett Tiger Reserve.

Prey availability	**Spraint Mean ± S.E**
Presence	0.38 ± 0.004
Absence	0.00 ± 0.00

Table 4.7.4. Association of mean otter spraint numbers to associated fauna in summer in Corbett Tiger Reserve.

Associated fauna	**Spraint Mean ± S.E**
Presence	0.31 ± 0.17
Absence	0.31 ± 0.00

Table 4.7.5. Association of mean otter spraint numbers to disturbance in summer in Corbett Tiger Reserve.

Disturbance	**Spraint Mean ± S.E**
Presence	0.004 ± 0.002
Absence	0.44 ± 0.005

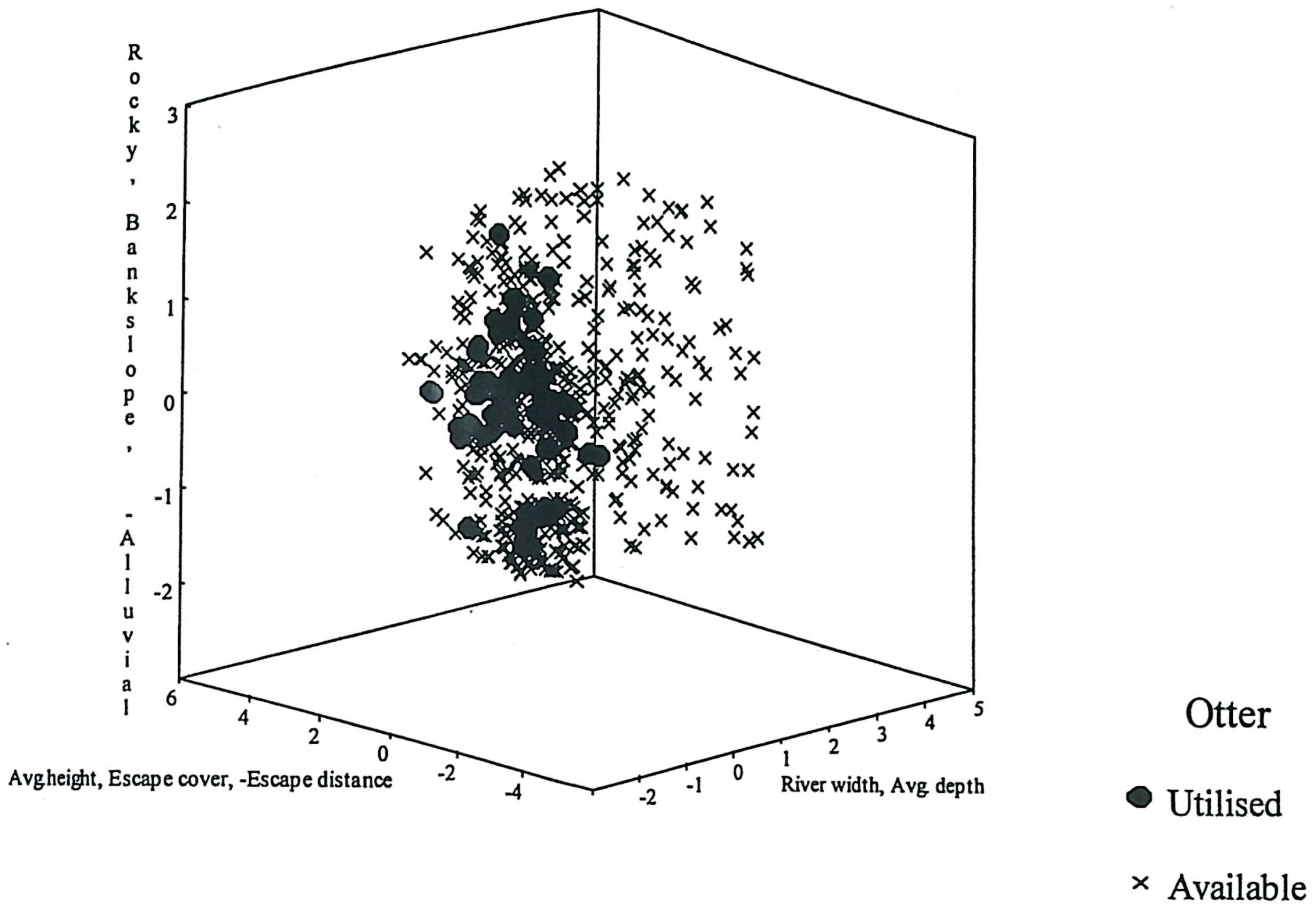


Fig. 4.3. Ordination of available and utilized plots of otters during the summer season in Corbett Tiger Reserve.

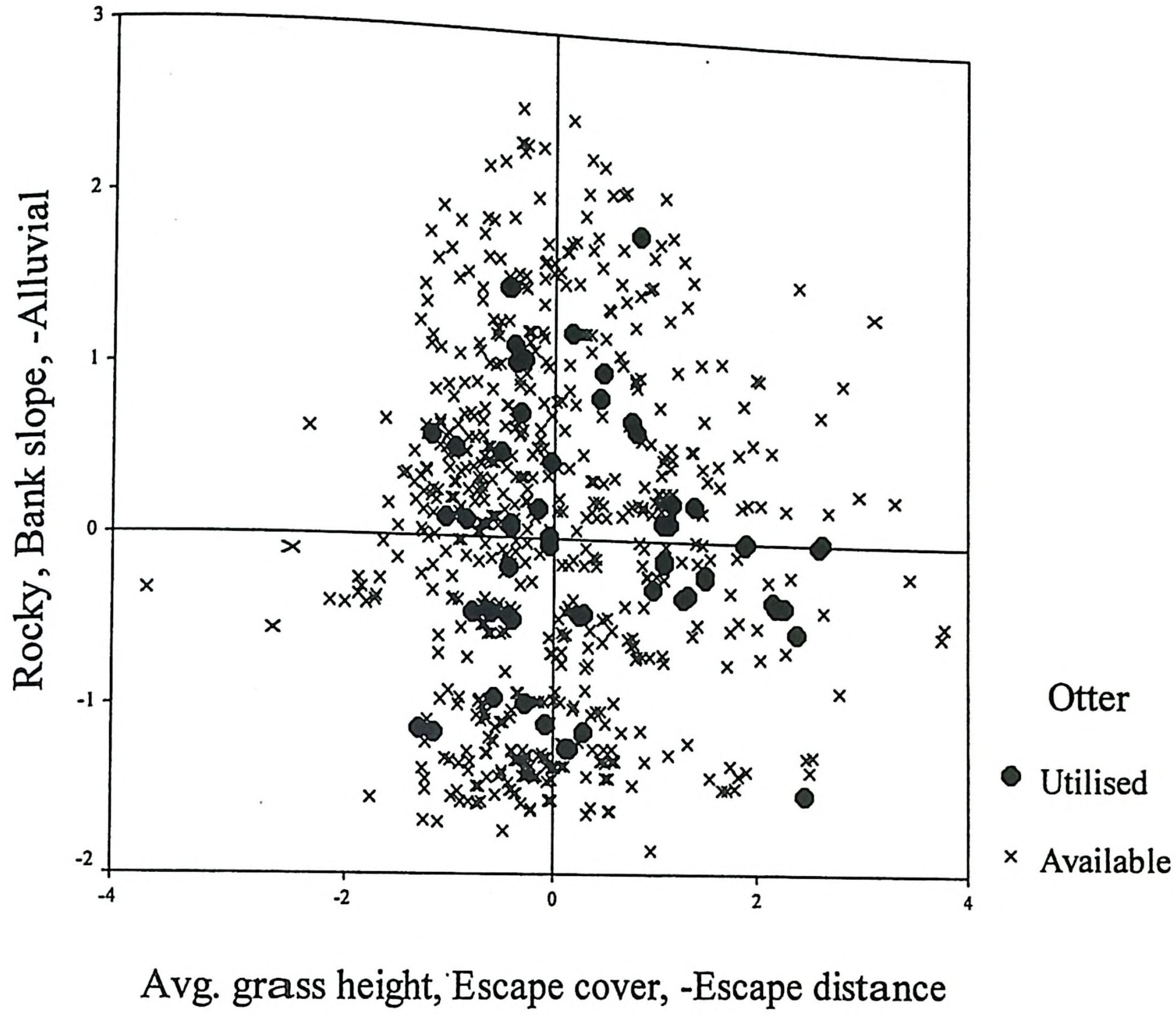


Fig. 4.3a. Distribution of available and utilized plots in relation to PC1 and PC2 during summer season in Corbett Tiger Reserve.

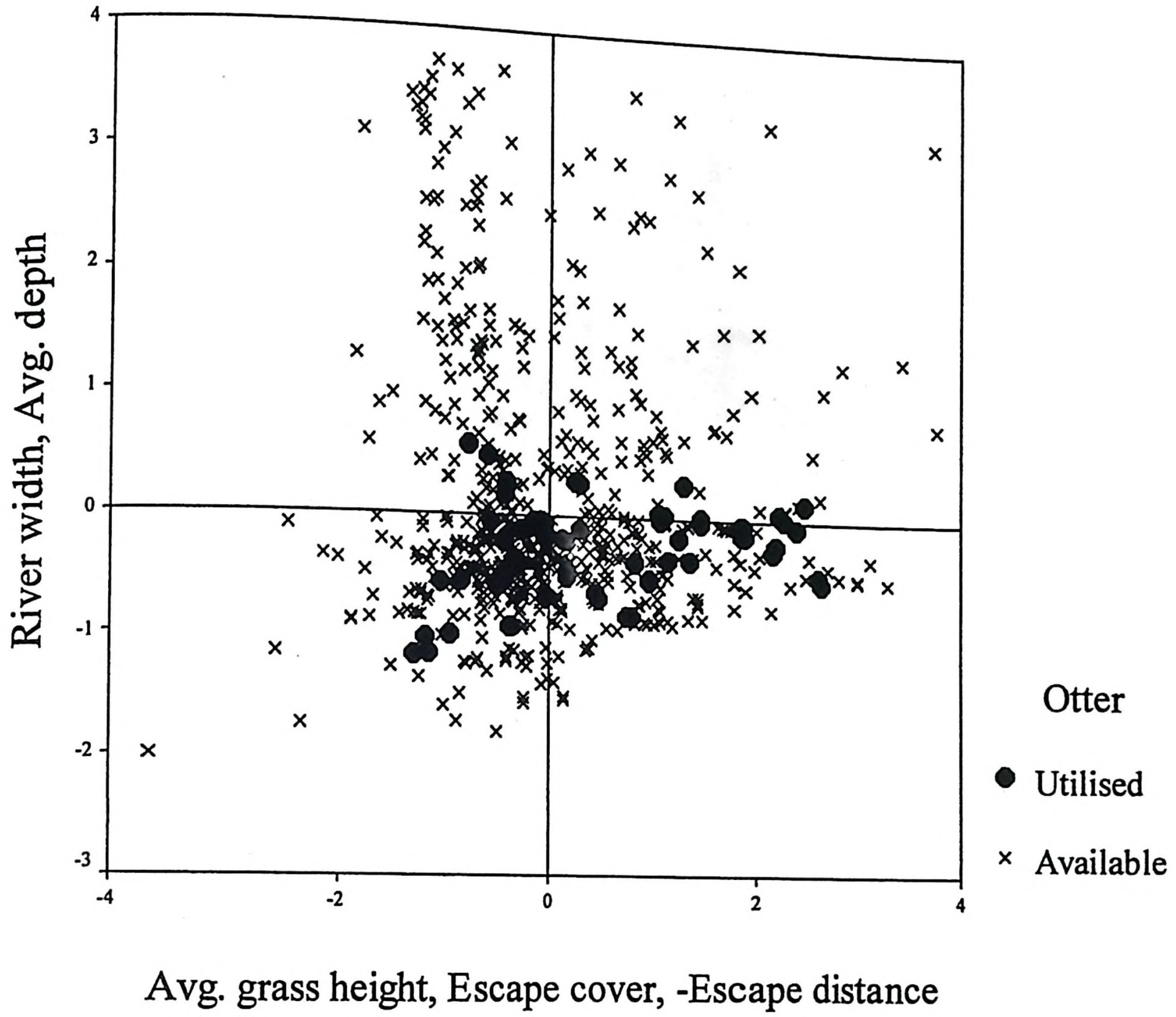


Fig. 4.3b. Distribution of available and utilized plots in relation to PC1 and PC3 during summer season in Corbett Tiger Reserve.

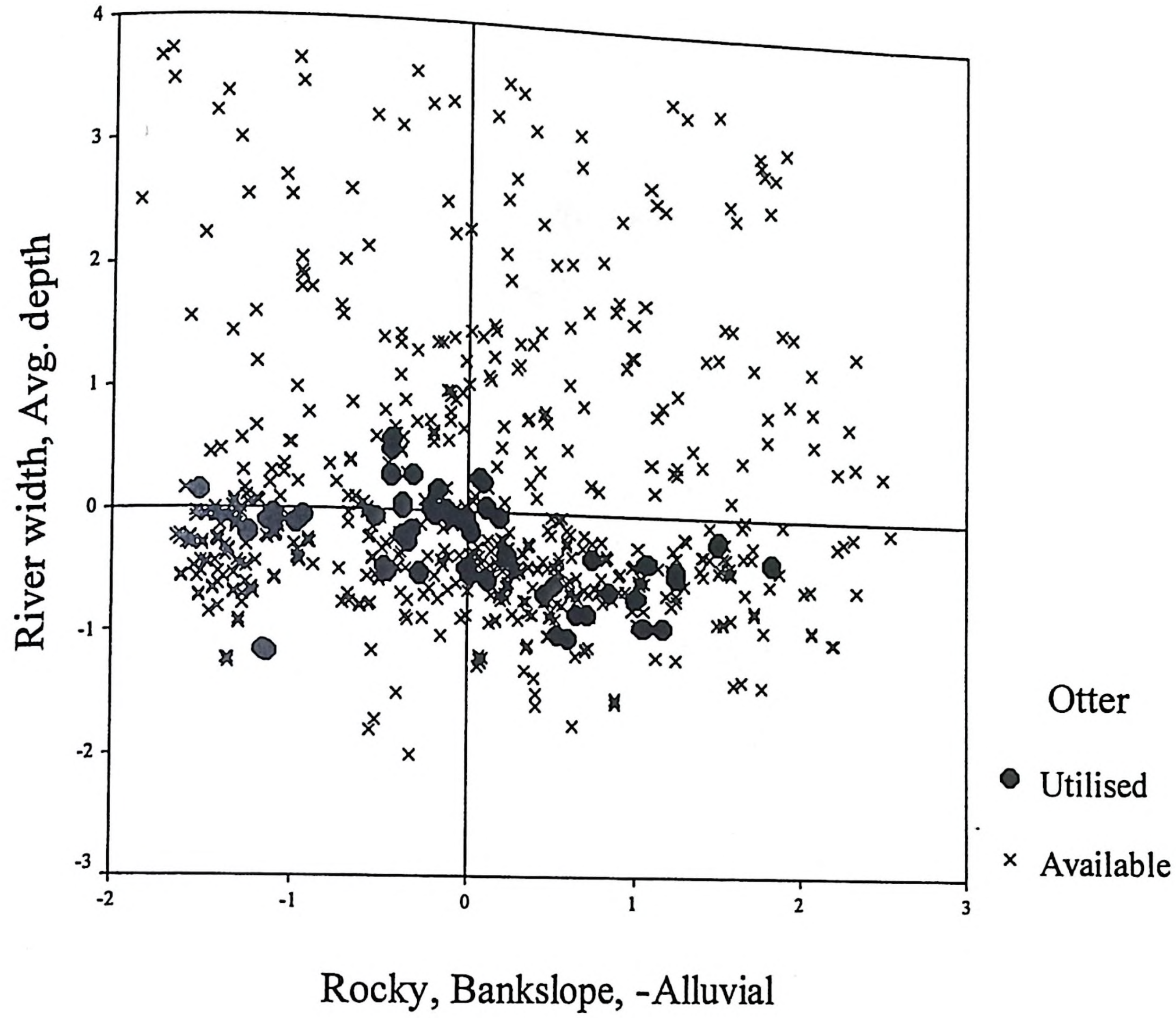


Fig. 4.3c. Distribution of available and utilized plots in relation to PC2 and PC3 during summer season in Corbett Tiger Reserve.

4.3.4. Reservoir *vs* riverine habitat of otters in Corbett Tiger Reserve

The first three principal components accounted for 43.88% of variance in otter habitat data (Table 4.8). The first factor was positively correlated with river width ($r = 0.860$ $p<.01$) and average depth ($r = 0.857$, $p<.01$) but negatively correlated with stream ($r = -0.542$ $p<.01$). The second factor was positively correlated with escape cover ($r = 0.832$, $p<.01$) and average grass height ($r = 0.760$, $p<.01$). The third factor was positively correlated with clayey stretch ($r = 0.789$, $p<.01$), escape distance ($r = 0.632$ $p<.01$) and dead log ($r = 0.561$, $p<.01$).

Figure 4.4 presents the distribution of utilised and available plots in relation to first, second and third component. Figure 4.4a is a plot of PCI in relation to PCII which shows that otters prefer areas with narrow river width, low average depth and with several streams joining the main course, while on Y axis it shows that otters prefer the area with moderate to high escape cover and average grass height. Figure 4.4b is a plot between PC I and PC III and shows the presence of otters in areas with narrow river width, low average depth and with several streams joining the main course while on Y axis otters prefer areas of low clayey stretch with presence of few numbers of dead log and short escape distance. Figure 4.4c is the plot of PCII and PCIII showing the preference of moderate to high escape cover and average grass height with low clayey stretch, short escape distance and presence of few numbers of dead logs. The logistic regression model ($R^2 = 0.95$) had an efficiency of 97.75% correct classification of available and utilized plots. The logistic regression model shows that the otters prefer sandy areas with low average depth (i.e. shallow water) (Table 4.9).

Table 4.10.1 presents the association of mean otter spraint numbers to different speeds of water current i.e. fast and slow. No spraints were recorded at sites with fast current while (1.13 ± 0.01) spraint were recorded at sites with slow current, however, the results were found to be significant ($F_{1\ 442} = 0.330$, $P<.5$). Table 4.10.2 depicts the association of mean otter spraint numbers present at different shoreline vegetation categories i.e. presence/absence. Spraints were recorded maximum at sites with presence of shoreline vegetation (1.56 ± 0.13) and results were found to be significant ($F_{1\ 440} = 46.872$, $P<.000$). Table 4.10.3 presents the association of mean otter spraint numbers to the presence/absence of prey availability. Although spraints were recorded only at sites with prey availability (1.14 ± 0.01), the results were however, not found to be significant ($F_{1\ 442} = 2.011$, $P<.157$). Table 4.10.4 shows the association of mean otter spraint numbers to sites with associated fauna. Although more spraints (1.19 ± 0.10) were recorded from sites which showed presence of associated fauna, the results were not found to be significant ($F_{1\ 442} = 3.040$, $P<.082$). Table 4.10.5 shows that high mean otter spraint numbers (1.16 ± 0.01) were recorded from sites that had disturbance, however, the results were not found to be significant ($F_{1\ 442} = 1.215$, $P<.271$).

Table 4. 8. Principal Component Analysis of the habitat variables showing component loading on three principal components for reservoir and the riverine systems in Corbett Tiger Reserve.

Variables	Component		
	PC I	PC II	PC III
Rocky	0.008	-0.009	-0.148
Sandy	-0.385	0.354	-0.452
Muddy	-0.0003	-0.377	-0.170
Clayey	-0.002	0.219	0.789
Alluvial	0.240	-0.246	-0.130
Escape cover	-0.007	0.832	0.003
Escape distance	0.288	-0.335	0.632
Deadlog	-0.007	-0.0003	0.561
Stream	-0.542	-0.192	-0.005
River width	0.860	-0.007	-0.004
Avg. depth	0.857	-0.189	0.109
Bank slope	0.257	0.120	0.255
Avg. grass height	-0.004	0.760	-0.101
% Varience	**16.48**	**14.3**	**13.09**
% Cumulative variance	**16.48**	**30.79**	**43.88**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 10 iterations.

Table 4.9. Summary of logistic regression model for predicting suitability of a sample plot for otters along the reservoir and the riverine systems in Corbett Tiger Reserve.

Variable	B	S.E	Wald	df	Sig.	R	Exp (B)
Sandy	1.5709	0.5730	7.5152	1	0.0061	0.1024	4.8108
Muddy	-3.1703	11.8134	0.0720	1	0.7884	0.0000	0.0420
Clayey	-3.7269	0.8702	18.3407	1	0.0000	-0.1763	0.0241
Escape distance	-3.3080	0.9791	11.4155	1	0.0007	-0.1338	0.0366
River width	-3.2674	0.9767	11.1920	1	0.0008	-0.1322	0.0381
Avg. depth	-7.7240	1.7280	19.9810	1	0.0000	-0.1849	0.0004
Constant	-10.5835	3.1935	10.9833	1	0.0009		

Table 4.10.1. Association of mean otter spraint numbers to water current along the reservoir and the riverine systems in Corbett Tiger Reserve.

Water current	**Spraint Mean ± S.E**
Fast current	0.00 ± 0.00
Slow current	1.13 ± 0.01

Table 4.10.2. Association of mean otter spraint numbers to shoreline vegetation along the reservoir and the riverine systems in Corbett Tiger Reserve.

Shoreline vegetation	**Spraint Mean ± S.E**
Presence	1.56 ± 0.13
Absence	0.25 ± 0.01

Table 4.10.3. Association of mean otter spraint numbers to prey availability along the reservoir and the riverine systems in Corbett Tiger Reserve.

Prey availability	**Spraint Mean ± S.E**
Presence	1.14 ± 0.01
Absence	0.00 ± 0.00

Table 4.10.4. Association of mean otter spraint numbers to associated fauna along the reservoir and the riverine systems in Corbett Tiger Reserve.

Associated fauna	**Spraint Mean ± S.E**
Presence	0.73 ± 0.22
Absence	1.19 ± 0.10

Table 4.10.5. Association of mean otter spraint numbers to disturbance along the reservoir and the riverine systems in Corbett Tiger Reserve.

Disturbance	**Spraint Mean ± S.E**
Presence	0.83 ± 0.27
Absence	1.16 ± 0.01

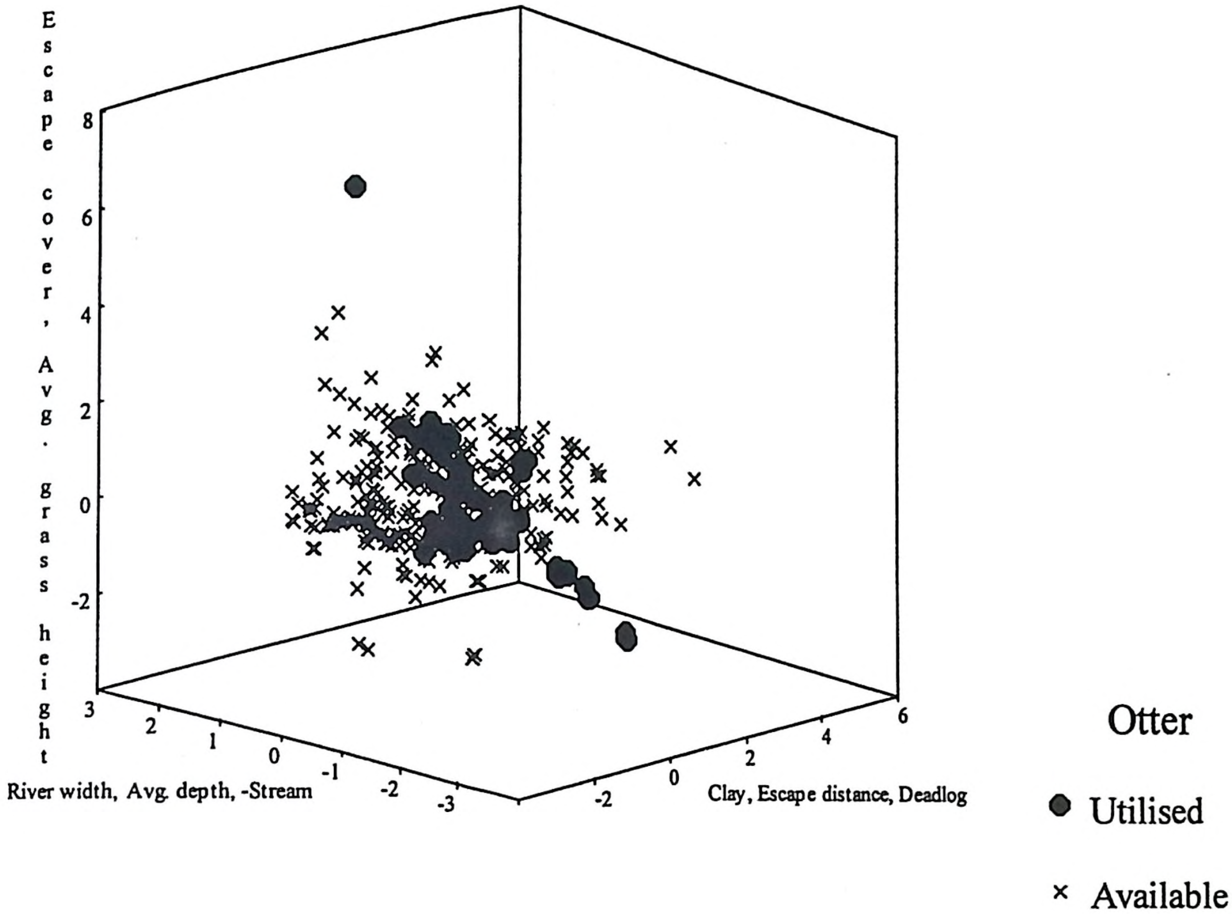


Fig. 4.4. Ordination of available and utilized plots of otters along the reservoir and the riverine systems in Corbett Tiger Reserve.

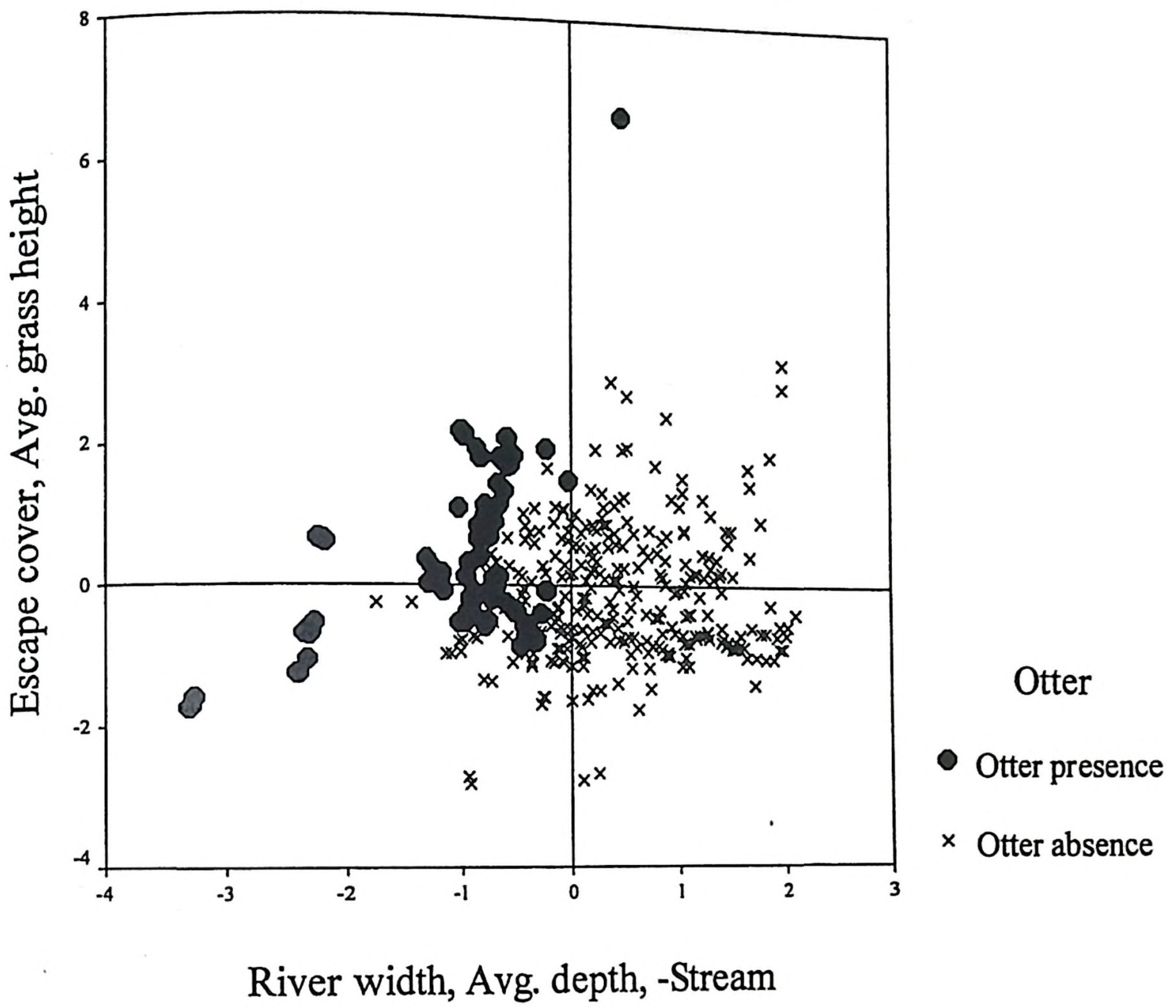


Fig. 4.4a. Distribution of available and utilized plots in relation to PC1 and PC2 along the reservoir and the riverine systems in Corbett Tiger Reserve.

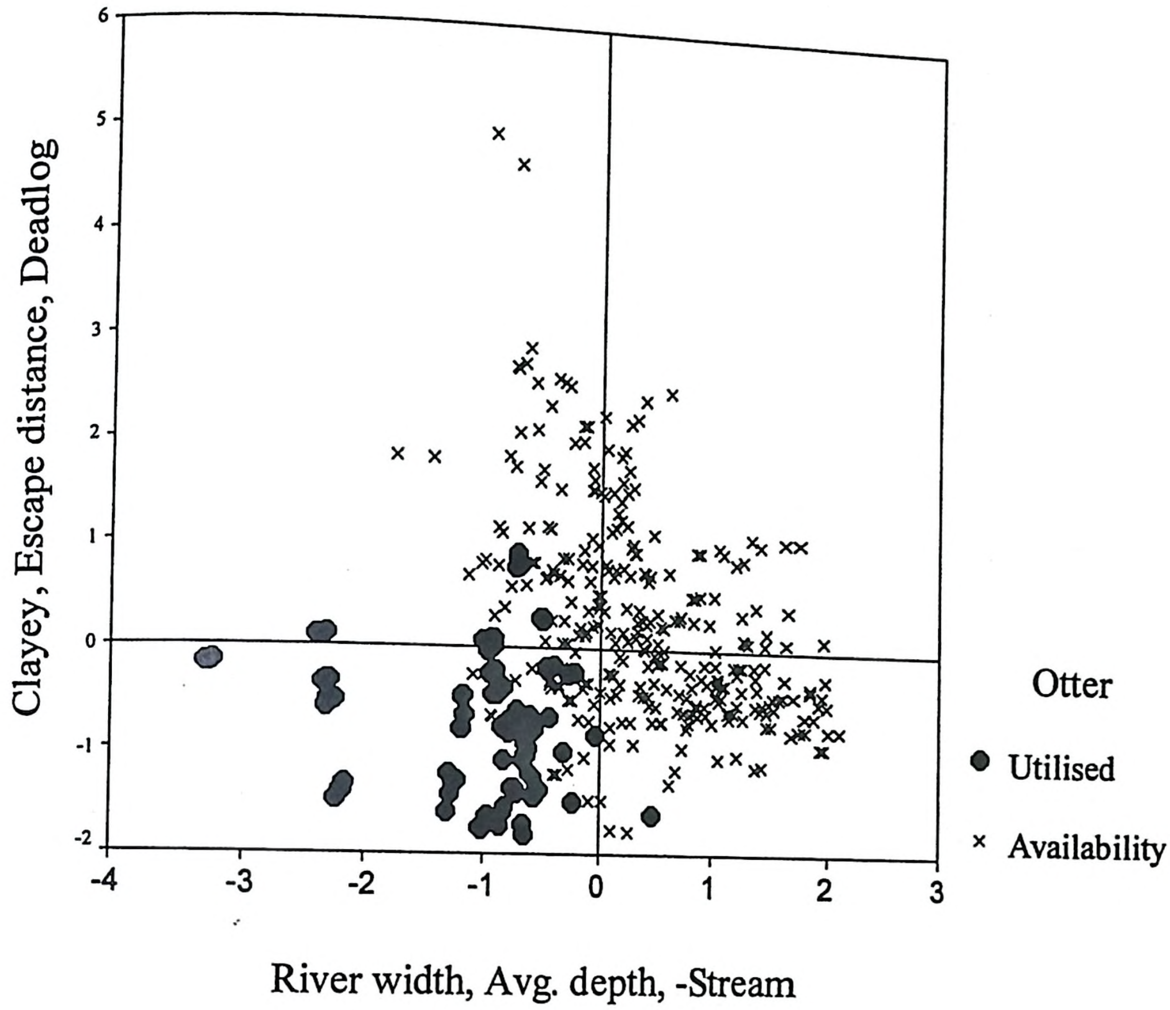


Fig. 4.4b. Distribution of available and utilized plots in relation to PC1 and PC3 along the reservoir and the riverine systems in Corbett Tiger Reserve.

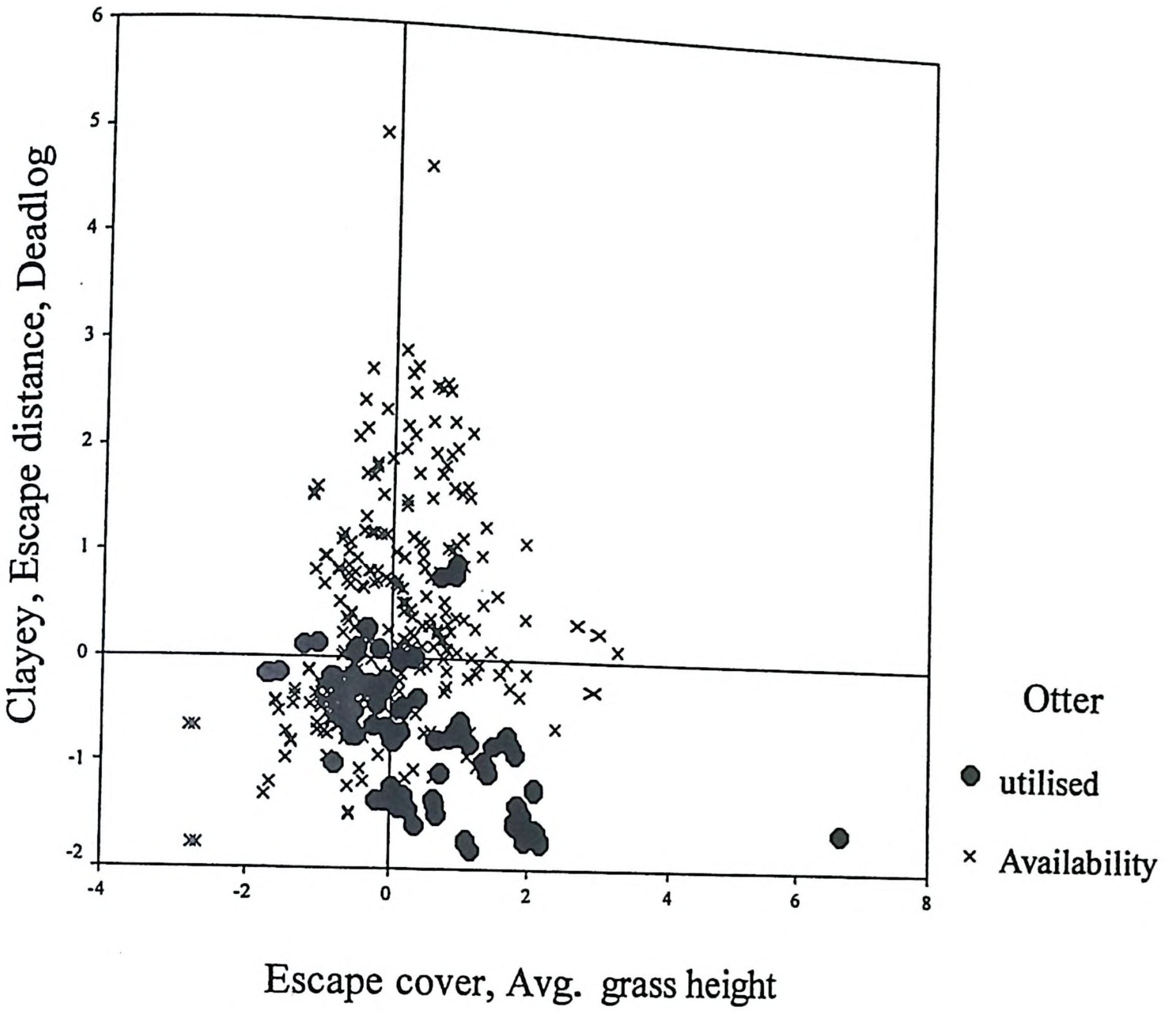


Fig. 4.4c. Distribution of available and utilized plots in relation to PC2 and PC3 along the reservoir and the riverine systems in Corbett Tiger Reserve.

4.3.5. Group Home-range

Home ranges of four otter groups identified in Corbett Tiger Reserve were developed using Kernell Home Range Method at 50% and 95% respectively. Kernel Home Range calculates a fixed kernel home range utilization distribution (Worton1989). Otter group at River Palain recorded the maximum area both at 50% (17.84 km^2) and at 95% (44.37 km^2) while otter group (A) at River Ramganga recorded the least area both at 50% (4.2 km^2) and 95% (28.03 km^2) (Table 11 and Fig. 4.5).

Table. 4.11. Home range areas of different otter groups in Corbett Tiger Reserve.

		Area (km^2)	
Site/Group	***n***	**50%**	**95%**
Ramganga A	7	4.2	28.03
Ramganga B	7	9.3	33.09
Mandal	6	6.72	22.09
Palain	11	17.84	44.37

n = Number of locations.

4.4. Discussion

The construction of dams is a significant environmental issue, mainly because of the impact it has on riparian habitats and fauna. The lotic systems are transformed into extensive lentic systems, promoting large-scale habitat disturbance (Alam *et al.* 1995 and Vié 1999). Dams have been inferred to negatively influence the distribution of Eurasian otters *Lutra lutra* and have frequently been suggested as a factor contributing for the decline of this species in Europe (Ruiz-Olmo *et al.* 2001). Freshwater systems are considered to be the selected habitats but they are heterogeneous and not all sections have the same significance and quality for supporting otters. Although reservoirs are used, they form artificial habitats (Ruiz-Olmo *et al.* 2005) and usually serve as travel lanes for otters (Sheldon and Toll 1964) or as feeding grounds (Pedroso *et al.* In Press).

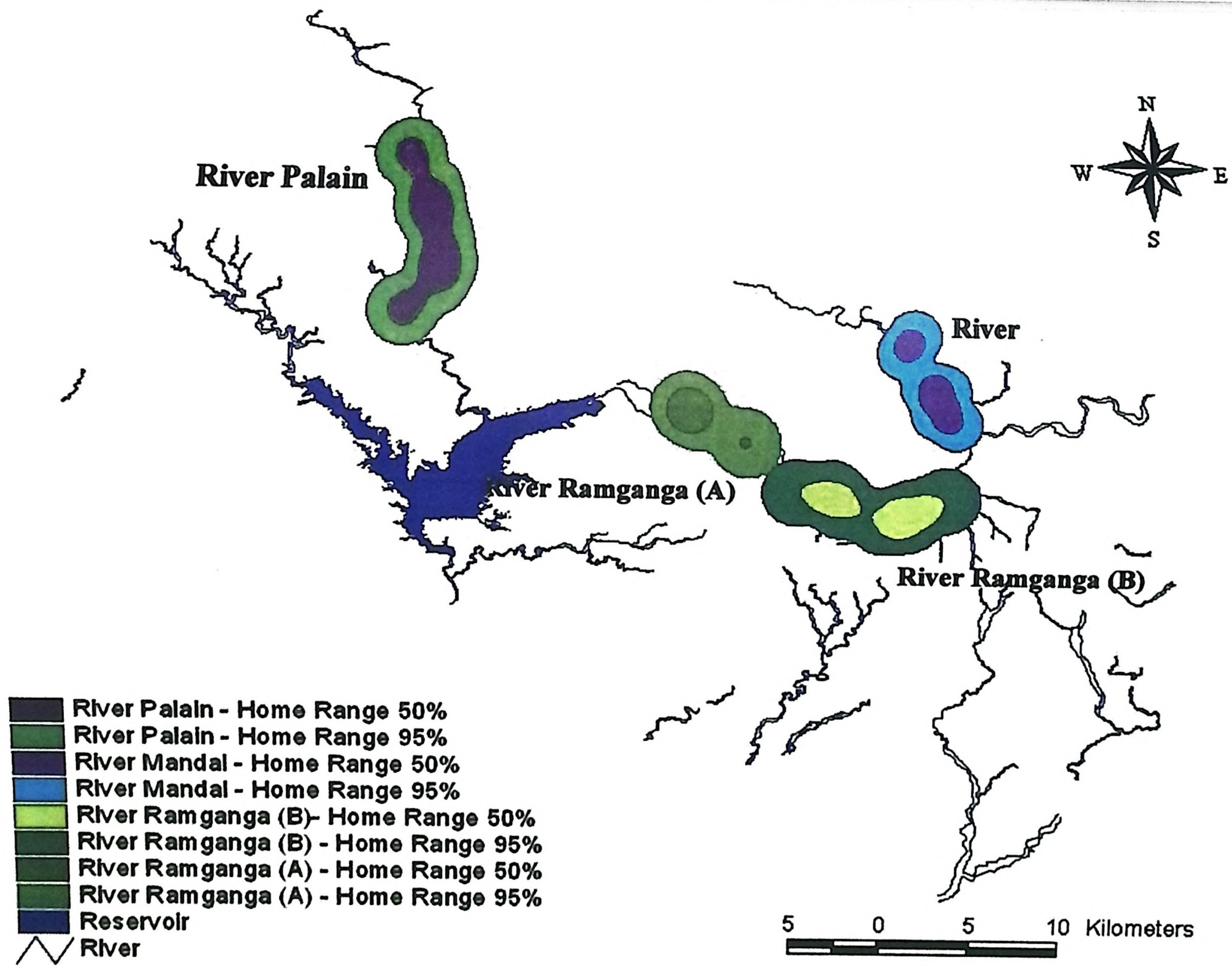


Fig. 4.5. Home range areas of different otter groups in Corbett Tiger Reserve.

A study conducted in Spain (Ruiz-Olmo *et al.* 2005) found otters to use stretches of the reservoir which provided shelter and resting sites and afforded good availability of prey. Similarly, Anoop and Hussain (2004) recorded presence of *Lutra perspicillata* along the shallower and narrower regions of the lake in Periyar Tiger Reserve in India. Rivers Ramganga, Mandal and Palain offer optimal habitats for otters in terms of denning and resting sites, sandy stretches with gentle bank slopes, slow water current and bank side vegetation serving as escape cover. Although intensive sampling was carried out along the reservoir, no signs of otter presence were recorded. This is attributed to steep bank slopes (47.38 ± 1.69, range 5° - 90°) and high water depth (699.95 ± 30.46, range 1 – 2313.75 cm), habitat features that are unsuitable for otters. Kruuk (1995) stated that large and deep reservoirs with steep shorelines are not ideal for otter foraging, which usually occurs in more shallow waters of lotic systems. The rapid and frequent fluctuation of water level results in scarce riparian vegetation that does not offer shelter for otters (Jenkins and Burrows 1980, Macdonald and Mason 1982, Bas *et al.* 1984 and Prenda and Granado-Lorencio 1995).

Estimating home ranges of species whose presence is restricted to specific dispersed habitats, being patchy or linear, is difficult, because estimates may include areas that the animal never uses (Perrin *et. al.* 2000). Stumpf and Mohr (1962) argued that the expression of home range in terms of linear units is justifiable for a number of species, including otters, and home ranges of otters living in riverine habitat are often estimated in linear units (Erlinge 1967; Melquist and Hornocker 1983; Green *et al.* 1984 and Hussain and Choudhury 1995). Similarly, length of coastal shore line has often been used to quantify the home range of otters living in marine habitats (Kruuk and Hewson 1978 and Arden Clarke 1986) and lacustrine habitats (Erlinge 1968). A typical group of smooth-coated otter consisting of male, female, and up to four young ones require 7 to 12 km of river for their territory and an even longer stretch of shoreline if living along the coast (Wayre 1978). During a radio-tracking study along the Chambal River in India, Hussain (1993) recorded a smaller home range length and area of smooth-coated otter as compared to that of the Eurasian otter, in Perthshire, Scotland and Northern river otter *Lutra candensis* in Idaho (Melquist and Hornocker 1983), but larger than that of Eurasian otter (Erlinge 1967) in Sweden. Sex differences in home range area are commonly found in carnivore species, including otters (Erlinge 1968; Green *et al.* 1984; Wynne and Sherburne 1984 and Hussain and Choudhury 1995). The spatial organization of males is influenced by three resources; food, cover and receptive females while that of females is governed by food and cover, and adjusted so that food availability is sufficient when food resources are low (Sandell 1989). Consequently, males have larger home range areas than females (Hussain and Choudhury 1995 and Perrin *et al.* 2000). The home ranges of different otter groups recorded in Corbett Tiger Reserve are small but they provide favourable habitat conditions for otters, suitable for denning, grooming and foraging sites.

Denning sites were usually rock crevices or boulders that served as a natural source of refuge. Dens were often associated with spraints, as also reported in the case of *Aonyx capensis* (Arden-clarke 1986); *Lutra lutra* and *Lontra canadensis* (Kruuk and Hewson 1978; Jenkins and Burrows 1980 and Newman and Griffin 1994). During otter surveys conducted in Europe, many den sites in lowland rivers were found in holes under the roots of mature trees growing close to the water and the species of tree was of great significance for the location of the holts (Macdonald *et al.* 1978). A similar observation was made by Anoop and Hussain (2004) in Periyar Tiger Reserve where otters were found to dig dens under the roots of large trees near the water's edge. However, no affinity towards any particular tree species was noticed, although a thick and shallow root system was found to be a desired characteristic. No such observations were made in the present study. Vegetation cover is important in providing suitable terrestrial habitats for otters in grasslands (Perrin and Carrugati 2000). Grasslands locally called *chaur* are a common feature in Corbett Tiger Reserve. They occupy a special and significant ecological status in the park and carry rich dense growth of various medium sized to tall grasses in varying degree. These are not only favored grazing grounds of the ungulates and elephants but also serve as ideal escape cover to small mammals like otters. Similar conclusions were reached in other studies (Procter 1963; Macdonald and Mason 1983; Green *et al.* 1984; Kruuk and Goudswaard 1990; Rowe-Rowe 1992; Melisch *et al.* 1996; Hussain and Choudhury 1997 and Anoop and Hussain 2004) where positive correlation existed between otter signs and percentage of vegetation cover. Perrin and Carrugati (2000) reported that burning of river banks was detrimental to the otters since it reduced cover and the availability of habitat suitable for holts. During the course of this study, an otter den was found abandoned after control burning along River Ramganga in Corbett National Park. Soft and absorbent material such as sand characterized the substratum of most of the grooming and basking sites. Otters are known to use soft substrate for grooming (Newman and Griffin 1994) or for drying their fur (basking) before entering the refuge (Verwoerd 1987). Since the river banks are not always safe, otters also use habitats with other kinds of substrates, such as rocks or logs (Procter 1963 and Anoop and Hussain 2004). Prey availability is probably the crucial factor in deciding the distribution of the otters. It is a well-known fact that animals follow their food abundance gradient and alter their home ranges accordingly (Macdonald 1983). It has been documented that the number of streams joining the main course of the river influences the congregation of fish (Anoop and Hussain 2004) and otters in Corbett Tiger Reserve were found to favour such areas since these provide with easy food with a minimum energy cost. Fish must be available year round if otters are to remain as permanent residents in an area (Melquist and Hornocker 1983).

The limiting factors are a primary concern, there are also other aspects of the habitat that are attractive to otters; referred as habitat preferences but which do not necessarily affect their numbers. Given that otters are generally habitat specific, the availability of suitable habitats may be limited and hence their favored habitats may cover smaller areas and could be more isolated. Although stream systems offer dispersal corridors over large distances, otters are highly selective in their habitat use and, as the study suggest show considerable site specificity. Several authors (Kruuk *et al.* 1986; Mason and Macdonald 1986; Hussain and Choudhury 1997 and Anoop and Hussain 2004) have reported site fidelity by many otter species. This may be related to availability of denning and resting sites or the limited diving ability of otters and the availability of sites with suitable water depths to permit foraging amongst the substratum. The detection of areas important for otters must be a main focus for otter conservation, and should be included in any conservation action plan. This will direct resources to areas of main concern for otters.

4.5. Summary

The conservation of otter is inextricably linked to the conservation of the habitat of the otter's prey and the availability of suitable sites for shelter. Rivers Ramganga, Mandal and Palain offer optimal habitats for otters in terms of denning, resting and foraging sites. Availability of habitat features such as; rocky and sandy stretches with gentle bank slopes, bank side vegetation serving as escape cover, slow water current and prey availability govern the distribution of otters in Corbett Tiger Reserve. The reservoir is an unsuitable habitat for otters; this is attributed to steep bank slopes (47.38 ± 1.69, range 5°- 90°) and deep water (6.99 m ± 30.46, range 1–23.14 m), habitat features that are unsuitable for otters. The home ranges recorded for different otter groups were small, though they provided favourable habitat conditions for otters.

CHAPTER 5

FOOD AND FEEDING HABITS

5.1. Introduction

Otters have evolved two distinct foraging modes; piscivory and invertebrate feeding. Piscivorous otters are represented by *Lutra* species and the giant river otter *Pteroneura brasiliensis*, whereas the invertebrate feeders are the clawless and small clawed otters (*Aonyx* spp.) and the sea otter *Enhydra lutris* (Chanin 1985 and Estes 1989). Food of otters is one aspect of their ecology, which has been studied quite thoroughly in different parts of the world. Eurasian otter *Lutra lutra* has been studied very extensively (e.g. Erlinge 1968; Fairley 1972; Hewson 1973; Webb 1975; Kruuk and Hewson 1978; Wise 1980; Jenkins and Harper 1 980; Wise *et al.* 1981; Kruuk and Moorhouse 1990 and Kruuk 1995). Detailed studies on smooth-coated otter *Lutra perspicillata* has been done by Tiler *et al.* (1989); Foster-Turly (1992); Hussain (1993); Kruuk *et al.* (1994); Haque and Vijayan (1995) and Hussain and Choudhury (1997). Other major studies include on Neotropical river otter *Lontra longicaudis* by Pardini (1998), on Cape clawless otter *Aonyx capensis* and spotted necked *otter Lutra maculicollis* by Perrin and Carrugati (2000). Wayre (1978); Foster-Turly (1992) and Kruuk *et al.* (1994) have studied diet of Oriental small-clawed otter *Aonyx cineria.*

Otters have generally been described as fish specialist (Erlinge 1972; Wise *et al.* 1981 and Mason and Macdonald 1986). However, several studies suggested that the otter may be better defined as an opportunistic predator, with its feeding behavior being dependant on the availability of prey, hunting strategies and seasonal changes in the diet (Erlinge 1967; Jenkins *et al.* 1979; Gormally and Fairley 1982 and Carss 1995).

In rivers with a low diversity of prey, otters tend to feed on few species only, however, where populations are diverse, the otter's diet may comprise several prey categories, though many of these will be taken in small amounts (Roche 1998). Coastal otters feed mainly on inter-tidal or benthic species (Kruuk and Moorhouse 1990), although they may alternate between marine and freshwater habitats (Kruuk *et al.* 1986). Fish migrations, whether for spawning or overwintering, can temporarily increase the availability or biomass of some species (Carss *et al.* 1990). Different methods have been used to assess the diet of otters, *i.e.* direct observation, examination of feeding sites, analysis of gut contents and spraints (Webb 1975). Gut content analysis is the best method for dietary studies of otters but this involve killing of animals (Webb 1975). There is only one published report on food habits of otters by using gut content analysis (Fairley 1972). Many of the prey items that the otters feed on can be identified and their size classes can be estimated fairly accurately by direct observation (Kruuk and Moorhouse 1990) but in areas where they are nocturnal in habit this method is of no use. Feeding sites can give clue only of about larger prey specimens, which are eaten when the otters are out of water but since most of the fish are eaten in the water itself, this method too is of not much use. Spraint analysis is by far the most valid and acceptable method used world over. Observations on diet of otter are useful for their conservation and to determine how the species copes with changes in aquatic ecosystems both in terms of prey population as well as habitat availability.

5.2. Methodology

5.2.1. Collection and cleaning of spraints

Otter scats were collected from three different River stretches *viz;* Ramganga, Mandal and Palain covering 100 km stretch of the study area. Collections were made from the entrance of dens, communal sprainting sites and feeding areas. Only fresh scats were collected and every scat was considered a single entity if separated 5 m apart (Melquist and Hornocker 1983; Newman and Griffin 1994 and Medina 1996). Scats were collected in paper bags that were labeled with date and site number. These were later washed by soaking them in detergent solution. After overnight soaking they were washed under tap water by keeping in an iron sieve of mesh size 1mm. They were then sun dried in shade and weighed and stored in polythene zip-lock covers for future analysis.

5.2.2. Assessment of fish availability

Fish availability was estimated along 10 km stretches in the buffer zone, using cast nets. For every site thirty samplings (efforts) were done for both winter and summer respectively. Number of species, frequency of catches and length were recorded for each catch. Identification of fish species caught was done by referring Talwar and Jhingran (1991).

5.2.3. Preparation of standard reference material of fish for spraint analysis

For spraint analysis standard reference collection were made for which trapping of fish was carried out using cast nets, strip nets and *Launja*. A list was prepared and one specimen each from all possible size classes were collected and boiled for 5 to 15 minutes and washed by keeping in a sieve under tap water so as to remove the digestible portions. The vertebrae, scales and eyeballs were retrieved and weights measured and were kept labeled in a polythene cover for reference.

5.2.4. Determination of size of fish (prey) consumed

Using linear regression, the relationship between the lens diameter and the vertebral length with the body size of the fish consumed was established as suggested by (Wise *et al.* 1981). The presence of species was confirmed by scale examination. Since, this method has restrictions, in the sense that it is not always possible to determine whether several vertebrae occurring in a scat have originated from the same fish or from more than one individual; following assumptions were applied as recommended by Anoop and Hussain (2005):

(i.) The total number of vertebrae is almost constant in all species of fish.

(ii.) The chance of single vertebrae passing through the digestive system without any damage is the same for all the vertebrae of all the fish.

(iii.) If the otters eat several fish belonging to a particular size class, the vertebrae length corresponding to that size class will be proportionately represented in the spraint.

Data analysis

Prey remains in otter scats were identified by the comparison of body parts with a reference collection of appropriate prey species. Different food categories were identified and data are presented for each food category using two methods (Jenkins *et al.* 1979; Wise *et al.* 1981 and Anoop and Hussain 2005); (i) Percentage frequency of occurrence (F%): number of spraints containing prey category *i* (occurrences) divided by the total number of spraints (n), multiplied by 100. (ii) Percentage bulk (Sc%): based on a scoring system of 1-10 to assess the importance of each prey item in a spraint (1 being a trace item and 10 a spraint entirely composed of one single prey category). The score for each item was then multiplied by the dry weight of spraint and the resulting figure was summed for each item in each sample and expressed as bulk percentage. Catch per unit effort (CPUE) was calculated to determine the fish availability for two different seasons i.e. winter and summer. Preference for major fish species was determined by calculating 95% Bonferroni Confidence intervals following Byers *et al.* (1984). The 95% confidence intervals were constructed by following the formulae:

$$P_{ie}-Z_{\alpha/2k}\sqrt{P_{ie}(1-P_{ie})/n}\ [P_{ie}[\ P_{ie}+Z_{\alpha/2k}\sqrt{P_{ie}(1-P_{ie})/n}$$

where P_{ie} is the observed proportional utilisation of each species and $Z_{\alpha/2k}$ is the upper standard normal Table value corresponding to a probability tail area of $_{\alpha/2k}$ and n is total number of fish recorded. For each species its proportional availability (P_{io}) in the sample was calculated by dividing its total number (n) from that of total number of all individuals (N) sampled for all species (P_{io} = n/ΣN). Utilisation was significantly greater or less than availability when P_{io} lay out side the 95% confidence limits constructed for proportional availability (P_{ie}) which was calculated by dividing number of fish fragments (vertebrae or scales) identified for each species (n) by the total number of identified (N) species (P_{ie} = n/ΣD).

5.3. Results

In Corbett Tiger Reserve 29 species of fish have been reported (Hussain 1995), however during this study only 19 species were recorded but during the actual sampling only 16 species were caught (Appendix I). Of these, the reservoir recorded five while 14 species were recorded from the rivers. Two species viz. *Ompuk pabda* and *Rimas bola* were recoded from the reservoir only while three species viz

Chagunius chaginio, *Labio dyocheilus* and *Tor tor* were common for both the reservoir and the rivers. Catch per unit effort (CPUE) was calculated to determine the fish availability. Reservoir recorded maximum CPUE in both winter (1642.43 gm/hr/trap) and summer (1354.65 gm/hr/trap) while River Kosi recorded least in both winter (268.2 gm/hr/trap) and summer (201.63 gm/hr/trap) (Fig. 5.1). Size class (cm) of fish species caught ranged between 3.9 ± 0.9 (*Puntius* spp) and 53 ± 2.08 (*Labeo dyocheilus*).

A total of 499 spraints collected between 2001 and 2004 were analyzed. Diet of otters is represented by four prey categories in which fish (84%) was the most frequently occurring item in the spraints and also formed the bulk (97.27%) of the diet (Table. 5.1). There were no significant difference in overall proportions of different prey categories used between winter and summer (Wilcoxon Signed Ranks Test; $Z = 0.0$, $p = 1.0$). Also, there were no significant difference between the sites (Friedman Test; chi square 0.61, $p = 0.74$) and between seasons (Wilcoxon Signed Rank Test; $Z = 0.0$, $p = 1.0$) (Fig. 5.2 a, b, c,). Total eight fish species were identified from the spraints, which belonged to two families i.e. Cyprinidae and Sisoridae.

Seven fish species were recorded from spraints for both summer and winter season (Table 5.2). *Glyptothorax pectinopterus* (41.66%, n = 155) formed the maximum contribution while *Chagunius chaginio* formed the least (3.22%, n = 12) during summer season whereas in winter *Labeo dyocheilus* recorded maximum contribution (38.8%, n = 196) and *Schizothorax richordsonii* recorded least (0.99%, n = 5). Table 5.6 presents the values of 95% Bonferroni confidence interval for the utilised fish species. During summer *S. richordsonii* was uitilised in proportion to availability, while *Banilius bendelisis* and *Glyptothorax pectinopterus* were preferred species i.e. utilised significantly greater than availability. *Chagunius chaginio, Garra gotyla gotyla, Puntius ticto* and *Tor putitora* were avoided. *Labeo dyocheilus* was neither recorded in sampling nor in diet. In winter *Chagunius chaginio* was uitilised in proportion to availability, while *Banilius bendelisis, Glyptothorax pectinopterus* and *Puntius ticto* were avoided. *Labeo dyocheilus, S. richordsonii* and *Tor putitora* were utilised in proportion to availability. *Garra gotyla gotyla* was neither recorded in sampling nor in diet.

During summer five fish species were recorded while seven species were recorded in winter in River Ramganga from the spraints (Table 5.3). *Puntius ticto* made the maximum contribution (50.24%, n = 104) while *S. richordsonii* formed the least (2.89%, n = 6) during summer. In winter *Labeo dyocheilus* recorded the maximum contribution (40.83%, n = 98) and *S. richordsonii* recorded the least (1.25%, n = 3). Table 5.7 presents the values of 95% Bonferroni confidence interval for the utilised fish species in River Ramganga. During summer *Glyptothorax pectinopterus and S. richordsonii* were uitilised in proportion to availability, while *Puntius ticto* and *Tor putitora* were preferred species i.e. utilised significantly greater than availability. *Chagunius chaginio* was avoided. *Barilius bendelisis, Garra gotyla gotyla* and *Labeo dyocheilus* were neither recorded in sampling nor in diet. In winter *Chagunius chaginio* was uitilised in proportion to availability, while *Labeo dyocheilus* was preferred species i.e. utilised significantly greater than availability. *Banilius bendelisis, Puntius ticto, S. richordsonii* and *Tor putitora* were avoided. *Garra gotyla gotyla* was neither recorded in sampling nor in diet while *Glyptothorax pectinopterus* was recorded in sampling but not in diet.

Seven fish species each were identified from spraints during summer and winter respectively in River Mandal from the spraints (Table 5.4). *Puntius ticto* formed the maximum contribution (29.41%, n = 45) while *Chagunius chaginio* formed the least contribution (1.96%, n = 3) in summer, however, in winter the maximum contribution were recorded for *Chagunius chaginio* (36.92%, n = 48) and least from *S. richordsonii* (1.54%, n = 2). Table 5.8 presents the values of 95% Bonferroni confidence interval for the utilised fish species in River Mandal. During summer *Puntius ticto* and *S. richordsonii* were uitilised in proportion to availability, while *Barilius bendalisis* and *Garra gotyla gotyla* were preferred species i.e. utilised significantly greater than availability. *Chagunius chaginio, Glyptothorax pectinopterus* and *Tor putitora* were avoided. *Labeo dyocheilus* were neither recorded in sampling nor in diet. In winter *Barilius bendelisis* and *S. richordsonii* were uitilised in proportion to availability, while *Chagunius chaginio* and *Labeo dyocheilus* were preferred species i.e. utilised significantly greater than availability. *Glyptothorax pectinopterus, Puntius ticto* and *Tor putitora* were avoided. *Garra gotyla gotyla* was neither recorded in sampling nor in diet.

Six fish species were identified from spraints during summer and seven fish species during winter in River Palain from the spraints (Table 5.5). *Puntius ticto* formed the maximum contribution (36%, n = 72) while *Chagunius chaginio* formed the least contribution (0.5%, n = 1) in summer, however, in winter the maximum contribution were recorded for *Labeo dyocheilus* (40.77%, n = 53) and least from *Glyptothorax pectinopterus* and *Puntius ticto* (2.31%, n = 3) respectively. Table 5.9 presents the values of 95% Bonferroni confidence interval for the utilised fish species in River Palain. During summer *Chagunius chaginio* and *S. richordsonii* were uitilised in proportion to availability, while *Barilius bendelisis* and *Puntius ticto* were preferred species i.e. utilised significantly greater than availability. *Glyptothorax pectinopterus* and *Tor putitora* were avoided. *Garra gotyla gotyla* and *Labeo dyocheilus* were neither recorded in sampling nor in diet. In winter *Barilius bendelisis* and *Labeo dyocheilus* were uitilised in proportion to availability, while *Chagunius chaginio* was preferred species i.e. utilised significantly greater than availability. *Glyptothorax pectinopterus*, *Puntius ticto* and *Tor putitora* were avoided. *Garra gotyla gotyla* was neither recorded in sampling nor in diet while *S. richordsonii* was recorded in sampling but not in diet.

Thirty five individuals belonging to different fish species were caught for the purpose of establishing a linear relationship between the vertebrae length and eyeball diameter to the total length of the fish. A total of 35 eyeballs and 175 vertebrae were measured for the dimensions. This data was subjected to linear regression using SPSS Software. The eyeball diameter and vertebrae length were related to fish length (Table 5.10; Fig. 5.3 and Table 5.11; Fig. 5.4) as following:

Total length of the fish = 53.7 + (55.3 x Eyeball diameter).

Total length of the fish = 53.2 + (67.4 x Veretebrae length).

Table 5.1. Diet composition of otters in Corbett Tiger Reserve.

Prey category	Number of occurrence	Rel. Frequency	Bulk Percentage
Fish	499	84	97.27
Barilius bendelisis	120	11.2	7.2
Chagunius chaginio	199	18.6	22.1
Garra gotyla gotyla	23	2.2	1.3
Glyptothorax pectinopterus	163	15.2	13.5
Labeo dyocheilus	196	18.3	26.2
Puntius ticto	236	22.0	21.9
Schizothorax richordsonii	20	1.9	1.1
Tor putitora	114	10.6	6.7
Crab	77	13	2.69
Frog	17	2.9	0.04
Bird	1	0.2	0.00

Sample size: n = 499.

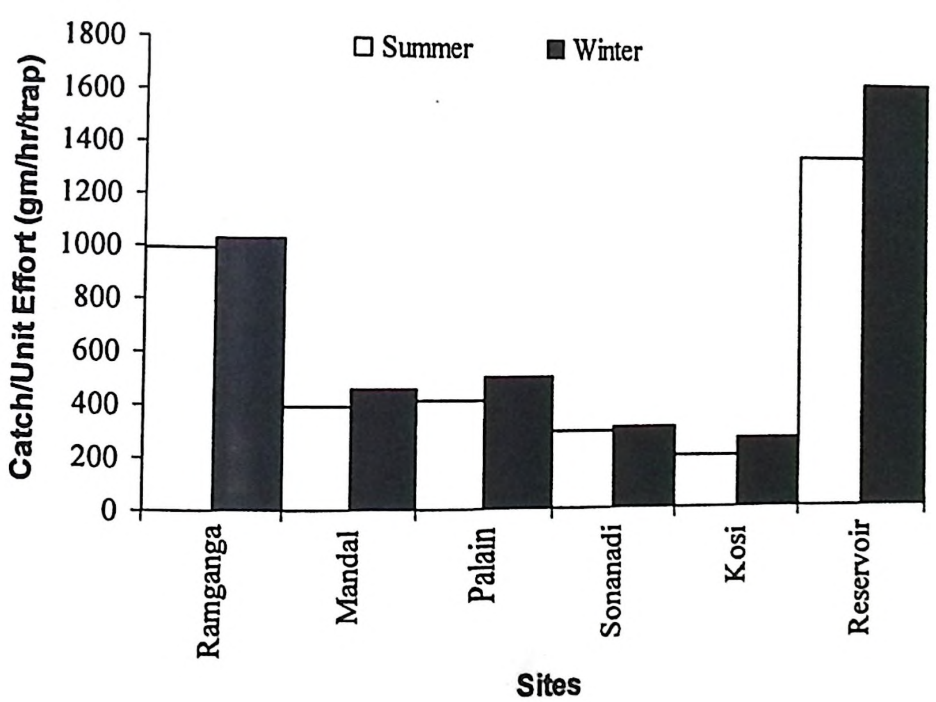


Fig. 5.1: Catch/Unit Effort (gm/hr/trap) recorded in summer and winter season across different sampling sites in Corbett Tiger Reserve and adjacent aquatic systems.

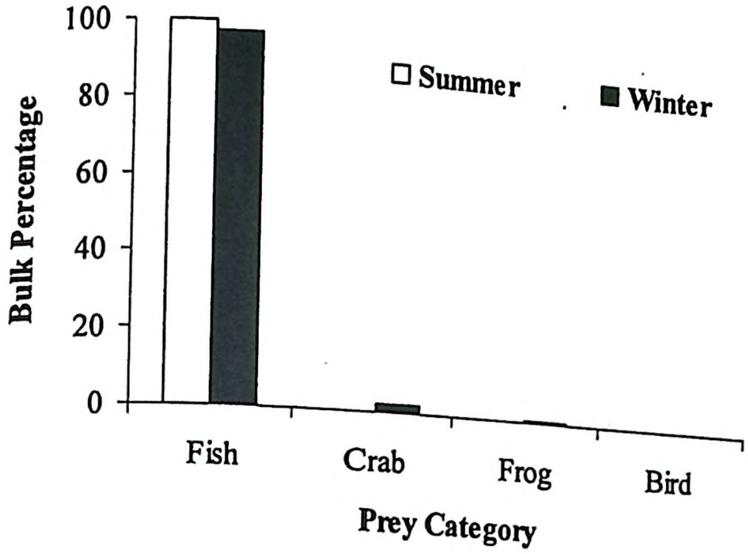


Fig 5.2a. Proportion of prey categories used in summer and winter in River Ramganga in Corbett Tiger Reserve (n = 499).

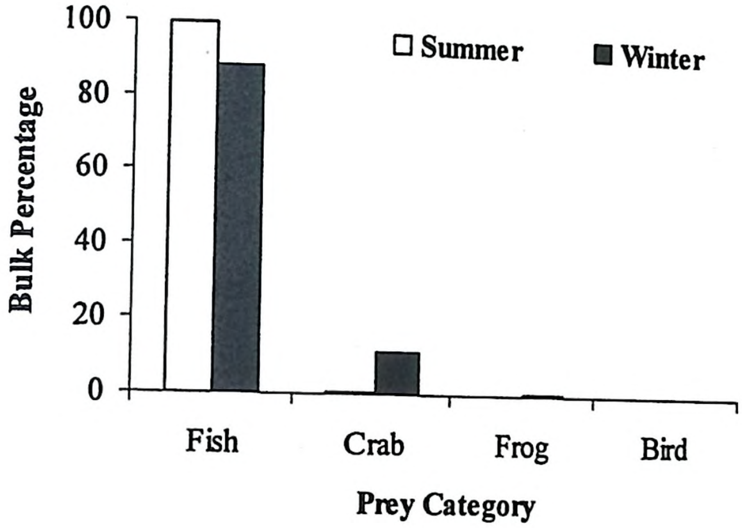


Fig. 5.2b. Proportion of prey categories used in summer and winter in River Mandal in Corbett Tiger Reserve (n = 499).

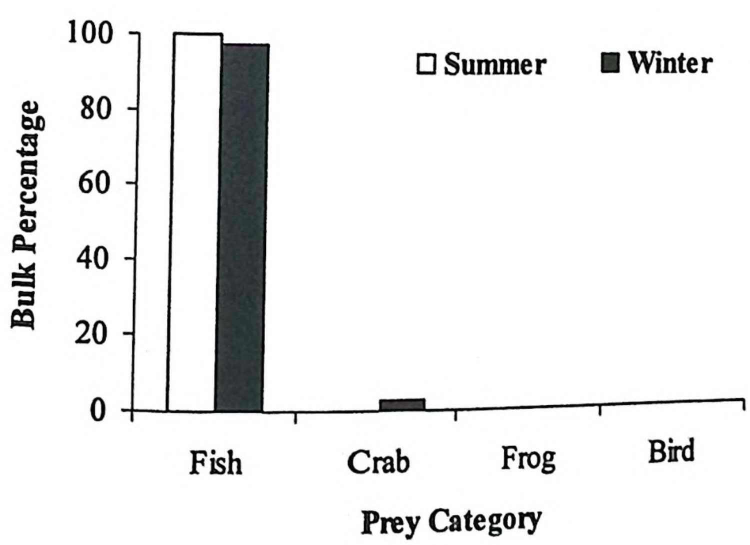


Fig. 5.2c. Proportion of prey categories used in summer and winter in River Palain in Corbett Tiger Reserve (n = 499).

Table 5.2. Percent of occurrence of fish species identified in otter spraint in summer and winter season. n = number of fish species recorded in diet composition, p = percent of occurrence.

Species	Summer			Winter		
	N	n	P	N	n	P
Barilius bendelisus	87	94	25.2	93	26	5.16
Chagunius chaginio	5	12	3.22	97	187	37.1
Garra gotyla gotyla	129	23	6.18	0	0	0
Glyptothorax pectinopterus	102	155	41.66	37	8	1.58
Labeo dyocheilus	0	0	0	102	196	38.8
Puntius ticto	110	221	5.9	84	15	2.9
S. richordsonii	20	15	4.03	11	5	0.99
Tor putitora	148	51	13.7	167	63	13.2

Table 5.3. Percent of occurrence of fish species identified in otter spraint in summer and winter season in River Ramganga. n = number of fish species recorded in diet composition, p = percent of occurrence.

Species	Summer			Winter		
	N	n	P	N	n	P
Barilius bendelisus	0	0	0	18	11	4.58
Chagunius chaginio	24	8	3.38	42	88	36.67
Garra gotyla gotyla	0	0	0	0	0	0
Glyptothorax pectinopterus	37	64	30.92	3	0	0
Labeo dyocheilus	0	0	0	18	98	40.83
Puntius ticto	21	104	50.24	19	7	2.92
S. richordsonii	9	6	2.89	5	3	1.25
Tor putitora	9	26	12.56	39	33	13.75

Table 5.4. Percent of occurrence of fish species identified in otter spraint in summer and winter season in River Mandal. n = number of fish species recorded in diet composition, p = percent of occurrence.

	Summer			Winter		
Species	N	n	P	N	n	P
Barilius bendelisus	5	42	27.5	9	6	4.62
Chagunius chaginio	15	3	1.96	23	48	36.92
Garra gotyla gotyla	2	23	15.03	0	0	0
Glyptothorax pectinopterus	27	28	18.30	19	5	3.85
Labeo dyocheilus	0	0	0	9	45	34.62
Puntius ticto	27	45	29.41	15	5	3.85
S. richordsonii	9	7	4.58	4	2	1.54
Tor putitora	20	15	9.80	27	19	14.62

Table 5.5. Percent of occurrence of fish species identified in otter spraint in summer and winter season in River Palain. n = number of fish species recorded in diet composition, p = percent of occurrence.

	Summer			Winter		
Species	N	n	P	N	n	P
Barilius bendelisus	11	52	26	17	9	6.92
Chagunius chaginio	3	1	0.5	21	51	39.23
Garra gotyla gotyla	0	0	0	0	0	0
Glyptothorax pectinopterus	38	63	31.5	18	3	2.31
Labeo dyocheilus	0	0	0	59	53	40.77
Puntius ticto	14	72	36	11	3	2.31
S. richordsonii	2	2	1	2	0	0.00
Tor putitora	21	10	5	22	11	8.46

Table 5.6. 95% Boneferoni confidence limit for available (*Pio*) and utilised proportion of different food material (*Pie*) in otter diet in summer and winter season in CTR. + = utilised significantly greater than availability, - = utilised significantly less than availability, 0 = Utilisation in proportion to availability, * = Neither recorded in sampling nor in diet.

	Summer				Winter			
Species	*Pio*	*Pie*	95% Bonferoni C.L Rating for *Pie*	Rating	*Pio*	*Pie*	95% Bonferoni C.L Rating for *Pie*	Rating
Barilius bendelisus	0.14	0.25	$0.15 \le Pie \le 0.31$	+	0.15	0.05	$0.01 \le Pie \le 0.09$	–
Chagunius chaginio	0.007	0.03	$-0.01 \le Pie \le 0.05$	–	0.16	0.37	$0.29 \le Pie \le 0.47$	+
Garra gotyla gotyla	0.21	0.06	$0.07 \le Pie \le 0.19$	–	0	0	0	*
Glyptothorax pectinopterus	0.17	0.42	$0.14 \le Pie \le 0.30$	+	0.06	0.02	$-0.01 \le Pie \le 0.05$	–
Labeo dyocheilus	0	0	0	*	0.17	0.39	$0.31 \le Pie \le 0..53$	0
Puntius ticto	0.18	0.05	$0.22 \le Pie \le 0.40$	–	0.14	0.03	$-0.00 \le Pie \le 0.06$	–
S. richordsonii	0.03	0.04	$-0.01 \le Pie \le 0.05$	0	0.02	0.009	$-0.01 \le Pie \le 0.03$	0
Tor putitora	0.25	0.14	$0.02 \le Pie \le 0.12$	–	0.28	0.13	$0.05 \le Pie \le 0.17$	0

Table 5.7. 95% Boneferoni confidence limit for available (P*io*) and utilised proportion of different food material (P*ie*) in otter diet in summer and winter season in River Ramganga. + = utilised significantly greater than availability, - = utilised significantly less than availability, 0 = Utilisation in proportion to availability, * = Neither recorded in sampling nor in diet, ** = species recorded in sampling but not recorded in diet.

	Summer				Winter			
Species	P*io*	P*ie*	95% Bonferoni C.L Rating for P*ie*	Rating	P*io*	P*ie*	95% Bonferoni C.L Rating for P*ie*	Rating
Barilius bendelisus	0	0	0	*	0.13	0.05	$0.009 \leq Pie \leq 0.091$	–
Chagunius chaginio	0.24	0.03	$-0.008 \leq Pie \leq 0.168$	–	0.29	0.37	$0.28 \leq Pie \leq 0.46$	0
Garra gotyla gotyla	0	0	0	*	0	0	0	*
Glyptothorax pectinopterus	0.37	0.31	$0.207 \leq Pie \leq 0.413$	0	0.02	0	0	**
Labeo dyocheilus	0	0	0	*	0.13	0.41	$0.317 \leq Pie \leq 0.503$	+
Puntius ticto	0.21	0.50	$0.388 \leq Pie \leq 0.618$	+	0.13	0.03	$-0.002 \leq Pie \leq 0.062$	–
S. richordsonii	0.09	0.03	$-0.008 \leq Pie \leq 0.168$	0	0.03	0.01	$-0.009 \leq Pie \leq 0.029$	–
Tor putitora	0.09	0.13	$-0.108 \leq Pie \leq 0.368$	+	0.27	0.14	$0.075 \leq Pie \leq 0.206$	–

Table 5.8. *95% Boneferoni confidence limit for available (Pio) and utilised proportion of different food material (Pie) in otter diet in summer and winter season in River Mandal.* + = utilised significantly greater than availability, - = utilised significantly less than availability, 0 = Utilisation in proportion to availability,* = Neither recorded in sampling nor in diet, ** = Species recorded in sampling but not recorded in diet.

	Summer				Winter			
Species	*Pio*	*Pie*	95% Bonferoni C.L Rating for *Pie*	Rating	*Pio*	*Pie*	95% Bonferoni C.L Rating for *Pie*	Rating
Barilius bendelisus	0.05	0.27	0.186 ≤ Pie ≤ 0.354	+	0.08	0.05	0.009 ≤ Pie ≤ 0.091	0
Chagunius chaginio	0.14	0.02	-0.006 ≤ Pie ≤ 0.046	-	0.22	0.37	0.28 ≤ Pie ≤ 0.46	+
Garra gotyla gotyla	0.02	0.15	0.083 ≤ Pie ≤ 0.217	+	0	0	0	*
Glyptothorax pectinopterus	0.26	0.18	0.107 ≤ Pie ≤ 0.25	-	0.18	0.04	0.003 ≤ Pie ≤ 0.077	-
Labeo dyocheilus	0	0	0	*	0.08	0.35	0.26 ≤ Pie ≤ 0.44	+
Puntius ticto	0.26	0.29	0.020 ≤ Pie ≤ 0.375	0	0.14	0.04	0.003 ≤ Pie ≤ 0.077	-
S. richordsonii	0.09	0.05	0.009 ≤ Pie ≤ 0.091	0	0.04	0.02	-0.006 ≤ Pie ≤ 0.046	0
Tor putitora	0.19	0.09	0.036 ≤ Pie ≤ 0.144	-	0.25	0.15	0.083 ≤ Pie ≤ 0.217	-

Table 5.9. *95% Boneferoni confidence limit for available (Pio) and utilised proportion of different food material (Pie) in otter diet in summer and winter season in River Palain.* + = utilised significantly greater than availability, - = utilised significantly less than availability, 0 = Utilisation in proportion to availability, * = Neither recorded in sampling nor in diet, ** = Species recorded in sampling but not recorded in diet.

	Summer				Winter			
Species	*Pio*	*Pie*	95% Bonferoni C.L Rating for *Pie*	Rating	*Pio*	*Pie*	95% Bonferoni C.L Rating for *Pie*	Rating
Barilius bendelisus	0.12	0.26	$0.171 \leq Pie \leq 0.35$	+	0.11	0.07	$0.022 \leq Pie \leq 0.118$	0
Chagunius chaginio	0.03	0.01	$-0.01 \leq Pie \leq 0.03$	0	0.14	0.39	$0.286 \leq Pie \leq 0.494$	+
Garra gotyla gotyla	0	0	0	*	0	0	0	*
Glyptothorax pectinopterus	0.42	0.32	$0.224 \leq Pie \leq 0.415$	-	0.12	0.02	$-0.006 \leq Pie \leq 0.046$	-
Labeo dyocheilus	0	0	0	*	0.39	0.41	$0.317 \leq Pie \leq 0.503$	0
Puntius ticto	0.16	0.36	$0.26 \leq Pie \leq 0.457$	+	0.07	0.02	$-0.006 \leq Pie \leq 0.046$	-
S. richordsonii	0.02	0.01	$-0.01 \leq Pie \leq 0.03$	0	0.01	0.00	0	**
Tor putitora	0.24	0.05	$0.006 \leq Pie \leq 0.09$	-	0.15	0.08	$0.026 \leq Pie \leq 0.135$	-

Table 5.10. Linear relation between eyeball diameter and fish length in Corbett Tiger Reserve.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.848[a]	0.720	0.711	18.1653	0.720	84.787	1	33	0.000

a. Predictors: (Constant), Eyeball diameter (mm)
b. Dependent Variable: Length (mm)

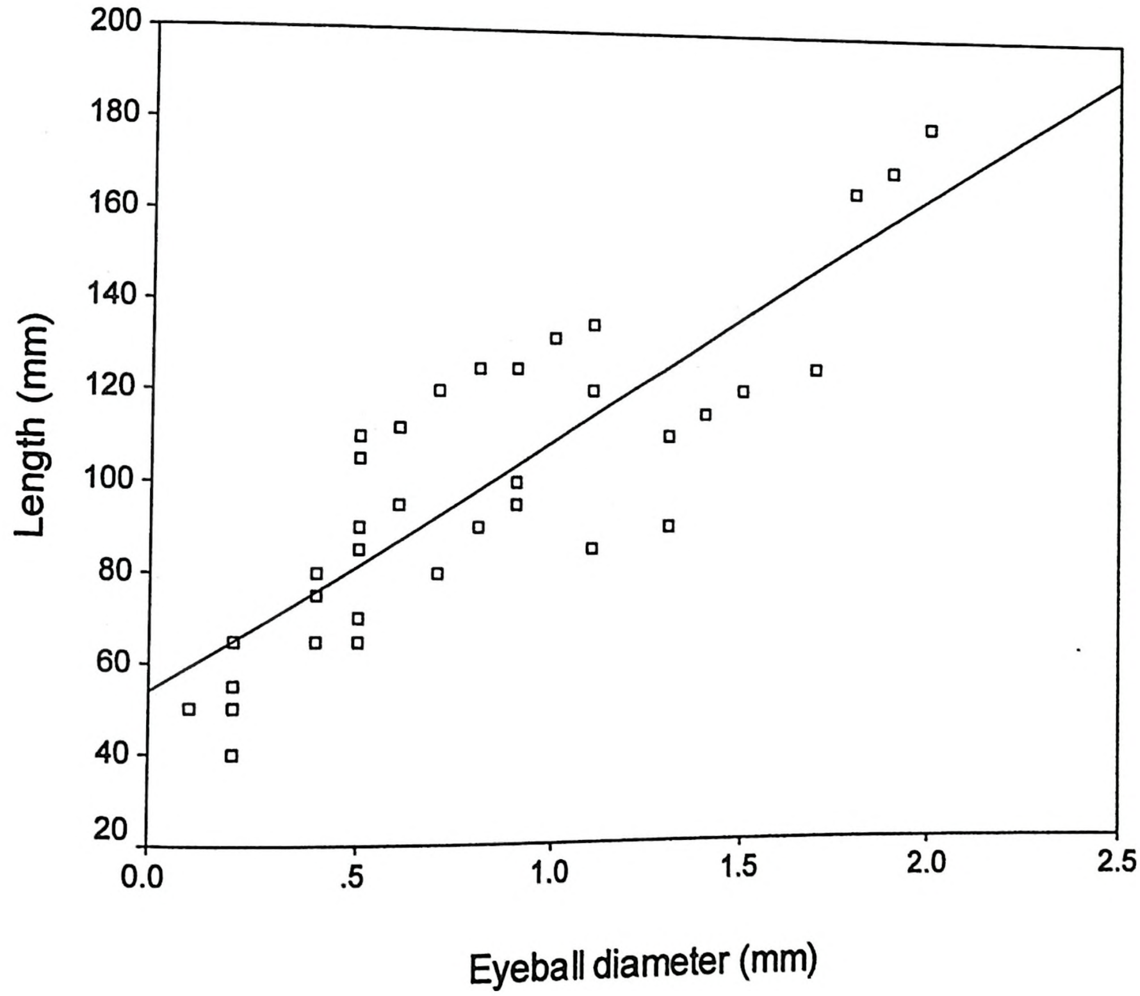


Fig. 5.3. Linear fit of eyeball diameter with total length of the fish in Corbett Tiger Reserve.

Table 5.11. Linear relationship between vertebrae length and total length of the fish in Corbett Tiger Reserve.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.947[a]	0.897	0.894	13.50946	0.897	313.805	1	36	0.000

a. Predictors: (Constant), Vertebrae length (mm)
b. Dependent Variable: Length (mm)

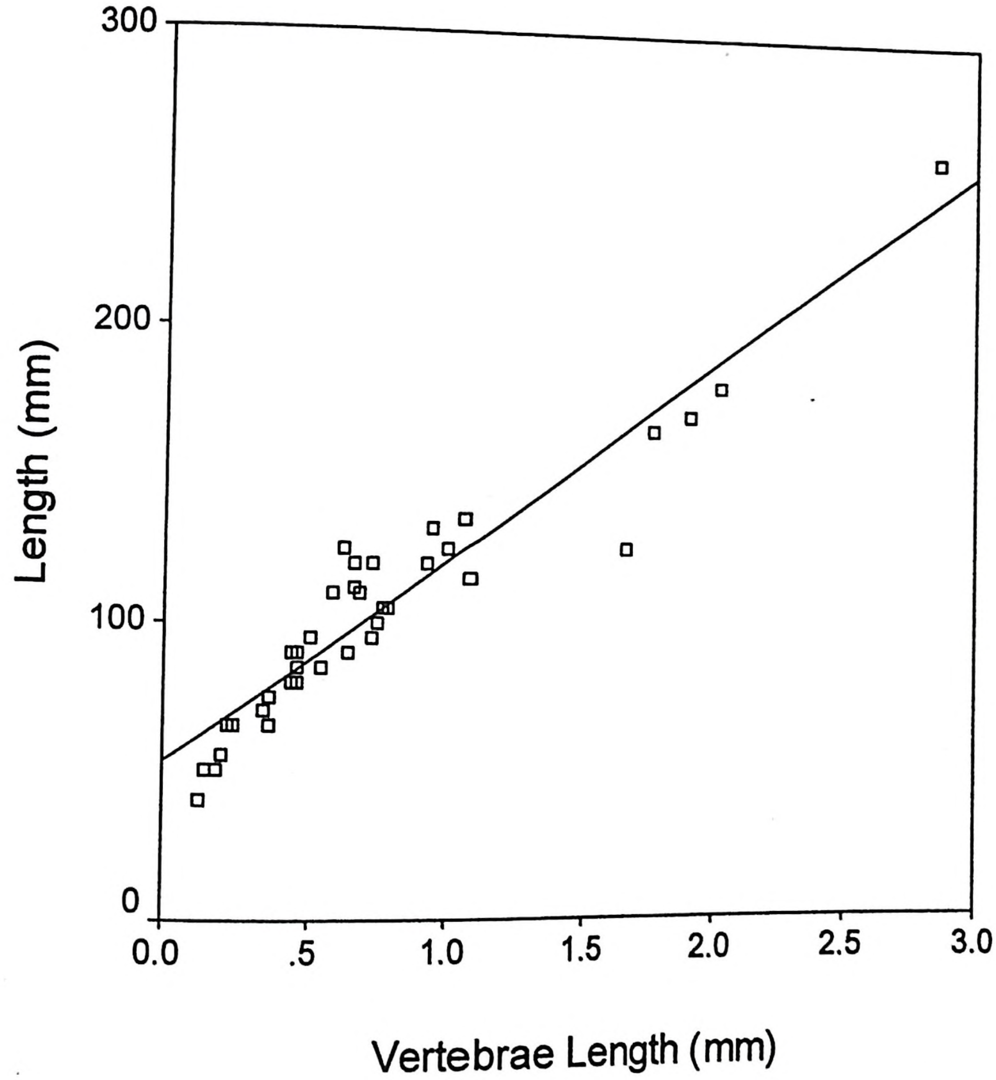


Fig. 5.4. Linear fit of vertebrae length with total length of the fish in Corbett Tiger Reserve.

5.4. Discussion

Otters are recognized as one of the top predators in freshwater systems, and thus have the potential to play an important role in the functioning of these systems. Otters feed on a whole range of prey but mainly fish (Webb 1975; Jenkins *et al.* 1979 and Wise *et al.* 1981) while in a few areas crayfish or frogs may predominate (Erlinge 1967). The reliability of analyses of spraints, as an indication of the relative frequency with which different prey is taken, has been investigated in detail. In general, the weight or volume of prey in spraints gives the most reliable estimate, although frequency of occurrence produces at least an accurate rank order of prey categories (Wise *et al.* 1981; Jacobsen and Hansen 1996 and Carss and Parkinson 1996). Aquatic birds are usually seasonal in the diet and are generally regarded as being of 'secondary importance'. Mammals are taken rarely, rabbit *(Oryctolagus cuniculcrs)* and water vole *(Awicola terrestris)* more than other species (Jenkins *et al.* 1979 and Wise *et al.* 1981). Aquatic insects are occasionally recorded as eaten deliberately, rather than ingested with other prey (Webb 1975 and Mason and Macdonald 1986). However, the results of such analysis appear convincing when proportions of various prey are expressed to the nearest 0.1% accuracy (Mason and Macdonald 1986) or even 0.01% (e.g. Lopez-Nieves and Hermando 1984). The validity of the technique has been assessed by feeding trials involving captive, tame otters and computer simulation of various spraint sub-sampling regimes (Carss 1996).

In the present study, the overall results indicate that otters are predominantly piscivorous. No significant differences were recorded in selection of different prey categories by smooth-coated otters between the seasons and across the sites, however, (Hussain 1993 and Hussain and Choudhury 1995) have established that the exploitation of secondary prey especially in winter such as bird, crab and shrimps may be a strategy for meeting additional energy requirements for thermoregulation and for rearing pups. Such secondary diet items have also been recorded for other otter species (e.g. Wise *et al.* 1981 and Weber 1990 for *Lutra lutra*; Melquist and Hornocker 1983 for *Lutra canandensis*). The items which occur in the otter's diet vary according to the species of otter involved, time of the year and place (Hussain and Choudhury 1997). In Corbett Tiger Reserve, the proportions of different fishes recorded in the diet are assumed to depend on the availability (abundance) of prey species and catching efficiency of otters, slower moving species being apparently favored (Erlinge 1968). Coastal otters feed mainly on inter-tidal or benthic species (Kruuk and Moorhouse 1990). The size of fish taken is also dependent on availability; small individuals usually predominate (Mason and Macdonald 1986). Seasonal variation in diet is thought to be affected by prey activity as well as abundance (Webb 1975; Wise *et al.* 1981 and Chanin 1981). In Corbett Tiger Reserve, otters used eight fish species and these numbers reflect true for other studies as well; Melquist and Hornocker (1983) identified seven fish species as potential prey of the American river otter in west central Idaho, Tiler *et al.* (1989) had identified 19 fish species as prey for smooth-coated otter in the Narayani river in the Royal Chitwan National Park, Nepal and similarly Hussain (1993) recorded seven fish species in the diet of smooth-coated otters in National Chambal Sanctuary that were consumed throughout the year and were considered as the 'principal diet'. Members of the family Cyprinidae were taken more frequently. In this study *Glyptothorax pectinopterus* formed the most favourable diet item during summer while *Labeo dyocheilus* was favoured most in winter. Chanin (1985) stated that food selection and preference in otters cannot always be discerened properly and even if considerable care is taken to analyse the diet, it is rarely possible to obtain mere rough indications of the relative importance of the prey consumed. As suggested by Wise (1980) in the assessment of fish body size from the remains of body parts in the spraint, the vertebrae length was preferred over eyeball diameter in this study as well. This was so because; the vertebrae are invariably present in the spraint however small or big the fish is and suffer less damage in passage through the intestine, they are identifiable to a particular region of the fish and can be identified to species or genus of the fish. Moreover, the length of the vertebrae does not vary considerably along the vertebral column and hence vertebrae length was preferred over width since projections from the lateral surface of the centra cause considerable variation in length measurements. Similar conclusions were drawn by Wise (1980) and Anoop and Hussain (2005). Freshwater systems are very sensitive to land-use changes, and the otter seems to reflect that in its diet. Any comparison of diet among rivers and habitats is based on the assumption that spraints reflect food consumed in the general area where the spraints were deposited. On this basis, the variation in otter diet among the different survey (river) sites probably reflects fish availability. Food resource availability plays an important role in the presence of otters in the reserve and the otter population consistency could well be related to preferred prey abundance. Other aquatic fauna such as gharial and mugger live within and around the otter habitat and hence dietary overlap and large-scale interspecific competition is obvious, at least with respect to fish. Further studies on resource partioning will be helpful in understanding the level of competition among these species.

5.5. Summary

The food habits of otters were studied by analyzing 499 spraints collected over the study period. Diet was represented by four prey categories in which fish (84%) was the most frequently occurring item and also formed the bulk (97.27%). There were no significant difference in overall proportions of different prey categories used between winter and summer (Wilcoxon Signed Ranks Test; Z = 0.0, p = 1.0). Also, there were no significant difference between the sites (Friedman Test; chi square 0.61, p = 0.74) and between seasons (Wilcoxon Signed Rank Test; Z = 0.0, p = 1.0). Total eight fish species were identified from the spraints, which belonged to two families i.e. Cyprinidae and Sisoridae; although members of the family Cyprinidae were taken more frequently. *Glyptothorax pectinopterus* formed the most favourable diet item during summer while *Labeo dyocheilus* was favoured most in winter. Size class (cm) of fish species caught ranged between 3.9 ± 0.9 (*Puntius* spp) and 53 ± 2.08 (*Labeo dyocheilus*). The selection of prey depend on the availability (abundance) of prey species and catching efficiency of otters, slower moving species being apparently favored.

CHAPTER 6

THREATS

6.1. Introduction

Otters in general are becoming increasingly rare outside of national parks and wildlife sanctuaries, and are threatened in many areas due to poaching, habitat destruction and reduction in prey biomass (Foster-Turley *et al.* 1990). Otters are at the top of the food chain and they are indicators of habitat quality. When pollutants such as heavy metals and organochlorines like PCBs contaminate the environment, otters are among the first species to disappear (Mason and MacDonald 1986). As both man and otter are competitors for the natural productivity of the area, it is not unusual to come across otters being clubbed to death (Nagulu *et al.* 1997).

The chapter addresses two questions;

(i.) What are the different forms of disturbance factors across the survey sites?

(ii.) What is the intensity of disturbance levels affecting otter populations?

6.2. Methodology

Data were collected on 6 variables perceived as threats to otters in the study area (Table 6.1). Based on the extent of severity these variables were ranked from 1-6 and recorded as presence/absence in respective plots. For analysis a qualitative score index for disturbance variables was developed. The index is expressed as percentage of disturbance intensity and is calculated as,

$$DI = \frac{{}^{j}\sum d_j}{{}^{i}\sum d_i} \times 100$$

where i = score given to i^{th} disturbance (ranging from 1-6).

J = observed disturbance in one plot.

DI = disturbance index (ranges from 0 to 100 per cent).

Table 6.1. Variables collected as threats to otters in Corbett Tiger Reserve.

Disturbance factors	Rank
Poaching	6 (High Intensity)
Destructive fishing practices	5
Domestic use of water and visible pollution	4
Removal of sand and boulder	3
Extraction of bank side vegetation	2
Livestock grazing	1 (Low Intensity)

6.3. Results

Among the used sites River Mandal recorded a maximum of 0.06 (60%) disturbance index, followed by River Palain 0.02 (20%) and 0.01 (10%) for River Ramganga (Fig. 6.1). Of the absence sites River Kosi recorded the maximum of 0.09 (90%) disturbance index. No single disturbance factor can predict the absence of otters from a particular site but however, if the cumulative effect is considered then disturbance do occurs in otter presence sites as well but these disturbances were recorded in the buffer areas. Within the otter presence sites i.e. Ramganga, Mandal and Palain various forms of fishing activities were a major form of disturbance (Mandal 6.5%, Ramganga 1.6% and Palain 1.1%) followed by livestock grazing (Palain 32.7%, and Mandal 21.7%) and removal of sand and boulder (Mandal 10.3% and Palain 0.3%) (Fig 6.2). There were instances of poaching also recorded from River Ramganga. Of the absence sites, livestock grazing (Sonanadi 75%, Kosi 46.3% and Reservoir 11.9%) and extraction of bankside vegetation (Kosi 25.6%) were recorded as the major form of (Fig. 6.2).

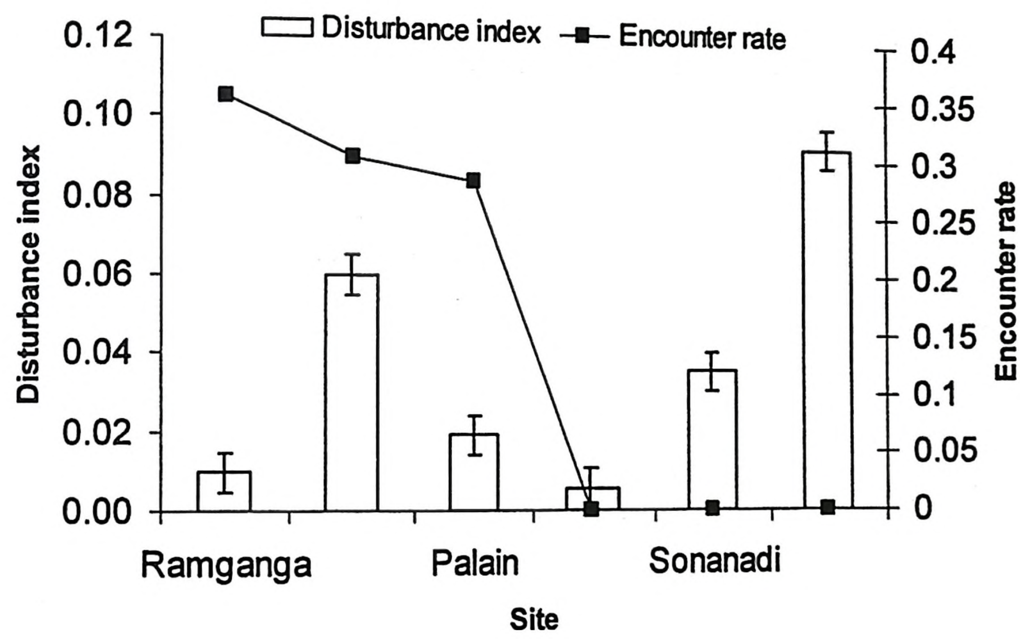


Fig. 6.1. Intensity of disturbance levels affecting otter populations in different sampling sites in Corbett Tiger Reserve and adjacent aquatic ecosystems.

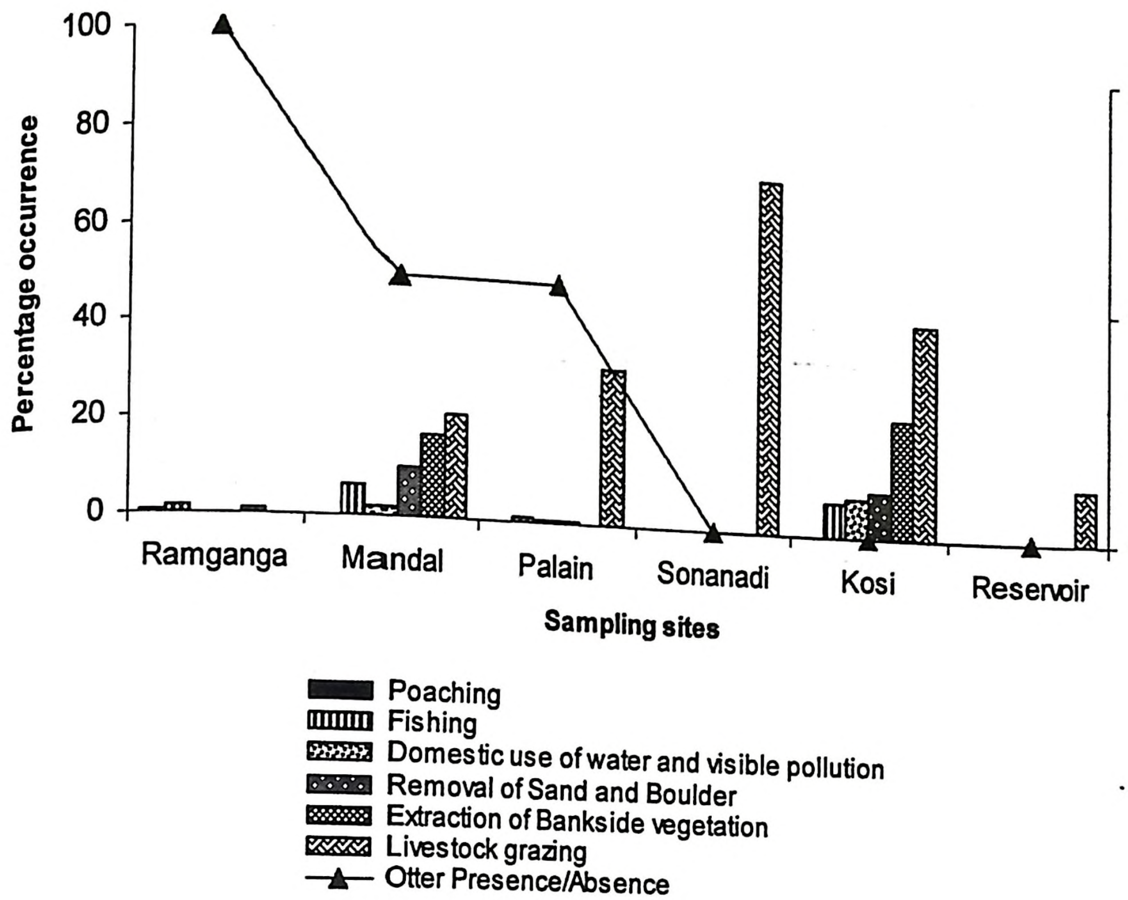


Fig. 6.2. Disturbance *vs* Otter presence.

6.4. Discussion

Presence of anthropogenic disturbance is known to negatively affect otters and scent-marking behavior of mustelids (Newman and Griffin 1994 and Perrin and Carugati 2000). *Lutra perspicillata* is rather more tolerant to human presence than the other two species (Shariff 1984; Foster-Turley 1992 and Anoop and Hussain 2004). In the present study, the effect of human activity and presence varied between different sampling sites (Table 6.2). Human presence along the riverbank was evident in areas that lay close to the vicinity of the reserve boundary, like village *Jamond* (along River Ramganga), village *Bhakuan* (along River Mandal) and village *Ramesera* (along River Palain). Fishing appeared to be the major form of disturbance and locals usually practice destructive methods such as, dynamiting 'ghan' or hammering and use

Ichthyotoxic plants to poison fish. This leads to indiscriminate killing of large number of fish (juvenile as well as brood fish) that adversely affects the population of fish and as well as water quality of the Rivers. Incidences of otter mortality were also recorded during the course of the study. On November 18, 2001 three dead otters (two pelts and one stuffed) were confiscated from Nepali poachers by the forest department (Sarin 2002). On December 20, 2001 two dead otters (one male and one female) were retrieved by the project team when surveying along River Ramganga. On June 15, 2005 while conducting fish sampling in River Ramganga we came across an otter carcass. On close examination, it revealed that the animal had died after being crushed/trapped under a boulder. There is heavy browsing and grazing along the banks and the mere presence of the cattle itself may dissuade otters from landing (Shenoy 2003). The local people also resort to burning of undergrowth in order to enhance the growth of fresh crops of fodder. The net result is that the banks are denuded of vegetation cover for the otters, making it too open for them to come to land escaping the predators. Sand mining is one of the major commercial activities associated with River Kosi, however within the reserve area sand and boulder extraction were recorded along River Mandal near *Bhakuan* village which is for domestic use. The depletion of sand from banks decreases the number of sites where otters can groom and bask (Kruuk and Balharry 1990 and Anoop and Hussain 2004). As evident from the study, otters tend to tolerate human disturbance and can use river stretches which provide prey and good escape cover, however, absence of anthropogenic pressure appeared to be important for denning sites, as all otter holts were found in secluded areas, far from human presence.

Table 6.2. Disturbance factors affecting otter occurrence across different sampling sites in and around Corbett Tiger Reserve.

Variables	Site with disturbance (Presence/Absence)	Otter (Presence/Absence)	Stretch
Poaching	Ramganga	Present	Opposite Dabaria chaur (Near Gairal FRH)
Destructive fishing practices	Ramganga	Present	From Jamond (near Domunda) to Marchula
	Mandal	Present	From Bhakuan to Maidavan
	Palain	Present	From Adnala/Vatanbasa to Ramesera
	Kosi	Absent	From Barrage to Teda and From Sunderkhal to Mohan
Removal of sand and boulder	Mandal	Present	From Bhakuan to Maidavan
	Kosi	Absent	From Teda to Chukumb
Extraction of bankside vegetation	Ramganga	Present	From Jamond (near Domunda) to Marchula
	Mandal	Present	From Bhakuan to Maidavan
	Palain	Present	From Adnala/Vatanbasa to Ramesera
	Kosi	Absent	From Barrage to Mohan
Domestic use of water and visible Pollution	Mandal	Present	From Bhakuan to Maidavan
	Kosi	Present	Teda, Sunderkhal, Chukumb. Pampapuri
Livestock grazing	Mandal	Present	From Bhakuan to Maidavan
	Palain	Present	From Adnala/Vatanbasa to Ramesera
	Sonanadi	Absent	From Berichaud to Hathikund
	Kosi	Absent	From Barrage to Mohan
	Reservoir	Absent	From Ringora to Shishumkhatta

6.5. Summary

Anthropogenic disturbances on otter population and its habitats were recorded from areas that lay close to the vicinity of the reserve boundary. Among the otter presence sites River Mandal recorded a maximum of 0.06 (60%) disturbance index and of the absence sites River Kosi recorded the maximum of 0.09 (90%). Sand and boulder extraction were the major commercial activities associated with River Kosi, however within the reserve area sand and boulder extraction were recorded along River Mandal near *Bhakuan* village, which is for domestic use. Along the pheripheral areas of the Reserve locals use destructive methods of fishing such as dynamiting, gill nets and Ichthyotoxic plants to poison fish. This leads to killing of large number of juvenile as well as brood fish which adversely affects the prey abundance of otters. Therefore it is imperative to regulate fishing practices in the Rivers. Since locals have civil rights to extract such resources, participatory programmes can be initiated to create awareness among locals about the ecological importance of otters in the surrounding water bodies. During the study period, poaching of otters was recorded from the peripheral areas of the National Park. This poses a threat to otter population in recolonisation. Effective protection measures should be strengthen at vulnerable points, *viz*; From Domunda to Marchula along the River Ramganga, From Domunda to Maidavan along the River Mandal and From Vatanbasa to Ramesera along the River Palain.

CHAPTER 7

CONSERVATION IMPLICATIONS

7.1. Introduction

There has been a great deal of concern about the decline in population of several otter species in many countries, especially since when otters are often considered as an indicator species of natural wetland communities (Kruuk *et al.* 1993). Research reveals that factors like pollution, habitat destruction, direct persecution, and accidental death (floods, roads, fishing devices etc.) have caused the disappearance of otters from most of its distribution range (Mason and Macdonald 1986). Studies on otters in India have revealed that otters are now mostly restricted to the protected areas, and that habitat destruction and poaching pose as a major threat as compared to other disturbances (Hussain 1999).

All the three Indian species *viz.* Eurasian otter *Lutra lutra*, Smooth-coated otter *L. perspicillata* and Oriental small-clawed otter *Aonyx cinerea* have been recorded in trade. Otters are mainly trapped for their pelts in many parts of the country, especially central India, Guwahati and south India. Seizure figures of wildlife offences in the country reveal that 20-30% of the fur trade is in otter skins. The main markets are Kanpur, Lucknow, Kota, Calcutta, Bangalore and Delhi. The otter fur trade, which is practiced in many parts of the world, routes out via Nepal and Bangladesh, to importing countries. Otters are often in direct conflict with fishermen who view them as vermin or competitors for fish and kill them (Foster-Turley 1992).

Developmental activities such as construction of dams adversely affect otter populations due to the reduction of water flow downstream denying access to prey and den sites (Ruiz-Olmo *et al.* 1991). Randell and Leatherwood (1994) have commented on the changes in prey dynamics which are the consequences due to waterway obstruction, such as; less diversity and small biomass of prey in impoundment upstream of dams due to lowered nutrient availability and reduction in prey due to blocked migratory rates. Despite the cognizance the biologists have taken of the possible deleterious effects of dams on fisheries, an assessment of the exact nature and the magnitude of the problems arising out of dam construction have not been made and the remedial measures have not been found. Fishways and fish-lifts (fish ladders) are contrivances provided at dam sites to help the migratory fish species to negotiate the dam height. The fishway structures, to be successful, should take into consideration the hydraulics of the stream and physiology and behaviour of the migrating fish. The flow properties of a fishway should be such that the effort required on the part of the fish to negotiate the fishway remains well under the limit of the capability of the fish to do so. In India, several fish passes (Khan 1940; Raj 1941; Devanesan 1942 and Chacko 1952) were constructed without due regard to the performance of the species that might make use of them. These fish passes have proved unsuccessful (Jhingran 1991), serving as traps for fishes (Khan 1940) rather than as an aid to their migration. Randell *et al.* (1991) commented on the deleterious effects on the Indus Dolphin (*Platanista minor* Owen 1853). The extent to which dolphins move through the barrages is unclear, though it is generally agreed that any upstream movement on their part is virtually impossible. Emigration through barrages, even if it occurred sporadically (during the peak of the flood-season), would seal the fate of subpopulations as small as those upstream. However, this 'rescue effect' (Brown and Kodric-Brown 1977) would only occur as long as the upstream donor subpopulation remained extant.

The challenge for biological research to develop effective, affordable management plans is much greater when there is concern not for just one species but for the biodiversity of the entire river ecosystem. As there is typically insufficient time in the few years between the proposal and construction of a dam to investigate and understand the biological system that will be affected, taking steps to minimize changes in downstream habitats may often be all that one can realistically hope to accomplish.

7.2. Conservation implications in context to Corbett Tiger Reserve

The conservation of otter is inextricably linked to the conservation of the habitat of the otter's prey and the availability of suitable sites for shelters. The findings of this study emphasize this relationship and indicate that activities which detrimentally affect the otter's habitat and that of its prey should be discouraged. The detailed approach adopted in the present work is clearly necessary to begin to understand the precise relationships between otter distribution and ecology and habitat attributes – information that is essential for conservation measures and the implementation of management practices to encourage and maintain healthy otter populations. In the light of the results of the study, management recommendations are suggested understanding that each recommendation would need to be adjusted to suit the local conditions and needs of specific otter site.

7.2.1. Habitat management

Sensible management of the natural ecosystem is one of the major prerequisites for ensuring the conservation of otters in the wild. This implies the management of forest, wetland and riparian habitats which requires adequate food supply throughout the year, maintenance of sufficient shelter in the form of riparian vegetation, secluded resting and breeding sites for otters. As evident from the findings, occurrence of otter is attributed to rocky and sandy stretches with gentle bank slopes and escape cover, shallow and slow water current with high prey availability. The available habitat suitable to otters in the Reserve is limited, confining them to middle reaches of the rivers. Gharial and mugger were observed living within and around the otter habitat and hence dietary overlap and large-scale interspecific competition is obvious, further constraining the availability of the resources for foraging, grooming and basking for otters. River stretches which provide ideal habitat conditions and are more frequently used need special attention in terms of management and protection. During the course of the study on one occasion it was observed that one group of otters along River Ramganga deserted their den on account of burning of riparian vegetation near the den site. As the presence of shoreline vegetation is a prerequisite for otter habitat, this should be maintained or wherever necessary restored. Hence, it is recommended that a buffer of about 25 m of riparian vegetation should be left unburnt while carrying out routine practices such as control burning. Sand banks are integral as nesting grounds for crocodilians and testudines and serve as ideal grooming and basking sites particularly for otters and crocodilians. With the current healthy population of both species and assuming a better future of both, the amount of sand banks available is inadequate (Fig. 7.1a and 7.1b).

7.2.2. Control of illegal activities

Poaching of otters poses a direct threat to otter populations and it is stressed that stringent measures are taken to stop this activity. Sand mining is one of the major commercial activities associated with River Kosi, apart from other anthropogenic disturbances. This has led to disappearance of otters from this site, which otherwise could serve as a suitable habitat. Within the protected area, anthropogenic disturbances and extraction of sand and boulder along riverine stretches were recorded along River Mandal, this again restricts otters from extending their home ranges and because of which the otter population have got restricted within small ranges in the middle stretches of the rivers. River Mandal along with River Ramganga form corridors which perhaps could help otters extend their home ranges. Locals resort to destructive methods of fishing such as dynamiting. Since locals have civil rights to extract such resources, participatory programmes can be initiated to create awareness among locals about the ecological importance of otters in the surrounding water bodies so that further degradation of riverine habitats can be controlled.

Much stricter regulations need to be enforced and patrolling extended to buffer areas i.e from Domunda to Marchula along River Ramganga, Vatanbasa to Ramesera along River Palain and Domunda to Maidavan along River Mandal (Fig. 7.3) especially during monsoon when otters are expected to move long distances chasing their prey i.e. fish which travels upwards for spawning.

7.2.3. Long term monitoring programme

Field surveys, using standard methods, should be conducted throughout the species range to determine the current distribution and status of that species. Keeping in mind the difficult field situations and other constraints, survey methods need not be rigorous but should be simple, less time consuming and cost effective. The otter and associated aquatic faunal survey should be done between Novmber and February covering all the water bodies of the Reserve. Such surveys should identify priority areas and seek to identify those habitat features that must be conserved if the species is to survive. This may include searches for habituated and non-habituated (deserted) den sites, presence of otter signs per km stretch (for computing relative abundance) and recording of presence of sufficient riparian cover. Otter sighting *logbooks* can be maintained at respective rest houses and visitors encouraged in recording their sightings as, date, place and numbers seen. Such information collated, can eventually be used for comparisons either seasonally or annually and later can be verified through rigorous field work and other statistical procedures.

7.3. Summary

The value of the reserve as otter haven relates to the availability of key habitat features and a broad prey base. Sampling sites *viz*; Rivers Ramganga, Mandal and Palain recorded presence of otters and need special attention in terms of habitat management and protection of identified otter den sites and river stretches which are more frequently used. As evident from the study, otters are confined to small areas and although the population seems to increase, it is vulnerable to anthropogenic and other stochastic disturbances. The comparison of historical information with present data suggests fluctuation in otter population over time. This could be because of intrinsic factors in the population or due to anthropogenic pressures such as poaching or due to intra-specific competition from reintroduced gharial and mugger. This necessitates development and implementation of long term monitoring programmes for otters and associated aquatic fauna in the Reserve.

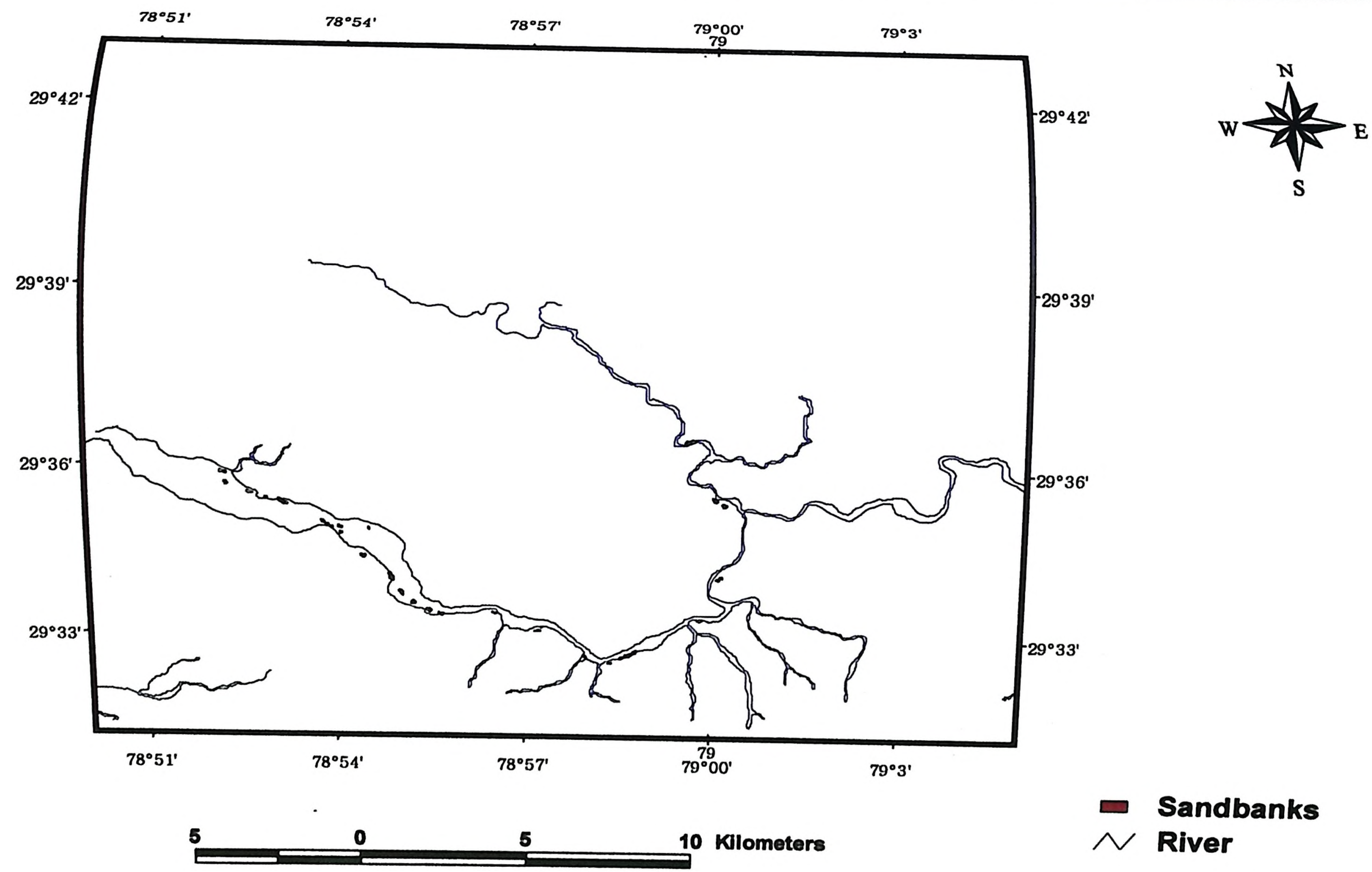


Fig. 7.1a. Location of sandbars along Rivers Ramganga and Mandal.

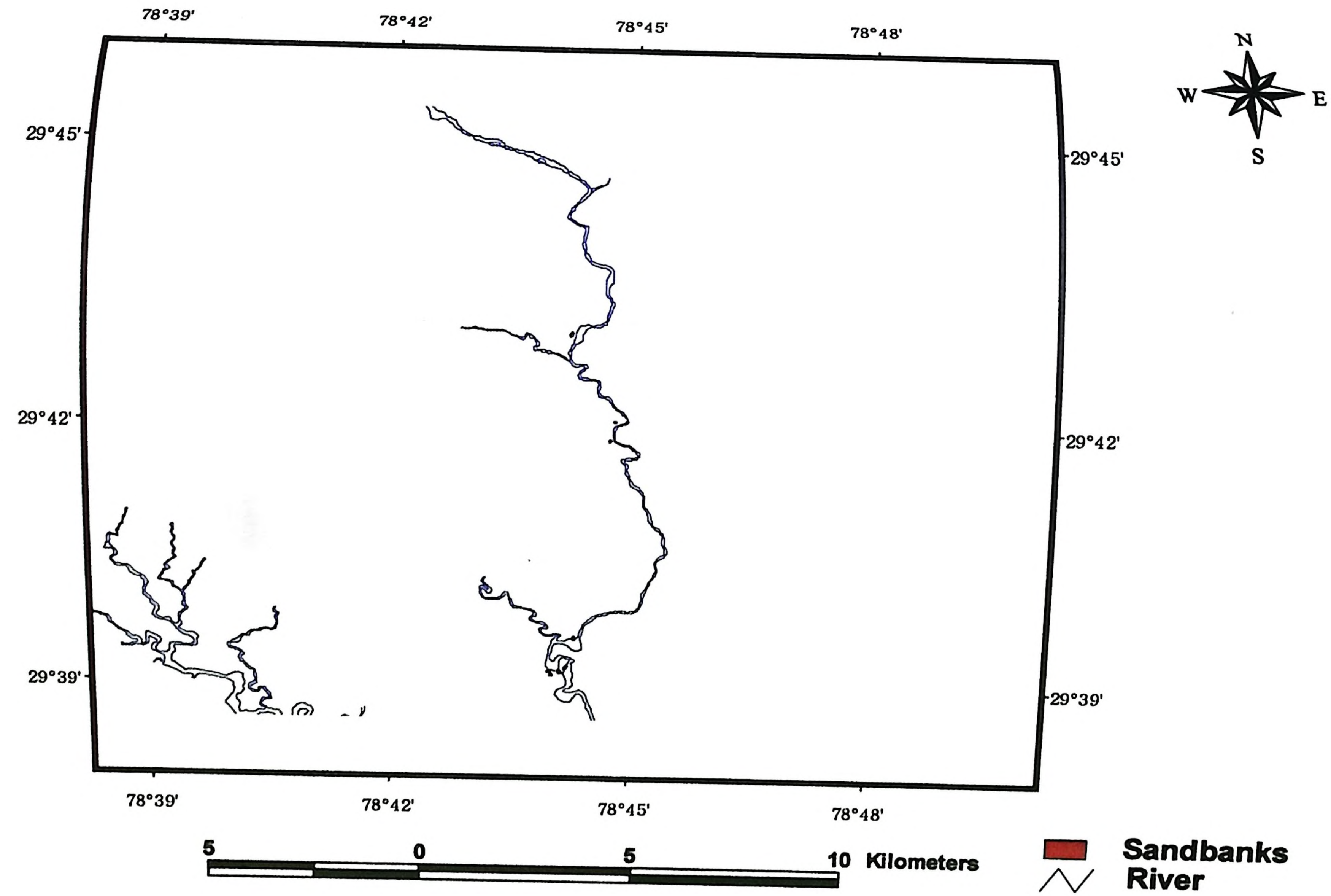


Fig. 7.1b. Location of sandbars along River Palain.

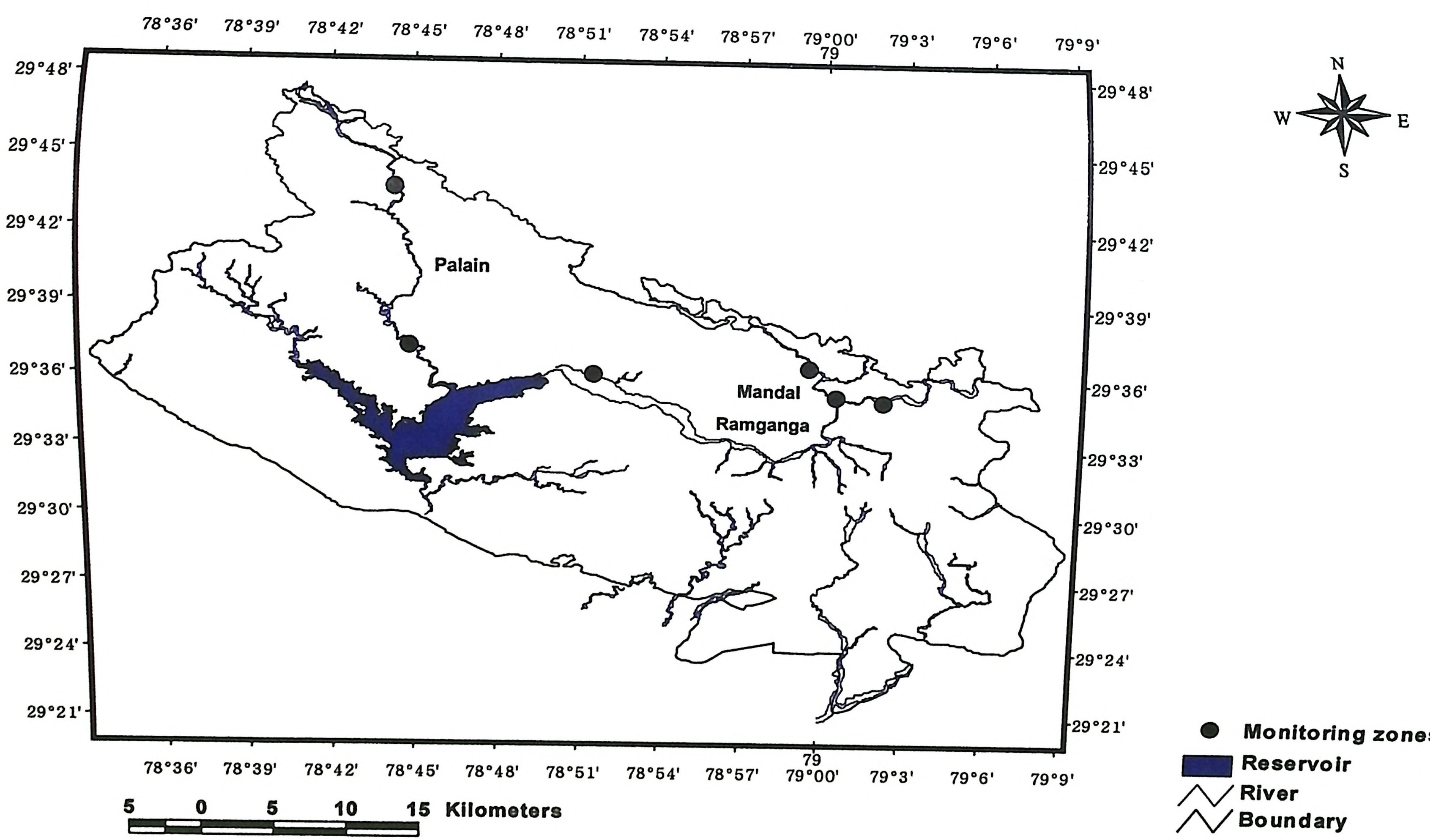


Fig. 7.2. Monitoring Zones for surveying otter population in Corbett Tiger Reserve.

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Ichthyofauna

Family	Zoological Name	Local Name
Clupeidae	*Gudusia chapra* (Hamilton-Buchanan)	
Cyprinidae (Carps)	*Amblypharyngopdon mola* (Hamilton-Buchanan)	
	Aspidoparia jaya (Hamilton-Buchanan)	
	A. morar (Hamilton-Buchanan)	
	Barilius barila (Hamilton-Buchanan)	
	B. barna (Hamilton-Buchanan)	Dhaur
	B. bendelisis (Hamilton-Buchanan)	Dhaur
	B. bola (Hamilton)	Gulab, Gallar,Trout
	B. corbetti Tilak & Husain	
	B. dimorphicus Tilak & Husain	
	B. shacra (Hamilton-Buchanan)	
	B. vagra (Hamilton)	Dhaur, Chippan
	Brachydanio rerio (Hamilton)	
	Carassius carassius (Linnaeus)	Gold Fish
	Catla catla (Hamilton-Buchanan)	
	Chagunius chaginio (Hamilton-Buchanan)	Chibban
	Chela laubuca (Hamilton-Buchanan)	
	Cirrhinus mrigala (Hamilton-Buchanan)	
	C. reba (Hamilton-Buchanan)	
	Cyprinus carpio Linnaeus	Common Carp
	Crossocheilus latius (Hamilton-Buchanan)	Saknera, ^Dhiya Sindaura
	Ctenopharyngodon idellus (Valenciennes)	Grass Carp
	Danio devario (Hamilton-Buchanan)	
	Esomus danricus (Hamilton-Buchanan)	
	Garra gotyla gotyla (Gray)	Bhagnera, Gotlu, ^Gotyla, ^Sindaura
	G. lamta Hamilton-Buchanan	Bhagnera
	Hypophthalmichthys moltrix (Valenciennes)	Silver Carp
	+*Labeo bata* (Hamilton-Buchanan)	
	L. calbasu (Hamilton-Buchanan)	Bhadua, Klaunch
	L. dero (Hamilton-Buchanan)	Unera
	L. dyocheilus (McClelland)	Kharat, Moyal, ^Gaydla
	L. gonius (Hamilton-Buchanan)	

Family	Zoological Name	Local Name
	L. rohita (Hamilton-Buchanan)	Rohu
	Osteobrama cotio cotio (Hamilton-Buchanan)	
	Parluciosoma daniconius (Hamilton-Buchanan)	
	Puntius carletoni (Flower)	
	P. chola Hamilton-Buchanan	
	P. conchonius (Hamilton)	Dumrua
	P. gelius Hamilton-Buchanan	
	P. sarana saran Hamilton-Buchanan	
	P. sophore Hamilton-Buchanan	
	P. terio Hamilton-Buchanan	
	P. ticto Hamilton-Buchanan	Dumrua, ^Budh
	Raiamas bola (Hamilton-Buchanan)	
	Rasbora daniconius (Hamilton)	
	Salmostoma bacaila (Hamilton-Buchanan)	
	S. phulo phulo (Hamilton-Buchanan)	
	Schizothoraichthys progastus (McClelland)	
	Schizothorax kumaonensis Menon	
	S. richardsonii (Gray)	
	Tor chelynoides (McClelland)	Karanchula
	T. putitora (Hamilton-Buchanan)	Mahseer
	T. tor (Hamilton-Buchanan)	Golden Mahseer, ^Katchura
	Psilorhynchus balitora (Hamilton-Buchanan)	
	Balitora brucei Gray	
	Nemacheilus beavani Gunther	
	N. botia (Hamilton-Buchanan)	Gadera
	N. corica (Hamilton-Buchanan)	Gadera
	N. doonensis (Tilak & Husain)	
	N. gangeticus (Menon)	
	N. montanus (McClelland)	
	N. rupecula (McClelland)	Gadera
	N. savona (Hamilton-Buchanan)	
	Lepidocephalus annandalei Chaudhuri	
	L. guntea (Hamilton-Buchanan)	
	Botia alomrhae Gray	
	B. rostrata Gunther	
	Norichthys seenghala (Sykes) ?	
	Mystus bleekeri (Day)	
	M. cavasius (Hamilton-Buchanan)	
	M. vittatus (Bloch)	
	Ompak bimaculatus (Bloch)	

Family	Zoological Name	Local Name
	O. pabda (Hamilton-Buchanan)	Lanchi
Schilbidae	*Ailia coila* (Hamilton-Buchanan)	
	Clupisoma garua (Hamilton-Buchanan)	
	C. montana Hora	
	Eutropiichthys vacha (Hamilton-Buchanan)	
	Silonia silondia (Hamilton-Buchanan)	
Amblycepitidae	*Amblyceps mangois* (Hamilton-Buchanan)	Nain
Sisoridae	*Bagarius bagarius* (Hamilton)	Gonch
	B. yarrelli Sykes	
	Euchiloglanis hodgarti (Hora)	
	Gagata cenia (Hamilton-Buchanan)	
	Glyptothorax cavia (Hamilton-Buchanan)	
	G. dakpathari Tilak & Husain	
	G. garhwali Tilak	
	G. horai Shaw & Shebbeare	
	G. pectinopterus (McClelland)	
	G. saisii (Jenkins)	
	G. telchitta (Hamilton-Buchanan)	
	Laguvia ribeiroi kapuri Tilak & Husain	
	Pseudecheneis sulcatus (McClelland)	
Notopteroidei	*Notopterus chitala* (Hamilton-Buchanan)	
	N. notopterus (Hamilton-Buchanan)	
Clariidae	*Clarias batrachus* (Linnaeus)	
Heteropneustidae	*Heteropneustes fossilis* (Bloch).	
Salmonidae	*Salmo gairdnerii gairdnerii* Richardson	Rainbow Trout
	S. trutta fario Linnaeus	
Belonidae	*Xenentodon cancila* (Hamilton-Buchanan)	^Sui machli
Synbranchidae	*Monopterus cuchia* (Hamilton-Buchanan)	
Centropomidae	*Chanda nama* Hamilton-Buchanan	
	C. ranga Hamilton-Buchanan	
Nandidae	*Nandus nandus* (Hamilton-Buchanan)	
	Badis badis (Hamilton-Buchanan)	
Mugilidae	*Rhinomugil corsula* (Hamilton-Buchanan)	
	Sicamugil cascasia (Hamilton-Buchanan)	

Family	Zoological Name	Local Name
Gobiidae	*Glossogobius gutum* (Hamilton-Buchanan)	
Anabantidae	*Anabas testudineus* (Bloch)	
Belontiidae	*Colisa fasciata* (Schneider)	
	C. lalia (Hamilton-Buchanan)	
Osphronemidae	*Osphronemus goramy* Lacepede, Gorami	
	+*Chana gachua*	
	C. marulius	
Channidae	*Channa orientalis* (Bloch and Schneidor)	Shoyan
	C. punctatus	
	+*C. striatus*	
	Ophiocephalus gachua Hamilton-Buchanan	
	O. marulius Hamilton-Buchanan	
	O. punctatus Bloch	
	O. striatus Bloch	
Mastacembelidae	*Mastacembelus armatus* (Lacepede)	
	M. pancalus (Hamilton-Buchanan)	

Species recorded during fieldwork in Corbett Tiger Reserve and its surrounding environs (along Rivers Kosi and Kolhuchaur); +New species recorded; ^Local Gharwali Name.

Source: Hussain, A. 1995; Bhartari, R. 1999 and Sinha, S. 2001.