HEAVY METALS AND PCBS IN EURASIAN OTTERS (*Lutra lutra*) IN SOUTH KOREA

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INTRODUCTION

Only one species of otter, *Lutra lutra,* inhabits South Korea, which located between32 to 38 degree latitude east. There are several types of coast on the Korean Peninsula: the west coast (Seohae) with wide mud flats over which tides range for several kilometers; rias coast in the south (Namhae) with numerous small islands while of the East(Donghae) there is a monotonous rocky coast .

On the other hands, many rocky MT are located in inland areas, and many kinds of human activities coexist throughout the country. Because of the recent increases in industrial developments factors in South Korea, habitat destruction has frequently occurred, while toxic pollutants have been produced and flowed into the ocean and river systems. As a result, the distribution of Eurasian otter population has decreased during a decade. The species, has had legal protection, as natural monument, no. 330, since 1982.

Because of the threat to the species, the levels of pollution were investigated as one factor, which might have contributed to the decline of the otter. To investigate this, collections of otter faeces and a number of organ body organs were analysed for pollutants. Samples were collected from various areas of South Korea, between 1995 and 1997.

STUDY AREAS AND METHODS

Otter faeces were collected from various habitats, such as coasts, rivers and reservoirs; allsamples were analyzed for heavy metals. In addition, faeces collected from the Yuncho area, were analysed monthly for PCBs .

Eight dead otters (4 adults and 4 juveniles) were legally collected from different habitats between 1996 to 1997. Samples of liver, kidney, bone, muscle, hair and other organs were analysed for heavy metals (Fig. 1).

For heavy metals analysis, weighed dry faeces and organ samples were digested in a mixture of nitric- and perchloric-acid on a hot plate. Samples were detected by inductively coupled plasma - atomic emission spectrophotometry. In case of PCBs, samples were digested in KOH/EtOH for an hour, and the extracts transferred to n-Hexane and evaporated. After clean up by silica-gel chromatography, the PCBs were analyzed by fused-silica capillary column GC with ECD.
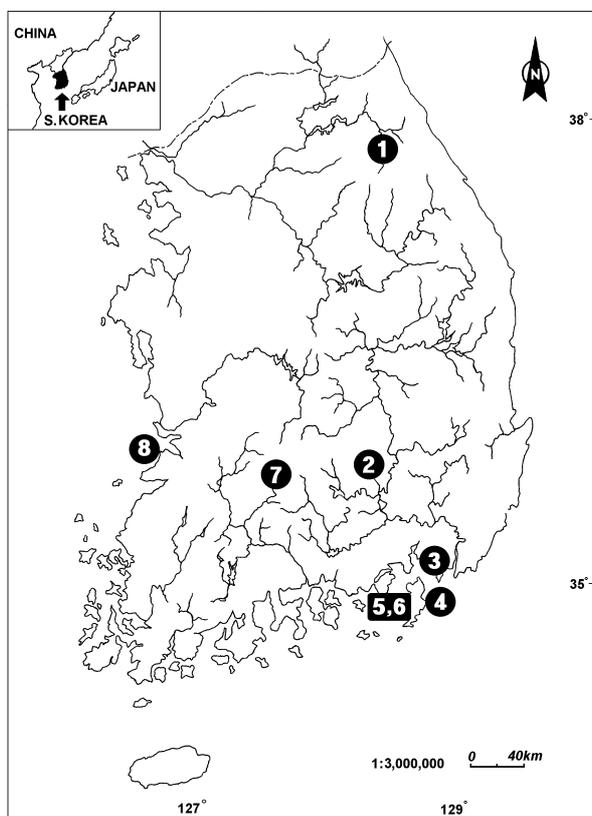
Figure 1. Sampling localities of otter dead bodies.
cub: 1,2,4,7; adult: 3,5,6,8; sea: 3,4,8; inland: 1,2,5,6,3

RESULTS

METALS IN OTTER FAECES

Heavy metal concentrations from 304 otter faeces collected in sea and river areas were compared. For most areas, the heavy metals concentrations were ordered Fe > Zn > Al > Mn > Cu > Pb > Cr > Cd (Table 1). When these results were compared with sea and river areas, they showed a different tendency of pollutant concentrations. Namely, the heavy metals of otter faeces on river in inland areas were higher than those cases of coastal areas, and that the concentration rates by element were especially higher in the case of Cr and Fe compared with the other elements analyzed (Fig. 2). Faeces, sampled in the Rivers Tamjin(TJ) and Sumjin(SJ) had much the highest concentration of heavy metals.

Table 1. Mean concentrations of heavy metals (mg/kg, dry) in otter faeces from Korea

Areas*		n	Cr	Zn	Cd	Pb	Cu	Fe	Mn	Al
Inland	YC	193	0.780	107.71	0.117	1.921	4.173	1424.9	68.17	103.45
area	SJ	50	0.758	221.67	0.139	8.802	9.115	2257.4	102.09	179.39
Sea	TJ	27	0.725	282.81	0.658	9.895	14.904	2862.5	158.20	219.65
coast	KJ	23	0.307	197.76	0.170	3.768	5.107	887.7	77.01	80.62
area	AM	11	0.171	145.26	0.255	4.388	7.772	758.8	69.02	165.27

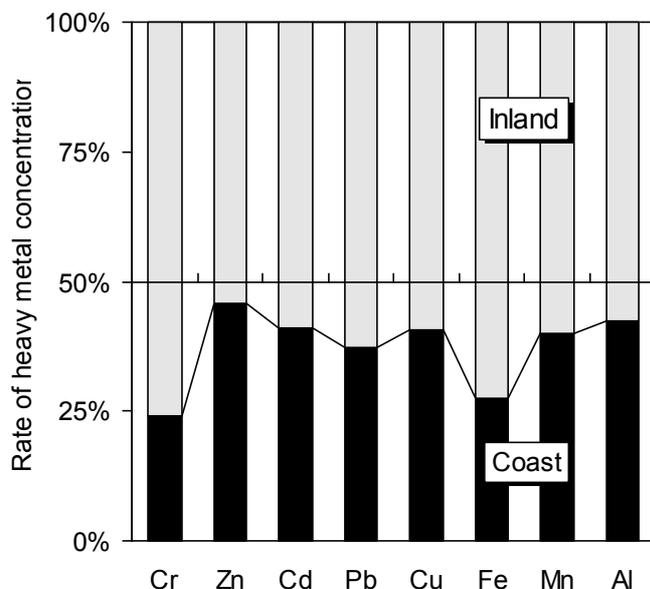*; YC, Yuncho-dam; KJ, Jukrim coast; AM, Anma archipelago; SJ, Sumjin River; TJ, Tamjin River.

Figure 2. Heavy metal comparison of otter feces with Inland and Coast area.

HEAVY METALS AND PCBS IN FECES OF YUNCHO-DAM

According to the monthly survey of otter faeces in the Yuncho-dam area (Table 2), the concentration of PCBs were higher during winter season than the other seasons, particularly during the summer season when levels were relatively lower (Fig. 3).

Compared with other studies, concentrations of heavy metals in Yuncho-dam were lower than those case of Greece (Mason, 1989), but the order of metal contents was similar to Zn > Cu > Pb > Cd. Moreover, the concentrations of PCBs were much lower than that found by Mason (1993). Our results suggest that the PCBs contamination is not significant in the Yuncho-dam areas.

As with previous studies, when we compared prey items in the faeces at same place (HAN, 1997), bird feathers were frequently found in the spraints during the same winter season. Namely, this Yuncho-dam area had been used as the wintering place for some migratory birds like waterfowl.

When we consider these results, we assume that much of theheavy metal content and PCBs in the faeces was obtained from these migrating birds.

Table 2. Mean concentrations of metals (mg/kg dry weight) and total PCBs (µg/kg dry weight[*]) in otter faeces collected from Yuncho dam in Nov. 1995 - Oct. 1996

Locality	n	Cr	Zn	Cd	Pb	Cu	Fe	Mn	Al	ΣPCBs
Yuncho-dam	93	0.78	112.5	0.13	1.9	4.3	1455	69.7	103.5	84
min		0.47	77.5	0.07	0.9	2.1	924	39.5	49.7	0.2~
max		1.38	162.3	0.24	5.3	8.0	2451	98.1	205.0	24

n; number of samples for heavy metal analysis; *; total PCBs (n=128)

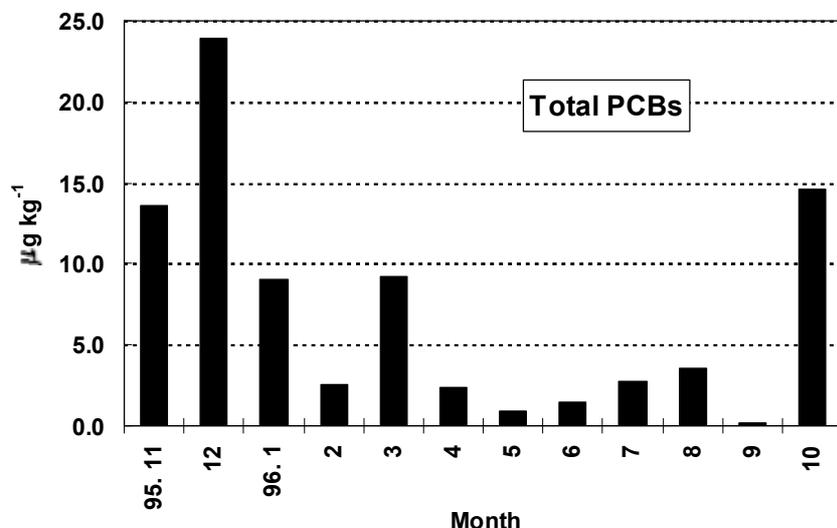[*] We were unable to verify this unit (the editors)

Figure 3. Monthly PCBs variation of otter feces in Yuncho-dam.

HEAVY METALS IN OTTER BODIES

The distribution of heavy metals in different organs of adult otters was examined. The concentration of the toxic element Cd was highest in the kidney and liver, while Pb was highest in hair and bone samples (Fig. 4). In the case of cubs, Cd and Pb were scarcely detected (Figs. 5).

When we compare these heavy metals concentration with the prior studies in other countries, the levels Cd detected were much higher than in other studies, while amongst the organs, kidney showed the highest Cd concentration (Figs. 6).
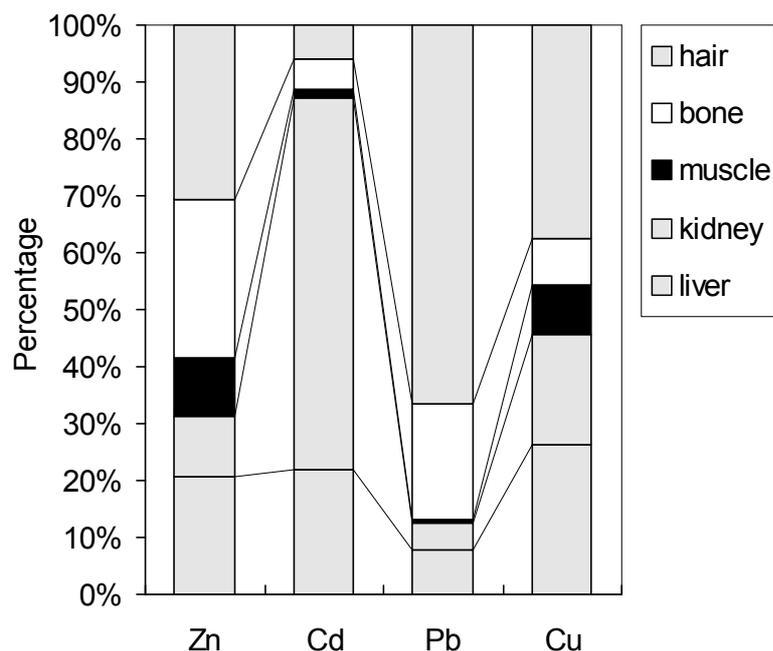

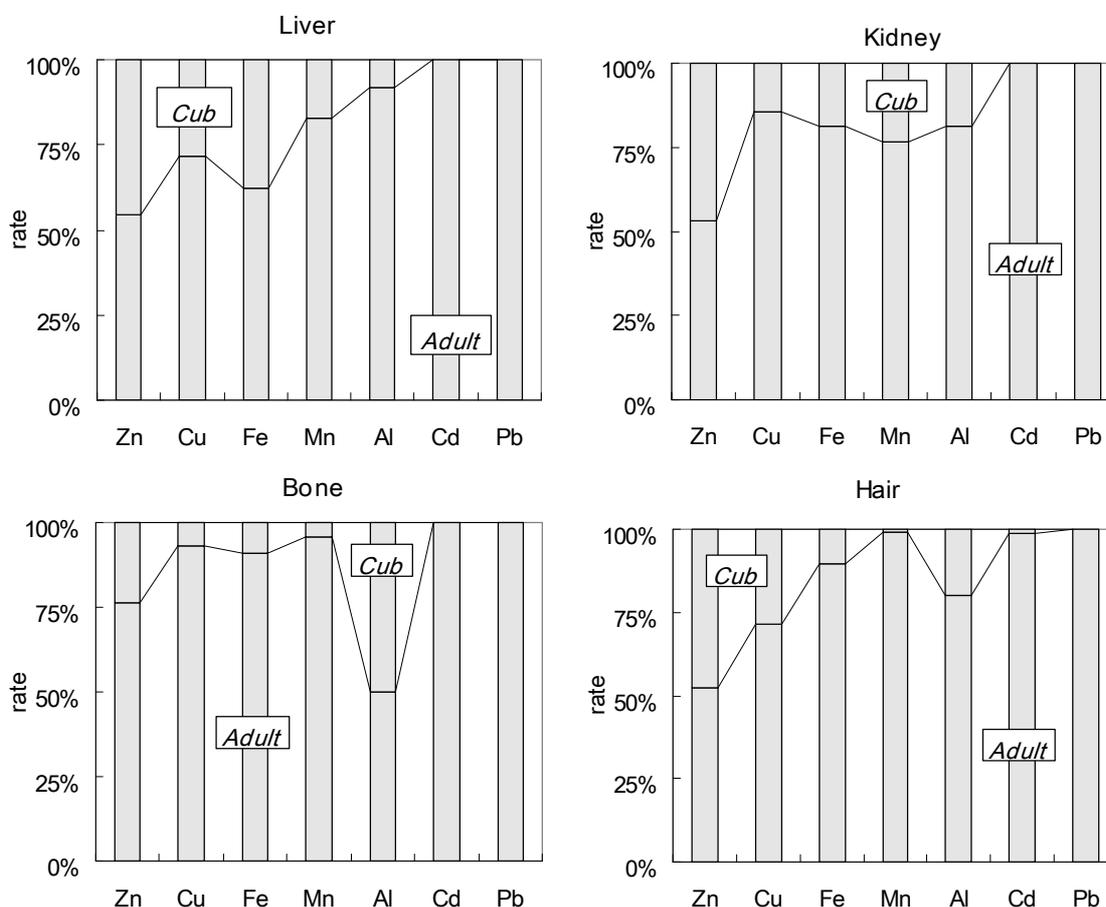**Figure 4.** Heavy metals comparison by each otter organs in Korea (n=8).

Figure 5. Heavy metals comparison between adult and cub otters (n= 4 adults, 4 cubs).

CONCLUSIONS

According to the recent economic development in South Korea, both habitat loss and deterioration in the water quality of rivers and coastal seas have become serious problems. Toxic pollutants continue to enter these water bodies.

To help identify the factors that might be threatening the survival of the otter in Korea, the levels of toxic contaminants in the otters faeces and carcasses were determined.

Heavy metals were detected in all faeces and carcasses. There were differences between localities with heavy metal concentration of dead otter being highest in an individual collected near the coast of the highly industrialized area of Pusan City.

Comparing the above results with those studies in other countries, very high levels of Cd were detected in this study, especially in the kidney.

These results reflect the change of environment, which is consequent upon the rapid social change of Korea. Consequently it will be necessary to protect the water resources and riparian geographical configurations that is the only habitat for the otter.
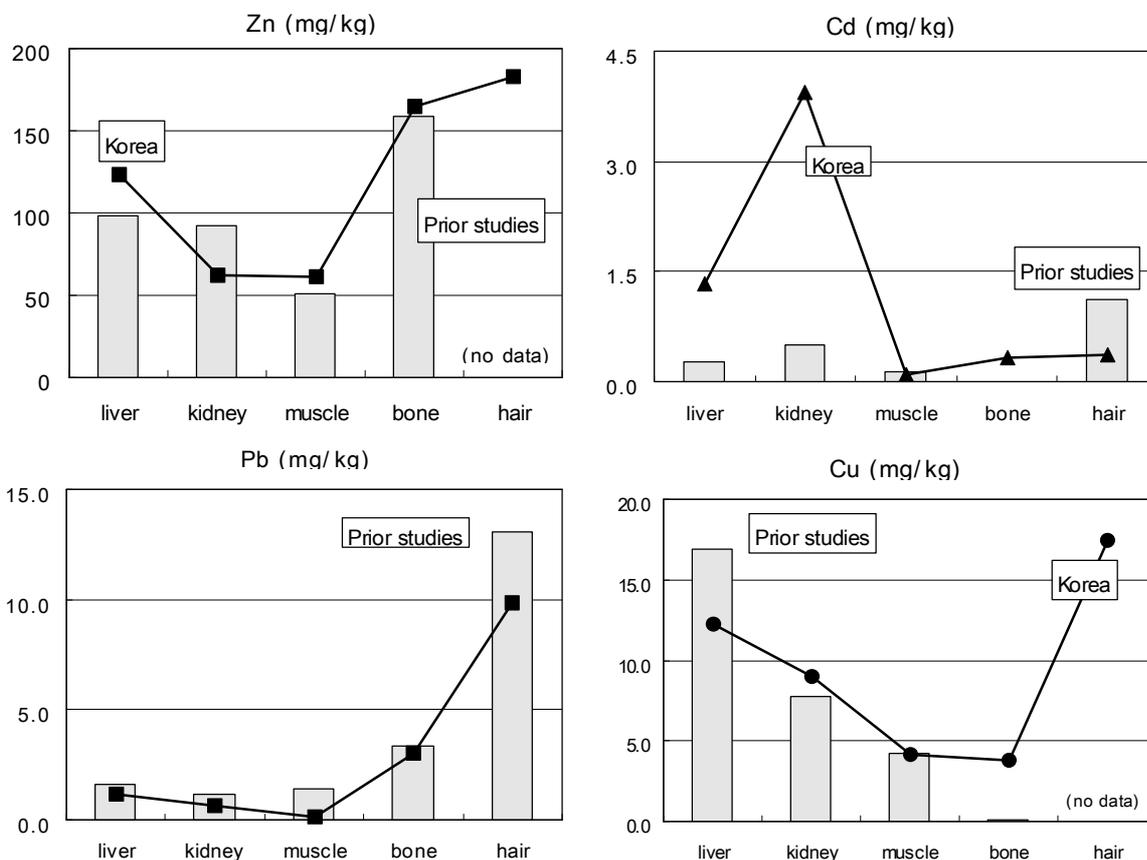
Figure 6. Heavy metals comparison of otter tissues compared with other prior studies.

Organs	References*
Liver	1a) 1b) 2) 3a) 3b) 4) 5) 6)
Kidney	1a) 1b) 2) 3a) 3b) 4) 5) 6)
Muscle	2) 5) 6)
Bone	3a) 3b)
Hair	5)

*; 1a) JEFFERIES and HANSON (1987, adult otter); 1b) JEFFERIES and HANSON, (1987, cub r); 2) WREN (1984, *Lutra canadensis*); 3a),3b) ANDERSON and SCANLON (1983, *Lutra canadensis*); 4) MASON (1988, fresh weight based); 5) MASON et al., (1986, fresh weight based); 6) BROEKHUIZEN (1989)

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GROSS ANATOMY OF FEMALE REPRODUCTIVE ORGANS FROM EURASIAN OTTERS (*Lutra lutra*) IN DIFFERENT STAGES OF THE REPRODUCTIVE CYCLE

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Abstract: Maturation status and reproductive cycle stage was determined in 460 female otters, including two captives, by the presence of foetuses, placental scars and/or by the histological structure of the ovaries. Reproductive organs of another 316 females were included in the search for macroscopic pathological tissues.

The reproductive organs of two unmated captive females indicated that ovulation is induced in the Eurasian otter. In young, immature females the uterus was small, with straight, dorso-ventrally flattened, translucent horns. The weight of the uterus in these young females varied from 0.14 to 1.63 g, increasing with age. The weight of resting uteri (not pregnant or recently parturient) of mature females varied from 1.17 g to 10.95 g. Apparently, the uterine walls thickened and the horns lost the translucent appearance about the time of the first oestrus. Uterine horns that were circular in cross section appeared to be associated with oestrus or pregnancy. Even before implanted embryos were visible the horns lengthened. They then attained a convoluted appearance because their attachments to the mesometrium did not enlarge correspondingly. Both horns lengthened, even if foetuses were only present in one of them. Recently parturient uteri were large and distended and the placental sites showed clearly, although the dark brown or black pigment accumulated only gradually, simultaneously with the shrinkage of the horns to their resting size. The placental scars then appeared to fade gradually and more slowly, but could still be seen as white scars after the dark pigment had vanished, lasting apparently up to about one year after parturition. Most females could be classified as immature or mature from the external appearance of the uteri. Tumours connected to the reproductive organs were found in 3.5% of the 5-9 year olds and 31.0% of the 10-14 year olds.

INTRODUCTION

Reproductive rates are important for population dynamics and for the survival probability of populations. Also, reproductive failure may signal detrimental changes in the living conditions of a population. The study of reproductive organs from dead animals is a useful method for assessing reproductive rates and reproductive health, especially in cryptic species, if these rates can be related to age and condition of the animals. However, the method is limited by the possibility to interpret anatomical findings.

The main anatomical features of the reproductive organs of female Eurasian otters (*Lutra lutra*) have been described previously (HEGGBERGET, 1988; ZOGALL, 1992) and will not be focused upon here. Changes associated with maturation and with different stages of reproductive cycles, and features that make it possible to identify these stages will be described. The possibilities to arrive at reliable conclusions by simple, quick, macroscopic methods will be investigated.

Some pathological conditions of the reproductive organs have been described previously (HEGGBERGET, 1988; CHRISTENSEN and HEGGBERGET,

1995; SIMPSON, 1997). Additional information on pathology is included in the present paper.

MATERIAL AND METHODS

Reproductive organs from female otters that died during 1973 -1996 in Norway were investigated. A total of 776 females were included in the present study. With few exceptions these females came from the west and north coast of Norway, north of 61° N.

Maturation status was determined in 460 females, by the presence of foetuses (n=22) or placental scars (implantation sites) from previous pregnancies (n=164) in the uterus, and/or by the histological structure of the ovaries. The ovaries were searched for large follicles and signs of previous ovulations (corpora lutea and corpora albicantia). Among these females the weight of the uterus was recorded in 100 cases, and the thickness of the uterine horns was measured in 58 cases. The reproductive organs of the remaining 316 females were externally, macroscopically inspected for presence of pathological tissues.

The otter carcasses were stored in a frozen condition before analysis. Uteri were thawed and open-slit longitudinally, or inspected by back-lighting if translucent, to locate implanted foetuses and placental scars. Weights were recorded before opening, after trimming off the mesometrium and cutting at the cervix and at the Fallopian tubes. All uteri with distensions, indicating foetuses or development of pathological tissue, were opened. Pigmented placental scars had to be located before fixation of the reproductive organs, due to immediate bleaching of the pigment in the fixative. Up to 1984 the ovaries were fixed in 70% isopropanol, softened in glycerine and acetic acid, sectioned at 30 microns (freeze sectioning) and stained in haematoxylin/iron alum (HEGGBERGET, 1988). From 1985 the technique was improved by fixing ovaries in 10% formaldehyd, sectioning them at 10 microns and staining in haematoxylin/eosin (HEGGBERGET and CHRISTENSEN, 1994).

The age of cubs was estimated by inspection of dental change and closure of cranial sutures (HEGGBERGET, 1996). The age of older females was estimated by counts of cementum incremental lines in histological sections of an incisor and a canine tooth (HEGGBERGET, 1984). All but five of the females in the study could be assigned an age.

RESULTS AND DISCUSSION

FEMALES WITH PARTLY KNOWN REPRODUCTIVE HISTORY.

Two unrelated captive females were found in the wild at about two months of age and kept together without any contact with other otters. They died at the age of six and seven years. They must thus have been sexually mature, but could not have mated. The ovaries of both females contained several relatively large vesicular follicles, with maximum diameters exceeding 2 mm, and a number of atretic follicles, in agreement with their mature status. However, no corpora lutea or corpora albicantia was found, which would have been evidence of previous ovulation. Thus, the conclusion by PECHLANER and THALER (1983), that ovulation is induced in the Eurasian otter, was supported,

but not conclusively. This is because corpora lutea from ovulations that did not result in pregnancy in spontaneously ovulating species have not been identified longer than two months and may degenerate without leaving long-lasting corpora albicantia (LANGVATN, 1992a). Even so, if these two unmated females had ovulated spontaneously during the previous oestrus, one might expect that the resulting corpora lutea would be still recognisable at the time of death, due the frequent oestrus of otter females. Cycle lengths of 30-40 days have been observed in captivity (GORMAN et al., 1978; TROWBRIDGE, 1983). The uteri of these two females were relatively small, weighing 1.70 g and 2.21 g, but the horns were round in cross section and opaque. As expected, no pigmentation resembling placental scars was present.

Two wild females were accidentally killed together with their cubs. In the first case three cubs were seen, two were killed. They were in the second half of their first year of life. Their mother was seven years old. Her uterus weighted 2.89 g and contained three white placental scars. Three small corpora albicantia were found in the ovaries. A seven-year-old mother and two cubs were killed in the second case also. These cubs were about one year old. Two hardly visible, white placental scars were found in the uterus of the female. Because the analyses of ovaries and uteri were made without knowledge of the family relationships, her ovaries were not selected for sectioning, and the uterus was not weighed in a fresh condition. The above findings show that the dark pigmentation of the placental scars disappeared within the first year after parturition, and the scars themselves were about to disappear at about 12 months post-partum.

Studies of more animals with known reproductive histories are needed, in order to exploit fully the potential of retrospective analysis of reproductive organs in otters.

OTHER FEMALES

SIZE OF THE REPRODUCTIVE ORGANS

The uterine weights increased significantly with age and maturation (Table 1). They decreased significantly with time following parturition (age of placental scars) only when recently parturient uteri (indicated by placental wounds) were included in the test (Table 1). Thus, the uterus shrinks to its resting size shortly after parturition. However, uterine weights overlapped among maturation stages. The weight ranges were 0.14 – 1.63 g (n=34) among immature anoestrous females, 1.08 – 2.74 g (n=5) among nulliparous (not previously pregnant) females in proestrus or oestrus (ovarian follicles >= 2mm, HEGGBERGET (1988), and 1.17 – 23.97 g (n=58) among non-pregnant parous (previously pregnant) females.

In nulliparous females the wall thickness of the uterine horns was significantly positively correlated with the size of the largest ovarian follicle (Pearson correlation coefficient, r=0.748: *P*<0.001: n=35). The wall thickness ranged from less than 0.5 mm to nearly 2 mm in nulliparous females, and from 0.5 mm to over 4 mm in parous females. The nulliparous females with the heaviest and thickest uteri were probably in oestrus judging by follicular sizes, and thus about to mature.

Table 1. Test result of analysis of variance of uterus weights (log-transformed) among categories of maturation status or time since parturition, with age as covariate, for Eurasian otter (Lutra lutra) females.

	df	F	*P*
A: Maturation stage Age (covariate) Total	2 1 85	37,883 16,637	<0,001 <0,001
B: Recently parturient females excluded Time since parturition Age (covariate) Total	3 1 48	2,567 6,690	0.087 0.013
C: Recently parturient females included Time since parturition Age (covariate) Total	4 1 55	18,368 8,154	< 0.001 0.006

A: Uterus weight relative to age and maturation. The 3 categories of maturation status were: immatures with small ovarian follicles, immatures with ovarian follicles of > 1 mm diameter, and matures.
B: Uterus weight relative to age and time since parturition in mature females, excluding the recently parturient ones. The 3 categories of time since parturition were: females with brown or black pigmented placental scars, white placental scars, and no visible placental scars.
C: Uterus weight relative to age and time since parturition, including the recently parturient ones. The 4th category was: females with placental wounds.

Correspondingly, LANGVATN (1992b) showed that uteri of nulliparous red deer (*Cervus elaphus*) hinds that had ovulated were significantly heavier than of those that had not ovulated. LANGVATN (1992b) also showed that the uterus attained its full development in size and appearance only after the first 2-3 pregnancies in red deer. Repeated pregnancies is likely to account partly for weight increase with age also in uteri of the Eurasian otter, considering the relatively small uteri of the two adult captive otter females that had never been pregnant.

APPEARANCE OF THE UTERI

The appearance of the uteri varied considerably, even among non-pregnant females. Uteri of immature females (n=200) were relatively pale and translucent, with straight, dorso-ventrally flattened, horns (Fig. 1). A permanent transition from a translucent to an opaque, darker, more vascularized uterus apparently took place in connection with the first oestrus, but young mature animals tended to have more translucent uteri than older mature animals (n=256). The increasing size of the uteri with age (Tab. 1) and an accumulating number of previous pregnancies probably explained this. Horns that were round in cross section tended to be associated with the presence of large follicles or new corpora lutea in the ovaries (n=70). Their colour, and that of pregnant uteri, was usually dark brownish red, probably due to an increase in the blood supply.

The uterine horns lengthened early in pregnancy, their free edge lengthing more than the edge attached to the mesometrium. This resulted in a curved and often convoluted appearance of the horns that was also present in some of

the non-pregnant females (Fig. 1). Foetuses were never positioned in the uterine body, only in the horns. As the foetuses enlarged the uterus widened along its whole length, but more around each foetus than between foetuses or in a non-pregnant horn. Dark pigment was often scattered in the endometrium between the foetuses.

Shortly after birth the number and positions of foetuses could be determined from dilations on the still generally enlarged uterus, and from wounds in the endometrium where the placentas had been attached. Following the regression of these swellings, masses of black or brown pigment collected at the previous implantation sites, demarcating the placental scars. These scars appeared like dark bands across the width of the longitudinally open slit uteri (Fig. 2). Thereafter the pigment was gradually reduced and finally disappeared, still leaving a white, difficult to detect, scar for some time, sometimes containing a small amount of shiny, orange pigment.

ESTIMATING LITTER SIZE FROM PLACENTAL SCARS

Placental scars of different pigmentation intensity were sometimes present simultaneously in a uterus (Fig. 2). STRAND et al. (1995) showed experimentally that abortions and previous pregnancies in the Arctic fox (*Alopex lagopus*) could produce scars that were paler than scars from the most recent litter, born at full-term. In the Eurasian otter different pigmentation can probably result from partial loss of foetuses, as partial resorption of implanted litters has been observed (HEGGBERGET and CHRISTENSEN, 1994; Heggberget in prep.). It is also likely to occur when a female becomes pregnant shortly after a previous pregnancy. In these circumstances counting the darkest set of scars will give an unbiased estimate of litter size. However, placental scars left by simultaneously born cubs may also fade at somewhat different rates (STRAND et al., 1995), in which case counting only the darkest scars will underestimate litter size.

CLASSIFICATION OF MATURATION STATUS BASED ON THE SIZE OR APPEARANCE OF UTERI

Uterus weights overlapped with the other maturation categories in 12% of the immatures, in 100% of the nulliparous females in proestrus or oestrus and in 40% of the parous females. Heggberget (1988) showed that also the lengths of the uterine horns and the weights of the ovaries overlapped among immature and mature females. Thus, many, but far from all, females can be correctly classified as immature/nulliparous or parous from one or more of the single size measurements. A combination of measurements by multivariate methods might increase the proportion that can be classified. However, classification by size is relatively time-consuming, although much simpler and less resource-demanding than histological studies of ovaries.

Classification of females as immature or mature from the external appearance of the uteri would be a quick, simple, and for some purposes sufficient method for determining female reproductive status, if sufficiently accurate. To test this, uteri from 98 females were first classified by back-lighting. They were longitudinally slit open and searched for placental scars

Figure 1. Uteri of non-pregnant Eurasian otter *Lutra lutra* females. Right to left: 5 months old immature female, 1 year old nulliparous female, 3 years old parous female (opening of the uterus showed no placental scars), 6 years old parous female (opening of the uterus showed weakly pigmented placental scars)

Figure 2. Placental scars (previous implantation sites) of differing pigment intensity present simultaneously in the longitudinally open-slit uterus of an Eurasian otter *Lutra lutra* female (arrows point at weakly pigmented scars).

and/or the ovaries were sectioned, stained and searched for corpora lutea and corpora albicantia. A one year old female that was classified as "probably mature" had only small follicles and no signs of previous ovulations or pregnancies, and was apparently erroneously classified, while 63 other females that were classified as certainly or probably parous had either placental scars, or corpora lutea/albicantia. Thus, all of them were mature, and the presence of placental scars indicated that 55 of them had been pregnant during the last year before death. The other eight may have had a longer time lapse since the last pregnancy. None of the 21 females that were classified as immature had corpora lutea/albicantia, and none of the six females classified as nulliparous had placental scars. No conclusion was reached from the external appearance of the uterus in seven cases, of which three proved to be mature and four immature. Thus, the external uterus analysis resulted in a correct classification in approximately 92 % of the cases. When only maturation or parous status needs to be known it is thus possible to classify most of the females correctly by the appearance of the uteri, and limit the more elaborate methods of opening uteri and sectioning ovaries to border cases, but experience is needed to use this method.

PATHOLOGY

Not all dilations of the uteri were caused by growing foetuses. Abnormal tissue formation in the reproductive organs was found in 14 females (1.8 %). These tissues were more or less globular tumours that varied from less than 5 mm to about 60 mm in diameter. Eight females had one to three intrauterine tumours extending from the endometrium. One of these females also had two small tumours close to one ovary. In two females the tumours were located in the vagina close to the cervix. One had two well-developed placentas but no foetuses in the uterus. Apparently, the foetuses had been resorbed. Four females had tumours on the outside of the uterus. The larger tumours positioned inside the reproductive tracts were identified to be fibroleiomyomas.

Tumours were found in none of the 0-4 year olds (n=598), 3.5 % of the 5-9 year olds (n=144) and 31.0 % of the 10-14 year olds (n=29). Successful pregnancy would be unlikely with most of these conditions, but it was mainly a problem of the old individuals. KEYMER et al. (1988) found similar tumours in an old otter female in Britain. Leiomyomas are common in the reproductive tract of some mammals, e.g. the domestic dog, after middle age (Jubb et al., 1985).

SIMPSON (1997) described cyst-like dilations of the uterine horns of two female otters from Britain. Among the Norwegian otters a 2-year-old female had 8-10 similar swellings of the uterine tract. One was positioned in the uterine body. These dilations were filled with disintegrated tissue remains, and lined with thin sheets of tissue, apparently of placental origin. I interpreted this as a failed pregnancy, which had consisted of an unusually large number of foetuses that were resorbed. Foetus resorption seems to be relatively common in the Norwegian otter population (HEGGBERGET and CHRISTENSEN, 1994; HEGGBERGET, 1998).

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ESTIMATING THE DENSITY OF OTTER *Lutra lutra* POPULATIONS USING INDIVIDUAL ANALYSIS OF TRACKS

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Abstract: A new technique for estimating the density of Eurasian otter populations was tested in the pond area of Upper Lusatia (Saxony, Germany). In winter 1996/1997 more than 600 footprints of 14 different tracks were recorded on frozen and snow-covered ponds by standardized photographic registration. Using suitable footprints of right front paws 33 specific measurements (distances and angles) were recorded. Using multivariate discriminant analysis for evaluation nearly 100% of the cases could be correctly classified. According to these results it seems that there is a realistic chance to identify individual otters by their tracks.

INTRODUCTION

Particularly in Central Europe, Eurasian otters (*Lutra lutra*) are rarely seen in the field. Therefore it is necessary to obtain information about diet, distribution, and population size by indirect means. In recent years tracks and spraints (faeces) have often been used for surveying otter populations. Their use is suited for identifying the presence or absence of otters and can give an indication of the distribution of the species. However, whether such surveys are also suitable to estimate population size and density is still being discussed (JEFFERIES, 1986; CONROY and FRENCH, 1987; KRUUK and CONROY, 1987; REUTHER, 1993). The problems are mainly caused by the complexity of the sprainting behaviour and the distinct spatial activities of otters.

Similar problems exist with other secretive mammal species. Some attempts have been made to identify individuals by their tracks, for example mountain lions (*Felis concolor*) in North America (SMALLWOOD and FITZHUGH, 1992) and leopards (*Panthera pardus*) in South Africa (STUART and STUART, unpublished).

As a part of the project "Function of non-fragmented and low-level disturbed landscapes for vertebrate species with high demands on area size (UZLAR)" supported by the German Ministry of Education and Research (BMBF), a new technique for estimating the density of otter populations was elaborated and tested in the pond landscape of Upper Lusatia (Saxony, Germany) by using individual analysis of tracks.

STUDY AREA

The study area (circa 50km²) is located at the western part of the pond landscape of Upper Lusatia nearly 60km north-east of Dresden. The landscape is characterised by forests and farmland with multitudinous fish ponds (mainly

carp), which represent an important feeding resource for the resident otter population.

MATERIAL AND METHODS

The data were collected in winter 1996/1997 by surveying frozen fish ponds covered with new-fallen snow for otter tracks. A sheet of ice with a thin blanket of snow provides favourable conditions for registration because it is more likely to find a longer trail of individual tracks on a plain substratum. The footprints of each track were recorded by single-image photography (f=50mm lens). For the photographic record a portable cubic frame (325 x 235 x 330mm) with scales at the bottom was constructed to ensure standardized conditions for all pictures.

Altogether 33 parameters were derived from the pictures of each footprint (29 distances measured with electronic calibre, square and 4 angles). Measurements included length and width of the footprint, length of heel, distances from outside heel to the centres of toes, distances from outside heel to the top of toes, distances between centres of different toes, angle of outer toes and heel, and angles of first toe centre and the remaining toe centres.

Discriminant analysis of track measurements was used to determine if individual otters could be identified by their tracks, as described by BACKHAUS *et al*. (1996). The canonical discriminant function takes the form:

$$y = b_0 + b_1X_1 + b_2X_2 + ... b_iX_i$$

(X_1, X_2, ... X_i: track measurements, b_1, b_2, ... b_i: discriminant coefficients, b_0: constant value)

Only Bayes-theorem was suitable for the classification of tracks, because different variances among the tracks were determined. Accordingly a conception of probability evaluated by Bayes-theorem was applied to classify footprints of unknown track membership (BACKHAUS et al., 1996). Measurements, which are not important for the efficiency of discrimination, were identified by a stepwise discrimination analysing RAO`s V, a transformation of Wilks lambda (RAO, 1952).

RESULTS

During four days 14 different tracks of otters were registered (tracks A to N), and standardised photographs made of more than 600 prints. It is assumed that all footprints of a single trail result from a single individual otter. Thus the set of photos of a single track could be combined into a single group. However, different tracks do not necessarily come from different individuals, because the maximum distance between two tracks was only 15 km.

We used primarily data of right front paws for analysis since they could be recorded most frequently (n=275) and include 13 of the 14 recorded track sets (there were no suitable imprints of the right front paw for track K).

An important aim of the analysis was to achieve an optimal separation of the recorded sets of photos of the different tracks (groups) so that we could identify those parameters, which are important for separation.

An analysis of variance of the measurements for each track set revealed that there are different variances among the tracks. This fact had to be considered in the course of discriminant analysis (e.g. Fisher`s classification functions are not appropriate for an analysis of this type data).

Following the first discriminant analysis using all parameters, 12 discriminant functions were evaluated (number of discriminant functions = number of groups (track sets) - 1). These discriminant functions enable an optimal track set separation as well as tests for checking the importance of the different measurements for separation. In order to illustrate that the results of discriminant analysis have to be understood in a multidimensional way, Figure 1 shows the results of two discriminant functions.

Altogether 83.3 % of the grouped cases, means sets of photos of the tracks, could be correctly classified. With the exception of track C (where only one in 38 photos was not correctly classified) and track H (where 20 of 62 photos of track H were correctly classified, whereas 42 photos were assigned to track L, represented in the data by only two photos), all cases could be classified to the correct tracks. So track sets with low number of repetitions, track B (5) and track L (2), were excluded from further analysis to avoid wrong classifications. Since the photos of track B and L were not classified to other track sets we assumed that these footprints belong to two different otter individuals, which differ from the residual individuals. Thus only 11 track sets remained in subsequent analysis.

After the exclusion, 99.2 % of the photos could be correctly classified. Only a single footprint of track C was assigned to track N and vice versa.

A random sub-sample of 25 footprints representing the different track sets was used for testing the evaluated discriminant functions for efficiency of separation. These 25 photos were treated as footprints of unknown track set membership ("ungrouped" cases). First, the discriminant functions were evaluated for the remaining footprints of known membership (grouped cases). Subsequently all cases of the sub-sample were used for discriminant analysis. This test was conducted using a conception of probability evaluated by Bayes-theorem.

The result of this analysis (Table 1) shows that only two of 25 cases were not correctly classified. So the separation of the grouped cases seems really efficient.

Additionally a stepwise method for discrimination was used to reduce the number of parameters. Using RAO`s method, which specifically has been developed to select redundant parameters, preliminary ten parameters could be excluded from analysis without any consequences for the separation of the tracks by discriminant analysis.
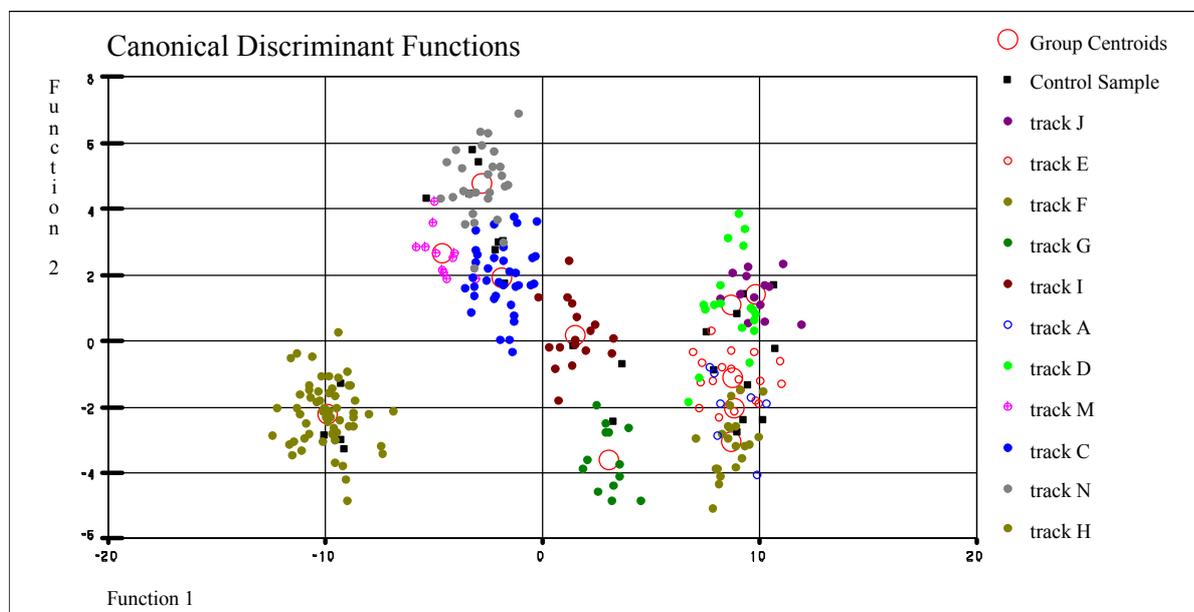
Figure 1. Discriminant analysis of 11 tracks (right front paws) using 33 parameters

Table 1. Test of discriminat functions for efficiency of seperation using random sample

group	number of cases	number of selected cases for test	correctly classified number	%
track A	8	1	1	100,0 %
track C	38	2	2	100,0 %
track D	21	2	2	100,0 %
track E	22	3	3	100,0 %
track F	23	2	2	100,0 %
track G	14	1	0	0,0 %
track H	62	4	4	100,0 %
track I	19	2	2	100,0 %
track J	15	2	1	50,0 %
track M	12	1	1	100,0 %
track N	32	5	5	100,0 %
total	266	25	23	92,0 %

CONCLUSIONS

The recorded tracks could be separated using discriminant analysis. The 13 analysed track sets could be assigned to 13 individual otters. But more discriminant analysis has to be conducted to consolidate the results. In contrast to the study in the US (SMALLWOOD and FITZHUGH, 1992), where the imprints of mountain lions were drawn on transparent foil, we decided to take photographs of the footprints. This procedure seems to be more practicable in the field and allows a simple and quick registration of footprints. In order to generate a useful method for surveying otter populations, the number of parameters has to be reduced. Further studies have to be conducted for testing this method using imprints of tracks on different

substrata like sand or mud. However, the here tested method might prove to be a suitable method for surveying population size of otters in the near future.

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NEW THREATS TO CONTINUOUS VIABLE OTTER POPULATION IN NORTHEASTERN PART OF SLOVENIA

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Abstract: A field survey using the 'standard' field survey technique (with some modifications) was used in the period from 1996 to 1998 to establish the presence of the otter in that part of Slovenia, northeast of the River Mura. Frequent otter signs were found at almost all checkpoints along rivers, streams and ponds, regardless of water quality, density of the bank vegetation and presence of disturbance. The population of otters in this part of Slovenia seems to be the most continuous and viable so far found in this country. There was a habitat corridor, connecting the otter populations in Styria (Austria) and across the state borders to Hungary. The greatest threats to the corridor are the main roads with traffic collisions, causing several otter deaths each year, as well as the proposed railway along the side of the streams. The potential role of corridor and artificial ponds as secondary habitats in maintainig and conserving viable otter population is disscused.

INTRODUCTION

No systematic field or national survey of otters (*Lutra lutra*) has been done in Slovenia. Three inquires, carried out about ten years ago by the Hunters Association of Slovenia (HÖNIGSFELD, 1985a,b), indicated a decline of otter numbers as well as changes in the distribution of the species compared with its reported historical distribution in the country a few decades earlier. But, in general, knowledge of otter distribution in Slovenia was poor.

Lutra lutra is included in the hunting law of the state Slovenia as a game species and was fully protected since 1976 (with recommandation of the Hunters Association of Slovenia from 1973). It is also protected by the Order of the Government of the Republic Of Slovenia on Protection of Threatened Animal Species (1993). The otter is included in the Red List of Endangered Mammalia in Slovenia (KRYŠTUFEK, 1992) as an endangered (E) species according to IUCN category.

In recent years, environmental impact assessments are mandatory by the state law for every development project planned in the natural environment of Slovenia. In 1996, such an assessment for a planned railway (Puconci – Hodoš – Hungarian border) recomended a detailed survey of otters in the Goričko country (Prekmurje, NE part of Slovenia). A survey in the neighbouring countries (Austria, Hungary), to the borders with Slovenia was also done (SACKL et al., 1996; KEMENES, 1991). A comparison of these results was of interest to us. Therefore the Ministry for the Environment and Physical Planning decided to support the survey on the otters in Prekmurje. The preliminary results of this work are described in this paper.

STUDY AREA

Prekmurje is the territory between the River Mura in the southwest and the catchment of the River Raab (Hungary) in the northeast. Within Slovenia, it is the only real part of the Pannonia with a continental climate; average temperatures in January and July are -3,2°C and 20,1°C, respectively. The study area was restricted mostly to the Slovenian part of the Goričko country in the north of Prekmurje (511 km^2). It is a hilly landscape with a maximum elevation of 418 m above sea level. The southern border consists of the diluvial terraces above the River Ledava, the northern border being the watershed between the Rivers Raab and Mura. Watercourses, rising in the hills and draining in a southeast direction, form a typical dendritic pattern belonging to the Mura catchment. No natural lakes occur in the area of Goričko.

MATERIAL AND METHODS

This was a local survey with the specific aim of determining what impacts, if any, the planned railway across Goričko would have on the otter population and which of the proposed three variants of the line to recommend. Only 15 squares of national UTM 10 km square grid covered the investigated area. A more detailed results were needed than those obtained with 'standard' method of survey (MACDONALD, 1983, 1990; ROMANOWSKI and BRZEZINSKI , 1997).

The field survey was based on the 1: 50 000 and 1: 25 000 maps. The chosen sites were bridges and other conspicuous places, such as large stones, logs etc. At each site a distance minimum of 200 m and maximum of 600 m was searched for spraints (feaces), tracks and other signs of otter presence. As soon as spraints were found the search was terminated and the site considered as positive; however, if only tracks or other signs were found, the search was continued with the intention to confirm or disprove otter presence by finding spraints. If no signs were found the site was considered as negative.

The field survey was undertaken between May 1996 and March 1998, mostly in the winter period. Seventy four sites, including rivers, streams, channals, reservoirs and ponds were visited (some of them on two or three occassions).

Generally, it was not necessary to extend searching because almost every bridge was positive (otter spraints were found). Because of the very dense grid of watercourses with many bridges in the study area it was usually not necessary to consider other potential sites.

At each survey site a data sheet was completed. This contained information on the quality, width and depth of water, and vegetation cover. The level of regulation and naturalness was also recorded, as was the level of human disturbance and type of agriculture. The availability of prey items were estimated from data collected by colleagues (specialists for other animal groups such as amphibians, fish, invertebrates) and working in the same project. The data will be used for further processing.

The spraints were collected and stored deep frozen for later spraint analysis.

Personal reports, such as direct observations of otters or road victims, from reliable people, mostly professional hunters, were included in the results. They were marked with different sign on the map.

RESULTS

Of the 74 sites in the catchment of Ledava visited and recorded to the map, 65 (87,84 %) were positive. The negative sites, in most cases, were considered as unsuitable ('unspraintable' ROMANOWSKI et al., 1996) bridges rather than absence of the otters. Usually there were several bridges on the same stream and otter signs were found only under suitable ones. Those considered 'unsuitable' were avoided by otters for the purposes of sprainting.

A wildlife movement corridor is a linear habitat, whose primary function is to connect two or more significant habitat areas (HARRIS and GALLAGHER, 1989; BEIER and LOE, 1992). An otter movement and habitat corridor, typically the stream (FORMAN and GODRON, 1986) was considered one of the most significant corridors in Prekmurje. It might be of great importance also for the establishment of the EECONET for the otters. Obviously it connects the population core area in the west (spreading over the state border to Austria) with that in the east (spreading over the state border to Hungary). We can track it from the lake (reservoir) of Ledava (Ledavsko jezero) through the River Ledava downstream to Puconski potok, through Mačkovski potok towards the north and then to Peskovski potok in the east and on to Mala Krka. On the first order stream Dolenski potok, the tributary of Peskovski potok, we have found a node (FORMAN and GODRON, 1986), namely the lake Hodoško jezero (reservoir), which we consider of extreme importance as rich secondary habitat for the otter.

The results are preliminary. We will proceed the detailed survey in Goričko and the whole Prekmurje to find out specific characteristics of otter habitats there and to propose conservation measures within the framework of the planned Goričko Nature Park.

DISCUSSION

Data collected during the field survey in Goričko demonstrate the common presence of the otter throughout the catchment of the River Ledava. (Nothing, however, can be said about the density of otter population.) The otter population in Goričko seemed to be the most stable and viable in Slovenia (HÖNIGSFELD, unpublished data).

Otters inhabit almost every tributary, regardless of its size. The regulations of streams, removal of bankside vegetation, cannelisation and other forms of human interference are generally considered as limiting factors for otter populations. This does not appear to be the case in our study area. The reason might be the fact that the investigated waterbodies are not heavily contaminated (or are not polluted at all), also they form a very dense dendritic pattern, with the majority of them being first-order streams. The cannalised streams which were found to have positive otter signs usually had their origin in the forested hilly area no more than 300 or 350 m above see level while at

least half of the streams are natural with well vegetated banks. More detailed analyses about limiting environmental factors are still needed.

There is no natural lake in the Goričko country, we therefore found the three investigated reservoirs of great importance for otters. In particular Hodoško jezero (Hodoš Lake), which occupied about 6 hectares and was situated near the Slovenian-Hungarian border, is regularly visited by otters; numerous spraints being found there every time the site was checked. Although man-made, this lake, as a node attached to the corridor, might serve as a significant food habitat in the cases when prey in other habitats is scarce. A special study, analysing the water quality and other characteristics of Hodoš Lake including a management plan, is in preparation.

The otter seems to be widely distributed and probably forming a viable population throughout catchment of Ledava (Goričko). The River Ledava which drains Murska Sobota (the capital of Prekmurje) is extremely contaminated downstream of the city, due largely to organic pollution. Nevertheless, we have found evidence of otters under every bridge, including one close to the town.

It must be stated that, with exception of very polluted Ledava, the stream corridor Puconski potok – Mačkovski potok – Peskovski potok – Krka has the best connectivity in both, structural and functional aspects (BENNETT, 1990) for the otter population in Goričko, thus being considered as the only suitable and safe (uncontaminated) corridor in this area. Unfortunately, there are two 'black' corridors, namely the main road passing Goričko and the planned international railroad connecting Murska Sobota and Hungary, which occupy the same valleys as the otter habitat corridor. Every possible effort has been done to reduce the interference of these two 'black' corridors, recommending that railroad planners should accept the 'soft' option and include 'proper' bridges (i.e. those suitable to otters), where necessary.

The conservation measures concerning the road will be very hard to implement. Several (2-3) otters killed by traffic are reported each year. The only measure which seems realistic to implement is to check the bridges, and where necessary make modifications so that they are suitable for otter use. Thus we can expect the otters using the stream corridor to use the bridge instead of crossing the road (STRIESE and SCHREYER, 1993).

There is another threat for otters found in Hodoško jezero recently: the traditional fish traps (baskets) which are still in use in northeastern Slovenia. Originally they are designed for fish catching but it's possible for otter to follow the fish inside and drown. It seems unsensible to suggest fishermen to use a stop-grids as reported from Denmark (MADSEN, 1991) because in Slovenia traps of all kinds are strictly forbidden by law. So the only measure seems to be a regular good control of otter habitats.

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THE NOVA REKA CHANNEL OX-BOW RESTORATION PROJECT: AN EXAMPLE OF EFFECTIVE RIVER REVITALISATION FOR OTTERS?

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INTRODUCTION

There are over 500 fishponds in the Trebon Biosphere Reserve and Protected Landscape Area (700 km^2), covering 7,000 ha (10%) of the surface area of the Reserve. The Reserve maintains a high-density otter population, the current estimate being about 120 individuals (SIMEK and SPRINGAR, 1998). Since the revolution of 1989, the economics of carp pond fishing have become increasingly difficult and, consequently, the otter and other predators are increasingly becoming scapegoats for losses in revenue and pressure for hunting licenses or other forms of control are increasing.

Studies have recently shown that, when there are concentrated populations of uneconomic fish species available in nearby channels or river pools, the otter may significantly reduce its consumption of carp (ROCHE, 1997a, 1997b, 1998). Further, FOERSTER (see DULFER et al., 1998) found that hunting success was significantly higher at such river pools, as compared with fishponds, particularly in winter. Experiments with the provision of highly stocked 'diversion' ponds are presently taking place in Austria (BODNER, pers. com.), however, such ponds are expensive, must be repeatedly stocked and must be kept free of ice in winter to be effective. A more cost-effective, 'environmentally-friendly' and, possibly, more effective long-term option is the improved management of rivers and reservoirs near to ponds. By revitalising ox-bows, backwaters, and shallow littoral zones, the numbers and biomass of fish may be increased and otters may then find it more profitable to forage at such sites.

THE NOVA REKA CHANNEL OX-BOW REVITALISATION PROJECT

The Trebon Biosphere Reserve and Protected Landscape Area Authorities (SCHKO) are spending 10 million Kč (US$ 30,000, 1998 rates) over five years on reconnecting and revitalising a series of ox-bows along a channelised stretch of river, the Nova Reka channel. As a result of this channelisation, which was undertaken approx. 30 years ago, this stretch of the riverbed has been eroded leading to a lowering of the rivers surface, which has consequently resulted in the disconnection of many ox-bows and backwaters and the loss of much valuable habitat for fish and other species. As a means of counteracting the negative results of such previous management, the reconnection of the ox-bows will form part of a long-term project to manage the channel in a more ecological manner.

Dredging of the ox-bows (begun in November 1997) took place on the outside meanders only, maintaining the natural contours of the original river.

Dredging also avoided possible otter resting sites or holts previously noted at the sites, and bankside trees with well developed root stocks were left undisturbed. Adjustable weirs along the channel will raise the water level and, in addition, open inlets will allow freshwater and fish into the ox-bow lakes, whilst outlet sluice gates will allow the water level in the lakes to be maintained, even during times of low water in the main channel (e.g. during hot summers or at times when ponds are being refilled after harvesting). The weirs are to be placed between the inlets and outlets of the ox-bows, thereby allowing movement of fish past the weirs and thereby reconnecting previously separated sections of the channel.

The Czech Otter Foundation Fund is currently monitoring three of the ox-bow lakes (two now reconnected and one with shallow muddy pools which is rarely connected to the river). Any otter activity, both before and after revitalisation, is being monitored, as well as any changes in the fish population (determined by seasonal electrofishing (not winter)). Finally, whilst there is unlikely to be any dramatic change (due to the number of nearby ponds), the diet of the otter(s) present is being determined through spraint analysis. This study will provide baseline data for the long-term monitoring of the sites. If, as expected, fish populations react favourably to such revitalisation measures, this may provide good evidence for the revitalising (or even construction) of such features for both fish and otter conservation, particularly in areas where it may lead to a reduction in carp predation.

PRELIMINARY RESULTS

This is a project in progress; however, some preliminary findings are available. Previous observations had shown that an otter(s) were constantly using a system of holts in the bankside of one of the dry ox-bows. During dredging, the otter avoided the site, however, approximately one week after construction work effectively ceased (some small-scale work continued), at least one otter had returned to the ox-bows and tracks and spraint were regularly found thereafter. Some of the holts appeared to be no longer used, apparently due to the rise in water level, however, freshly dug earth at other holts indicated a possible enlargement of suitable sites.

In the first five months following revitalisation, electrofishing data revealed a five-fold increase over the previous fish species diversity in the connected and dredged ox-bows. In the control ox-bow (unconnected) only tench (*Tinca tinca*) was found in remaining pools; whereas tench, roach (*Rutilus rutilus*), ruffe (*Gymnocephalus cernua*), *Pseudorasbora parva*, and pike (*Esox lucius*) were all found in the re-connected ox-bows. Numbers and biomass, however, were still low at this time. Aquatic vegetation has been slow to colonise these revitalised sites due to excessive tree cover and leaf fall in autumn. Unfortunately, these trees are privately owned and cannot, as yet, be thinned out. The relative abundance of carp in the diet at the three sites ranged between 0 and 69 % over the winter collection period. Interestingly, spraints from the revitalised ox-bows contained 71 % less carp than spraints found close to the unconnected ox-bow. However, these sites are relatively close together and differences in diet composition with such a small data set,

and over such a small area, are unlikely to be representing true changes in predation behaviour.

DISCUSSION

Preliminary data indicate that, whereas unconnected ox-bows can provide good shelter for the otter (holts/resting sites) they lack fish and, therefore, the otter feeds elsewhere, often taking economic fish species. Long-term monitoring will provide information as to whether (a) fish use the reconnected ox-bows as over-wintering sites, refuge sites (from fast flows), and spawning sites and (b) whether otters will find that hunting success increases at these ox-bows and that it becomes more profitable to hunt more often at these sites than, for example, in ponds. Preliminary data are encouraging: the increase in fish species diversity at the ox-bows indicates that fish are getting into the ox-bows. As time passes, and vegetation returns to the ox-bow, the prey biomass should rise, thus, increasing the chance of improved hunting efficiency.

Such revitalisation programmes may not only reduce the predation on economic species, and thereby ease the conflict between otters and fishermen, they should also improve conditions for a host of other aquatic and semi-aquatic species. Further, when undertaken in areas away from present otter populations, they could provide features that may encourage or enable the migration of otters into those areas where they are presently absent or in low numbers.

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CONSERVATION STATUS OF OTTERS IN THE TARAI AND LOWER HIMALAYAS OF UTTAR PRADESH, INDIA

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ABSTRACT: The Eurasian otter, the smooth-coated otter, and the Oriental small-clawed otter occur on the Indian sub-continent. The existing populations of Indian otter species and their habitat have never been systematically surveyed. To assess the status of otter populations, an ecological survey was carried out between 1995-96 in and around Corbett and Dudhwa Tiger Reserves, Katerniaghat Wildlife Sanctuary, and Alaknanda valley along the Alaknanda River. During the survey 74 sites were examined for signs of otter presence, of which 47 sites were inside Protected Areas (PAs) and 27 adjacent to the PAs. Inside the Pas, 32 sites (68%) showed signs of otters, whereas signs were found in only two sites (7%) outside the PAs. The presence of otter signs positively correlated with bank-side vegetation (*P*<0.05), indicating the importance of shoreline vegetation to otters. Inside the PAs, otter habitats were unmanaged, while outside they were subjected to severe anthropogenic pressures. As a conservation measure it is suggested to monitor wetland hydrology and prey availability, and reduce grazing pressure and aquatic weeds in wetlands within PAs. Boundaries of the PAs need to be realigned to include otter habitats adjacent to PAs.

INTRODUCTION

Most otter species live naturally at low population densities largely because their food sources are widely dispersed and the environment is unable to support a high density of top predators within a restricted area. This natural system of regulating population densities causes problems for many species if they become over exploited and, as a result, are threatened with extinction. Furthermore, should their habitat be destroyed or become fragmented, animals can no longer survive in these now hostile environments, and re-colonization is prevented. Several factors are involved in the decline of otter populations world wide, both in terms of population size and current distribution. Historically this was largely due to over-hunting while at present habitat destruction and pollution are the most critical threats to the survival of otters (MASON and MACDONALD, 1986). The decline of otter populations over their entire range has generated an increasing interest in the conservation of these species (FOSTER-TURLEY and SANTIAPILLAI, 1990).

The Eurasian otter (*Lutra lutra*), the smooth-coated otter (*Lutra perspicillata)*, and the Oriental small-clawed otter (*Aonyx cinerea)* occur on the Indian sub-continent. Their current status is not known due to the lack of data on their distribution but it is believed that populations are in decline. Intensive poaching, loss of habitat due to the construction of dams and barrages, as well as pollution are thought to be the major causes of the declining otter population in India (HUSSAIN, 1993; HUSSAIN and CHOUDHURY, 1997). The majority of confiscated animal skins and furs in India are the pelts of common and smooth-coated otters (Hussain unpublished data) originating from the lower Himalayas and Tarai region of Uttar Pradesh, West Bengal, Sikkim and Assam. An

extensive network of Protected Areas (PAs) exists in India covering all biogeographic zones. However, very few of them are based on detailed habitat and species management plan, and fewer still make any effort to involve local people in the designing or maintenance of these areas. While designing these PAs, no specific conservation efforts were made for otters, and no estimate of their populations were made in these PAs. In 1995 the Wildlife Institute of India undertook a study to assess the status of otter population in the Tarai and lower Himalayas with the following objectives; a) to validate the survey techniques developed for Asian otter species, b) to determine the status of otters in the Tarai and lower Himalayas, and c) to assess the levels of interaction with other aquatic fauna, and of anthropogenic pressures on otter populations in the region. This paper presents the result of the study.

STUDY SITES

At the initial stage, the following sites in the Tarai and lower Himalayan region have been surveyed; Corbett and Dudhwa Tiger Reserves, Katerniaghat Wildlife Sanctuary and the Alaknanda valley along the Alaknanda River. The rationale for selecting Tarai and the lower Himalayas as survey sites was that, historically these areas were stronghold of otters largely because of extensive networks of swamps, marshes and hill streams. At present the entire area is under increasing anthropogenic pressures, and most of the swamps and marshes have been reclaimed for cultivation. Nevertheless, there are reports of otter sightings from these PAs and systematic surveys are needed to identify the status of otter populations in the region.

Katerniaghat Sanctuary

The Katerniaghat Wildlife Sanctuary (Fig. 1) was created in 1976 in recognition of the general importance and diversity of its wildlife, which includes remnant populations of gharial *Gavialis gangeticus*, Gangetic dolphin *Platanista gangetica*, as well as swamp deer (*Cervus duvauceli duvauceli)* and hog deer *(Axis porcinus)* (Oliver, 1985). Approximately 40% of the total area of 400 km^2, including a core area of 140 km^2, is comprised of savanna woodlands, tall grasslands and small proportion of forested swamps. The vegetation community of Katerniaghat is similar to Dudhwa, and the swamps are dominated by *Phragmites karka, Arundo donax, Sclerostachya fusca, Carex obuscuriceps* and *Cyandon dactylon*. The northern and the western boundary of the Sanctuary is formed by the Girwa River and is contiguous with the Royal Bardia National Park on the Nepal side.

Dudhwa Tiger Reserve

Dudhwa is situated in the northern Uttar Pradesh along the Indo-Nepal border (Fig. 2). The total area of the Reserve is 614 km^2 (QURESHI and SAWARKAR, 1992). The perennial River Suheli is its southern boundary and the Mohana River forms the northern boundary. Fifty four percent of the reserve is covered with sal forest, 23% comprises of grasslands dominated by *Phragmites-Themeda-Imperata* type. The park is interspersed with several shallow pools/swamps dominated by *Phragmites karka, Arundo donax, Sclerostachya fusca, Carex obuscuriceps* and *Cyanodon dactylon* (DABADGAHO And

SHANKARANARAYAN, 1973). These pools are locally known as tals. The tals are important as habitat for swamp deer (*Cervus duvauceli*), rhinoceros (*Rhinoceros unicornis*) and turtles. The approximate percentage of the total area of wetlands in the Reserve is 8-10%. However, detailed information on the extent and hydroperiod of these wetlands is lacking. Most of the tals contain water throughout the year and depth of the pools varies from 0.5 to 2 metre, except for the shallow ones which dry up in the month of May for a brief period (JAVED and HANFEE, 1995). Monsoon sets in by the first week of June and on average the area receives an annual rainfall of 1300-1600 mm.

Corbett Tiger Reserve

The reserve is situated at the foothills of the Western Himalayas along the Delhi-Ranikhet national highway (Figure 3). The area falls in the Bhaber tract of the lower Himalayas, which is characterised by deep dry boulder deposits at the base of the outermost Himalayan hills. The altitude varies from 350-1200 m with undulating topography. The soil is alluvial. The park is spread over 1319 km^2 consisting of 521km^2 of core zone (National Park), and additional areas of Sonanadi Wildlife Sanctuary (301km^2) and Reserve Forest (497km^2) as buffer zones. The River Ramganga flows for about forty kilometers along the northern and southern boundaries of the park. A number of springs flow inside the park, although the main source of perennial water is the Ramganga River. Vegetation in the major areas of the park consists of mixed deciduous tropical and sub tropical forests with sal (*Shorea*) as the dominant species. Besides, the park consists of a number of *chaurs*, or grasslands, that provide ideal grazing ground for herbivores.

Alaknanda Valley

The Alaknanda River, a major tributary of the Ganges originates from the Alkapuri Glacier. It is formed by the junction of the Dhauli and Vishnu Ganga Rivers at Vishnuprayag. The Alaknanda is the main river of the Garhwal Himalayas. It joins the Bhagirathi River to form the greater Ganges drainage system. The Garhwal Himalayas have a very rich floristic composition; the tropical and sub-tropical forest zone lying between 300-1200 m altitude is dominated by *Shorea*, temperate forest zone between 1200-2600 m, sub-alpine forest zone between 1800-3000 m, alpine forests and meadows above 3000 m (RAJWAR, 1993). The physiographic characteristics of the Garhwal Himalayas vary from low valleys and narrow strips to very high mountains and between these extremes of elevation are high valleys, narrow plains, foothills and low mountains. In the Alaknanda valley the river passes through high gorges with sparse vegetation. The present survey has been conducted along the Rishikesh-Badrinath route through the township of Srinagar, Chamoli and Pipalkoti up to Joshimath. Along the entire Alaknanda, fallen rocks and boulders, deep crevices and caves provide suitable den sites for otters (BHATT, 1992).
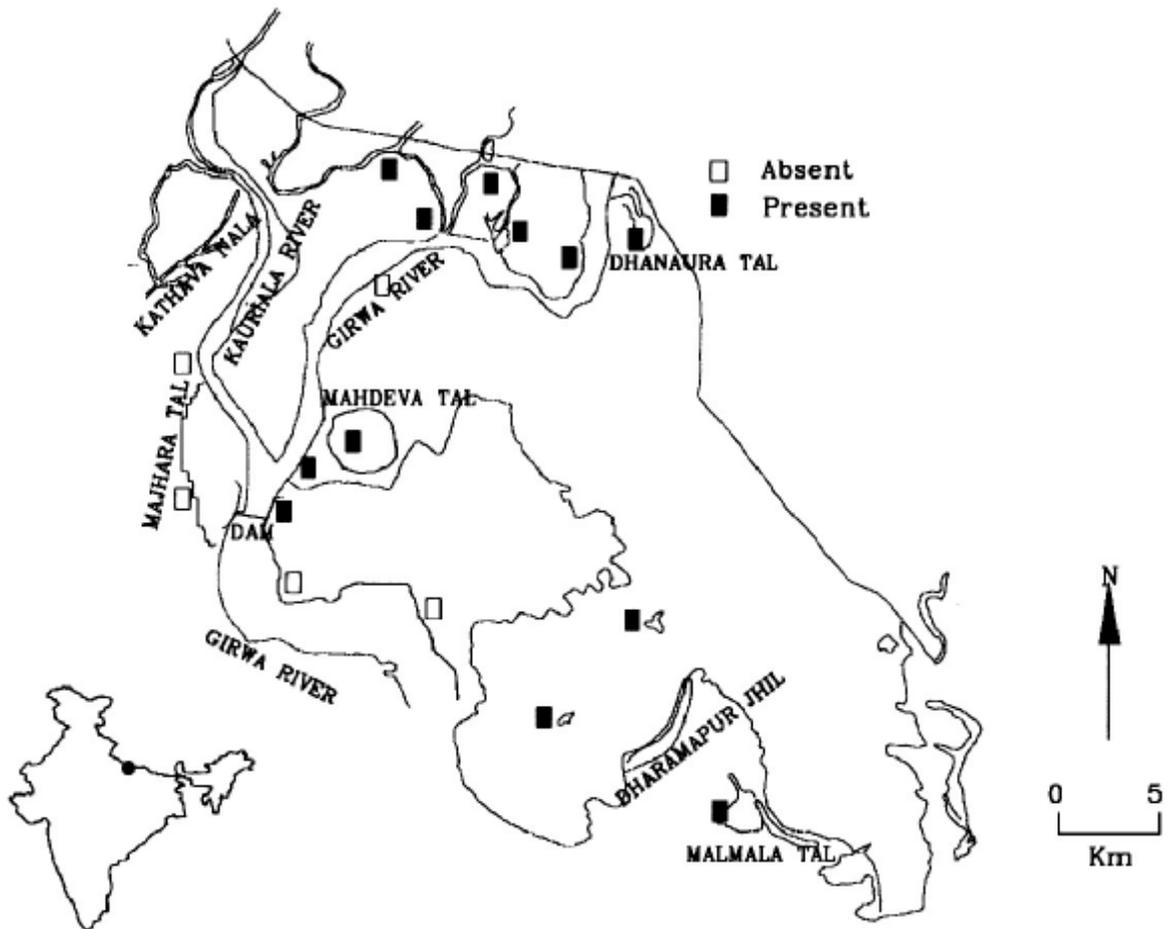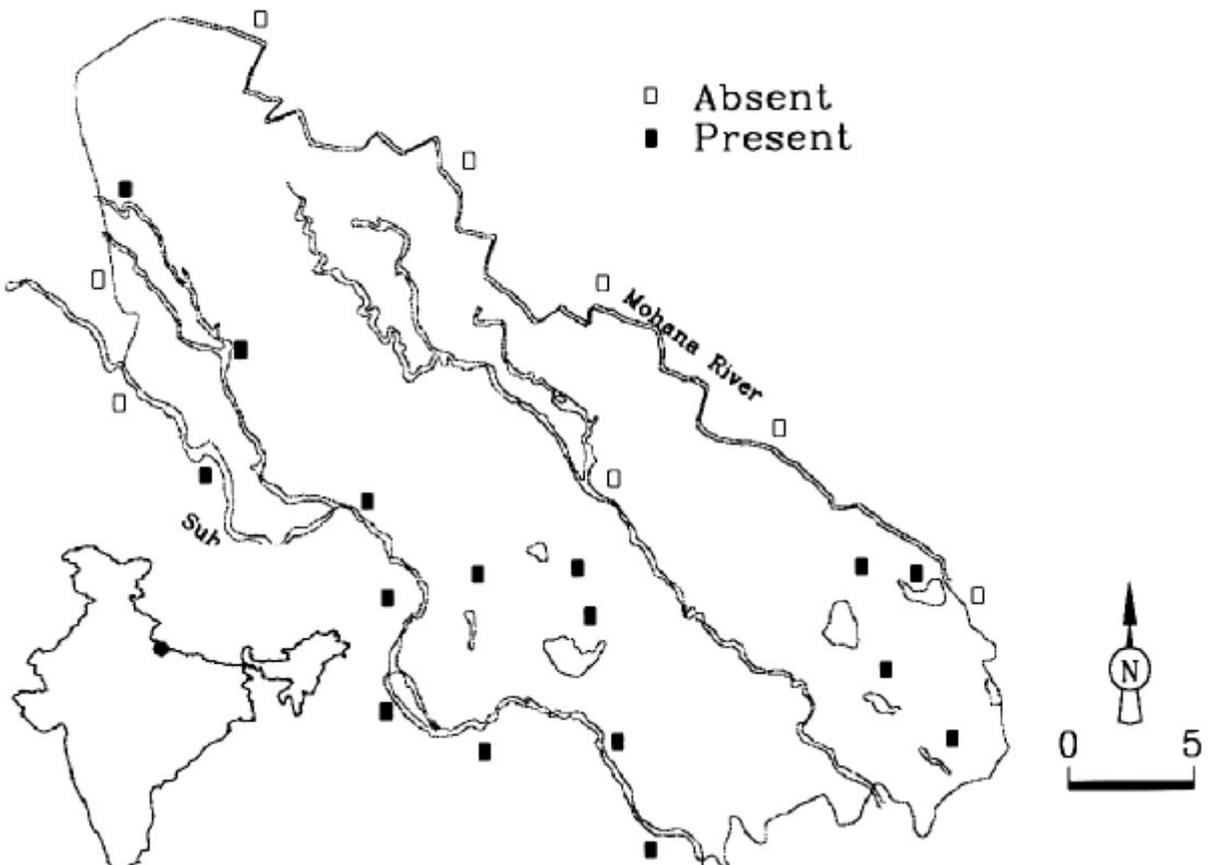
Figure 1. Map of India showing survey locations

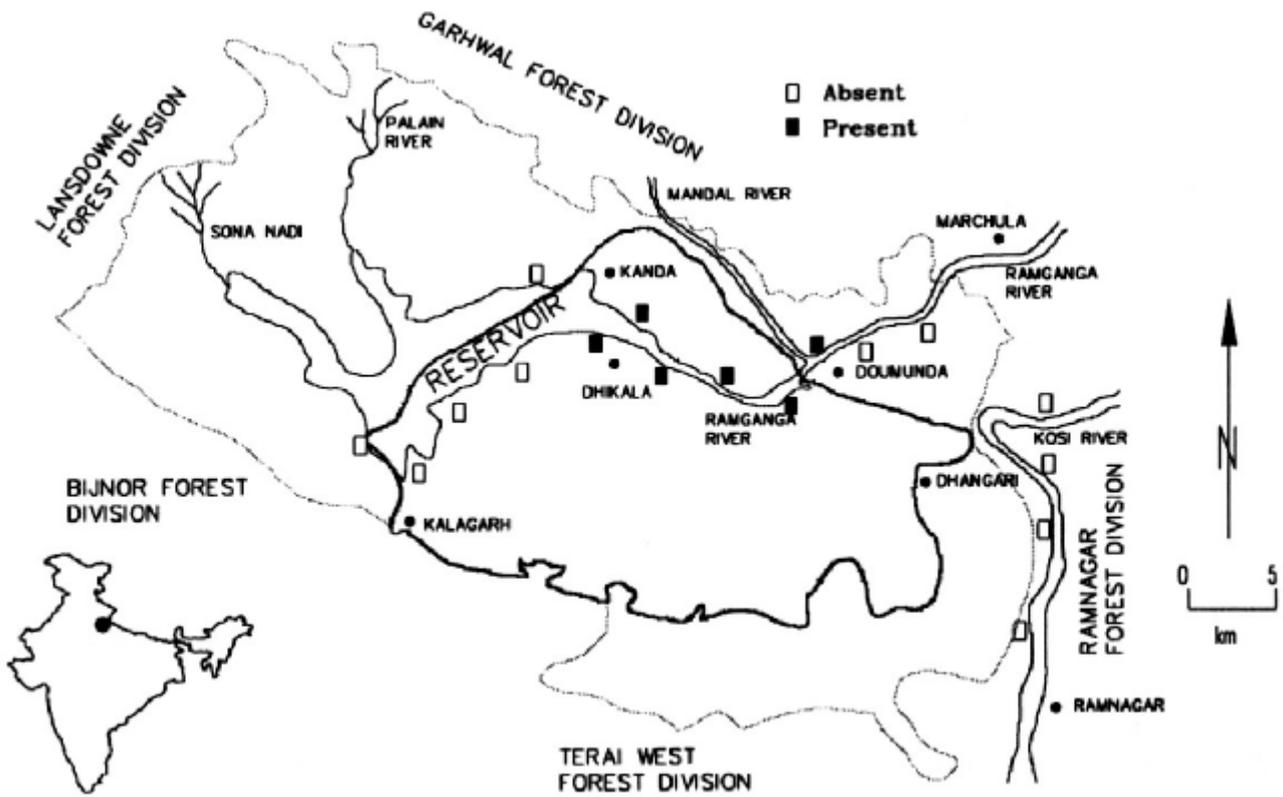**Figure 2.** Katerniaghat Wildlife Sanctuary showing distribution of otter

Figure 3. Dudhwa Tiger Reserve showing distribution of otter
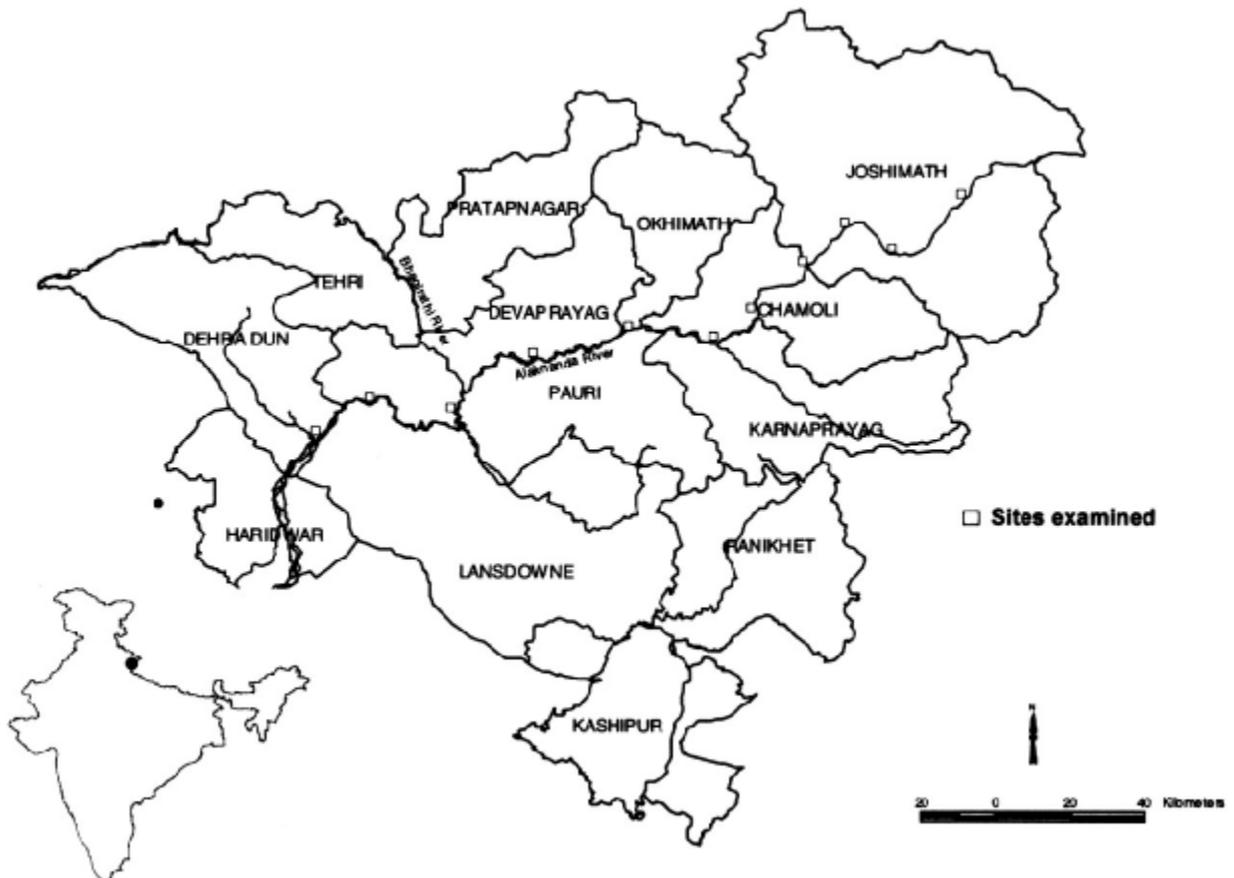

Figure 4. Corbett Tiger Reserve showing distribution of otter

METHODOLOGY

Survey Design

Indirect evidences of otter presence, such as foot prints, spraints, dens and resting sites, were searched for along the rivers, reservoirs, canals and other water bodies. At each site a maximum of 500 m. of shoreline within 25 m. strip along the water edge was searched. In the case of smaller pools, entire perimeter of the pool was checked. The method adopted for the survey was primarily based on MACDONALD and MASON (1983), CHEHEBAR (1985), HUSSAIN (1993) HUSSAIN and CHOUDHURY (1997) for surveying different species of otters. During the survey at each site data on the following parameters were collected:

a) Land use/altitude/habitat types;
b) characteristics of signs;
c) distance searched;
d) shoreline substrate;
e) shoreline vegetation;
f) disturbance such as fishing, grazing, mining or other use;
g) level of visible pollution;
h) bank alteration;
i) water current;
j) water depth;
k) hydroperiod;
l) aquatic weeds;
m) prey availability; and
n) associated fauna.

During the survey fishermen, trappers and local tribes were interviewed to get information on illegal trapping, sightings of otters, and of other aquatic fauna.

Methods of analysis

The occurrence of positive sites in different habitat types were compared using Kruskal-Wallis one way analysis of variance to examine their importance to otters Associations between parameters and otter presence was compared using Chi-square contingency table, and Fisher's exact probability test was used to examine the factors that influence distribution of otters within a habitat (SIEGEL, 1956).

RESULTS

Distribution pattern of otter

During the survey 74 sites were examined for signs of otters, of these 47 sites were inside PAs and 27 out side. Sites were classified into four categories; upland rivers (20 sites), lowland rivers (21 sites), swamps and marshes (24 sites), and lakes and reservoirs (9 sites). Inside the PAs, 32 sites (68%) showed evidence of otters, whereas signs were found at only two sites (7%) outside the PAs. Of these 74 sites, otter presence was recorded at 34 (46%). Of the 34 positive sites, 32 (68%) sites were inside the PAs and only 2 (7%) outside

(Table 1). Number of positive sites in each habitat varied significantly (K-W test, $\chi^2=10.1$: *P*=0.01). A total of 16 positive sites (67%) were recorded in swamps and marshes, 11 (52%) in lowland rivers, 6 (30%) in upland rivers, and 1 (11%) in reservoirs and lakes (Table 2). Of the 13 parameters examined, six *viz*. altitude, bank cover, prey availability, water depth, water current and bank alteration showed positive associations with otter's presence (Table 3). Of these, associations with bank side vegetation (*P*<0.001) and prey availability (*P*<0.001) was strong, indicating the importance of shoreline vegetation and prey availability for otters.

Table 1. Landuse type and otter's presence in the Tarai and lower Himalayas of Uttar Pradesh

Area status	Total sites	Signs present	%
Protected areas	47	32	68
Outside protected areas	27	2	7
Total	74	34	46

Table 2. Habitat types and otter's presence in the Tarai and lower Himalayas of Uttar Pradesh

Habitat types	Total sites	Signs present	%
Upland rivers	20	6	30
Lowland rivers	21	11	52
Marshes and swamps	24	16	67
Lakes and reservoirs	9	1	11
Total	74	34	100

Table 3. Associations of habitat features with otter's presence in the Tarai and lower Himalayas of Uttar Pradesh

Relationship	χ^2-value	d.f.	*P* value
Altitude/otter	32.56	1	0.005
Bank cover/otter	13.54	3	0.001
Prey availability/otter	31.92	3	0.001
Water depth/otter	12.64	3	0.005
Water current/otter	8.32	3	0.03
Bank alteration/otter	11.02	3	0.004

Status of otter populations

The area-wise distribution of otters has been summarised in Table 4. Of the 74 sites examined, the highest percentage of positive sites for otter activities were recorded from Katerniaghat Wildlife Sanctuary, followed by Dudhwa Tiger Reserve, and Corbett Tiger Reserve. In Alaknanda Valley presence of otter was not recorded. Conservation status of otters from different regions has been discussed below.

Table 4. Distribution of otter presence across different protected areas and regions in the Tarai and lower Himalayas of Uttar Pradesh

Protected area/Region	Total sites	Signs present	%
Corbett Tiger Reserve	17	6	35
Dudhwa Tiger Reserve	30	16	53
Katerniaghat WL Sanctuary	16	12	75
Alaknanda Valley	11	0	0
Total	74	34	46

Katerniaghat Wildlife Sanctuary

In this Sanctuary the otter habitat consists of seasonal swamps. Extensive use of these swamps during winter was observed. The main otter habitat is the Girwa River and its tributaries where evidences of otter breeding were also recorded. Of the 16 sites examined, nine were in swamps and seven along the Girwa and its tributaries. According to reports (Forest Department, personnel communication) in the Girwa River the otters coexist with 19 adult gharial and 11-12 river dolphins. However during the survey only six gharials were sighted.

Dudhwa Tiger Reserve

A total of 30 sites were examined of which 14 were swamps and 16 lowland rivers (Suheli and Mohana Rivers and their tributaries) (Table 6). Otters were using these swamps mostly during monsoon and winter, where, as in summer, they migrated to perennial rivers.

Evidences of breeding and natal dens were mostly recorded from Kakraha, and Bankey Tal. This indicates that the swamps are acting as nursery *i.e.* for rearing pups. During summer these tals become unsuitable for otters as most of them dry up by April, and the animals migrate to the perennial water sources.

Table 5. Status of otters in Katerniaghat Wildlife Sanctuary

Habitat types	Total sites	Signs present	%
Girwa River	10	7	80
Area adjacent to PA	1	0	0
Swamps and marshes	5	5	100
Total	16	12	75

Table 6. Status of otters in Dudhwa Tiger Reserve

Habitat types	Total sites	Signs present	%
Suheli River	12	8	67
Mohana River	5	0	0
Swamps and marshes	13	8	62
Total	30	16	53

Corbett Tiger Reserve

The major otter habitat in the Corbett Tiger Reserve is the Ramganga River and the Kalagarh Reservoir. All the sites checked along the Ramganga River showed extensive use by otters. A 14 km stretch was walked and habitat suitability for otters assessed. Forty-one potential den sites and two occupied dens were located. Of the two occupied dens, one was made of logjams, the other a dug-out hole on a clay island. Temporary resting sites along many islands, under logjams were also recorded. Prey availability appeared to be high in the Ramganga River. In this 14 km stretch 11 gharial and two mugger were also sighted.

Along the Kalagarh Reservoir five sites were examined but with no evidence of otters. This may be because of bare shorelines of the reservoir. In the reservoir, four adult gharials and two muggers (*Crocodylus palustris)* were seen.

Table 7. Status of otters in the Corbett Tiger Reserve and adjacent rivers.

Habitat types	Total sites	Signs present	%
Ramganga River	6	6	100
KalaRarh Reservoir	5	0	0
Kosi River	6	1	17
Total	17	6	35

Alaknanda valley

Along the Alaknanda river 11 sites were examined, six were without vegetation comprising of rocky cliffs and boulders while five had bank-side vegetation. Though the Alaknanda appears to be good habitat for otters with fairly high prey biomass, evidence the species was not found. This could be due to intense human pressure along this river. Otters may have been present in deep gorge areas but as the sites were inaccessible they were not checked.

DISCUSSION

Significance of the study

Before embarking on any effort to conserve an otter species it is imperative to determine its distribution and relative population status (MACDONALD, 1990). One objective of this study *i.e.* to assess the status of otter population in the Tarai and lower Himalayas, was to gather baseline information on the distribution and abundance of otters for monitoring future change. Given an increased probability of adverse effects on wildlife populations everywhere and particularly in the Tarai region, in the event of any catastrophic disturbance, habitat degradation and modification, this work can be used for conserving otters. In this study, attempts were not made to determine the degree and extent of the impact of disturbances on the otter population as these are subjective. Nevertheless, disturbance factors at each site and their possible impact on otters and their habitat were also recorded.

Constraint with the survey methods

There is no simple method for censusing river otters, although the distribution and presence of otters in an area can easily be determined by searching for tracks, scats and other signs (MELQUIST and DRONKERT, 1987). Because otters are secretive, thinly distributed and largely nocturnal, their presence and status have to be assessed by counting number of signs, particularly spraint, left by the animals on water ways. There are a number of factors influencing marking intensity (MACDONALS and MASON, 1983), therefore this measure cannot be used as a direct indicator of population size (MACDONALD and MASON, 1985). Absence of otter signs in a particular place does not necessarily mean the absence of otters in that area. Occasionally, otters may inhabit an area without depositing spraint (MELQUIST and HORNOCKER, 1983; JENKINS and BURROWS, 1980), but this behaviour is very infrequent (CHEHEBAR, 1985).

Spraints are an inherently difficult criterion for determining otter's presence or numbers because, like scent marks, their deposition will be affected by several behavioural and individual variables (KRUUK and CONROY, 1987). Some otter species usually defecate in communal latrines and at one site regularly (HUSSAIN and CHOUDHURY, 1997). It is often difficult to count

the number of spraints deposited in a given period, thus making it difficult to use spraints to assess their number and density. In this study the survey was conducted with an aim to prepare an index of positive sites of otter activity and to identify areas which need special management measures for the conservation of otters. The survey method was designed to check sites randomly along the water ways assuming a general relationship between the level of marking and the success of the population, with fragmented and declining populations leaving fewer signs than healthy breeding ones (MACDONALD and MASON, 1985).

The Katerniaghat Wildlife Sanctuary has the greatest potential for otters among all the areas examined. This PA has been protected since 1975 as a gharial Sanctuary. Since its creation major inputs have been given for the management of gharial, and strict enforcement measures taken and fishing banned. Consequently the otter population in the Sanctuary has benefited from such management measures and continued to breed. However, as evident from this area, any surplus otters migrating out from the source to adjacent sinks did not survive. Outside severe pressure on the tals and in the mainstream of Girwa River was observed. Inside the Sanctuary the otters are competing with about 11 adults gharials and their 23-30 offspring, and with a smaller population of Ganges river dolphin. However, since fishing is banned in the Sanctuary it appears that the availability of prey is not a limiting factor. In Dudhwa, otters were using most of the swamps during monsoon and winter. Natal dens were observed in Kakraha and Bankey Tal areas. Winter being the breeding season the swamps are extensively used as natal dens and nurseries. By February-March the swamps begin to dry and the fish biomass appears to become depleted. As a result, otters move to the perennial rivers situated at the southern boundary. The land use pattern here consists of seasonally cultivated crop fields and the areas are highly disturbed. It is believed that this causes large scale disturbance to otters. Within the Reserve the swamps are unmanaged and there is high density of *Nymphea* spp. spreading in the entire swamps making it unsuitable for otters. The edges are exposed, often with very little vegetation cover due to periodic burning and removal of biomass. Apart from this in some swamps, for example in the Bhadi Tal area, there is severe encroachment by *Sysbenia* spp. Though impact of siltation on swamps in the Dudhwa and adjacent Katerniaghat Sanctuary is not severe, nevertheless the wetlands are slowly becoming shallower due to the accumulation of undecomposed organic materials (peat formation) which in turn reduces the hydroperiod and prey availability. All the swamps in Dudhwa as well as in the Katerniaghat need immediate management attention. In the Corbett, within the core area, otters are extensively using main stream of the Ramganga River. Two natal dens were recorded, one nearer to the Garel rest house area and another close to Dhikala. Of the two natal dens the one close to Dhikala was of logjams partly dugout whereas the site near Garel was a dugout pit on an island. Although this 14 km stretch of the Ramganga is the best available otter habitat within the core zone of the Reserve, the adjacent Kalagarh Reservoir is hardly used by otters. This may be because of a) open shoreline, which hardly provides any cover for otters, b) probably otters are avoiding the lake because of deep water and low prey species richness. From the quantum of spraint, and the different locations of the den sites it is believed that two families of otter with

group size varying from three to five are currently present within this 14 km stretch of the Ramaganga River. In the Alaknanda Valley the otters have probably been extirpated, or because of high degree of human use, be restricted to smaller tributaries. As described originally by Atkinson (1882) they may be small-clawed otter *Aonyx cinerea concolo,r* which in the region can sustain themselves in smaller hill streams as in the case of their cousin *A. cinerea nirnai* of southern Indian hill ranges. Further surveys in this region covering most of the tributaries of Alaknanda and Bhagirathi are necessary.

Conservation implications

MASON and MACDONALD (1986) have identified some important environmental factors that influence the success of otter populations. Adequate, uncontaminated food supply especially of fish, and sufficient shelter in the form of bank-side vegetation, crevices *etc*. providing both resting and breeding sites are basic essentials. Additionally a sympathetic public and enforceable legislation are advantageous. As the survey was extended to PAs and areas lying outside of the PAs, a comparative information on the status of habitats emerged. It was observed that outside of these PAs, there are many wetlands that are suitable otter habitats, but due to intensive fishing pressure they do not provide adequate food supply to sustain any significant otter population. Inside the PAs the prey density appears to be high and could sustain small breeding populations, but the extent of such wetlands are small. Major riverine otter habitats form the boundary of the PAs where disturbance factors limit the occurrence of otters to small isolated groups.

As far as the effective legislation is concerned the Wildlife Protection Act, 1972 lists all otter species as Schedule I. But in the Tarai and hill areas of Kumaun poaching of otters for pelts still exists. Strict enforcement of Wildlife Protection Act is needed. Beside public awareness and education programme emphasizing the importance of otters for wetlands is required.

During the survey many points related to the conservation of otters have emerged. These need to be discussed in length. One of the major points is that the identity of the otter species from the survey areas could not be established. As such otters are difficult to identify in the field, besides there were very few sightings during the survey. Though the footprints along the Ramganga and in Dudhwa indicated that the otters in the Corbett are *Lutra lutra*, whereas in Dudhwa and Katerniaghat they are *L. perspicillata,* this needs to be confirmed. In Dudhwa, the swamps are being used by otter as denning areas, and nursery. These swamps are being filled with vegetative matters, which in turn has altered the hydroperiod and productivity. For proper maintenance of the swamps detailed ecological study on the dynamics of these swamps is urgently required. In both Dudhwa and Corbett Tiger Reserves, rivers have been used as boundary of the park and have not been included within the PAs as an ecological entity. This aspect of park management should be looked into.

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A NOTE ON THE HISTORICAL RECORD OF OTTER DISTRIBUTION IN INDIA, WITH SPECIAL REFERENCE TO LOWER HIMALAYAS AND TARAI

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Abstract: Three species of otters occur in the Indian subcontinent. While conducting recent otter surveys it was realized that lack of consolidated information on historical distribution of otter do not reveal clear picture about the current distribution range and their disappearance from certain localities. While summarizing the historical distribution of Indian otter species from the foot hills of Himalayas of Uttar Pradesh State, this paper concludes that all three species were reported from the region during 1823 and 1887 though the occurrence of various sub species is doubtful.

INTRODUCTION

There are thirteen species of otters distributed all over the world except Australia, Antarctica and some oceanic islands (MASON and MACDONALD, 1986). Otters being the top predators of the wetland ecosystems play a significant role in maintaining the aquatic species community. Since last two decades biologists all over the world are paying special attention to conserve otters as they are increasingly getting rare because of shrinkage of habitat, reduction of prey biomass and poaching. Information on the past distribution of otters from many parts of the world, Asia for instance, is scattered. Consequently, although in recent years the distribution range of many otter species has shrunk drastically, current surveys are unable to reflect this as it is not known which species of otters occurred in the past. This paper gives an account of the historical distribution of otters from India, with special reference to the foot hills of Himalayas.

Historical distribution of otters in India

Five otter species occur in Asia, of which three species occur in the Indian sub-continent *viz*. the Eurasian *otter (Lutra lutra)*, smooth-coated otter (*Lutra perspicillata*) and the Oriental small-clawed *otter (Aonyx cinerea)* (POCOCK, 1941; PRATER, 1974; HUSSAIN and CHOUDHURY, 1997. POCOCK (1941) identified four sub-species of *L. lutra*, two sub-species each of *Lutra (Lutrogale) perspicillata*, and *Aonyx (Amblonyx) cinerea* from the British India (Table 1).

Historically, the smooth-coated otter (*Lutra perspicillata*) (*Lutrogale perspicillata,* Geoffroy or *Lutrogale tarayensis*, Hodgson) was distributed from the Himalayas southward to Karnataka and eastward to Burma (POCOCK, 1941) (Figure 1). As the original specimen described by Hodgson was from the Nepal Tarai and from Himalayas (locality not mentioned) the species was named as *tarayensis.* POCOCK (1939) identified two sub-species, *Lutrogale perspicillata perspicillata* and *L. perspicillata sindica*. The former species is distributed in

Peninsular India, Himalayas, Assam, Burma, Indo-China, Malay Peninsula, Sumatra, and Borneo; whereas the later occurs in the Indus valley in Pakistan at least from Bhawalpur southwards to Sindh. An isolated population was reported from southern Iraq (MASON and MACDONALD, 1986).

Table 1. Summary of the historical distribution of otter from the Indian sub-continent as reported prior to 1941.

Species	Distribution
Lutra lutra	Out of Europe, reported from Northern India from the north of Ganges, northeast, south India from Tamil Nadu and Kerala, extending to Sri Lanka. No reports from Central India. Recent confirmed report from Andhra Pradesh
L. lutra kutub	Kashmir, Himachal Pradesh (Kangra) and Tibet. Locality type Kashmir
L. lutra aurobrunnea	Nepal at high altitude, Garhwal Himalayas at lower altitude. Locality type (aurobrunnea and Nepalensis) Nepal
L. lutra monticola	Himachal Pradesh (Kangra), Kumaun Himalayas, Nepal Sikkim, Assam. Locality type Nepal
L. lutra nair	Southern India, east coast India. Northward range unknown. Locality type (nair) Pondicherry, (indica) Madras and (ceylonica) Nuwara Eliya, Sri Lanka
Lutra perspicillata	Distributed over Pakistan and most of India. Out side India in Burma, Indo-China, Malaya, Indonesia, Sumatra, Java, Borneo
L. perspicillata perspicillata	In India from the Himalayas eastward in Assam (north east India) southward till Tamil Nadu, Karnataka and Kerala. Locality type from Tarai (tarayensis), Nepal, Mount Abu (Rajasthan), Ghazipur near Banaras, Madras Presidency, Ankulum Lagoon, Travancore, and Trivandrum
L. perspicillata sindica	From Himalayas westward to Sindh (Pakistan), wide distribution in Indus valley. Locality type Chak in the Sukkur district
Aonyx cinerea	Southern Peninsular India, Himalayas from Kulu (Himachal Pradesh), Kumaun and Nepal, Sikkim towards east in Assam, Burma, southern China, Malaya, Indonesia and the Sunda Islands to Borneo and Palawan
A. cinerea concolor	Himalayas from Kulu (Himachal Pradesh), Kumaun, Sikkim and Nepal towards east in Assam, Upper Burma. Locality type (cocolor) Garo Hills of Assam, (indigitata)
A. cinerea nirnai	Hill ranges of the south Indian states of Tamil Nadu, Karnataka and Kerala. Locality type Virajpet, south Coorg

Eurasian otter (*Lutra lutra)* was distributed in north of the Ganges river extending throughout Himalayas, in eastern region along the Orissa coast, up to Madras, and then to south India up to Sri Lanka (Figure 1). As far as the sub-species were concerned, POCOCK (1941) refuted the occurrence of *L. lutra nair,* in north India but explained that the otters of the Himalayas could be *L. lutra moniticola*. The two other sub-species found in Himalayas are, *L. lutra kutab* in Kashmir Himalayas and *L. lutra aurobrunnea* from Nepal and Garhwal Himalayas particularly at the lower altitudes. Finally to avoid further confusion in the distribution range of all the sub-species POCOCK (1941) combined all the five Himalayan sub-species *viz. moniticola, aurobrunnea, vulgaris, kutub* and *nair* into three sub-species *L. lutra monticola* distributed in Kangra (Himachal Pradesh), Kumaun, Nepal, Sikkim and Assam, and *L. lutra aurobrunnea* in Nepal

and Garhwal, and *L. lutra kutub* in Kashmir. Nevertheless, authenticity of the occurrence of these sub-species in the Himalayan region is doubtful.
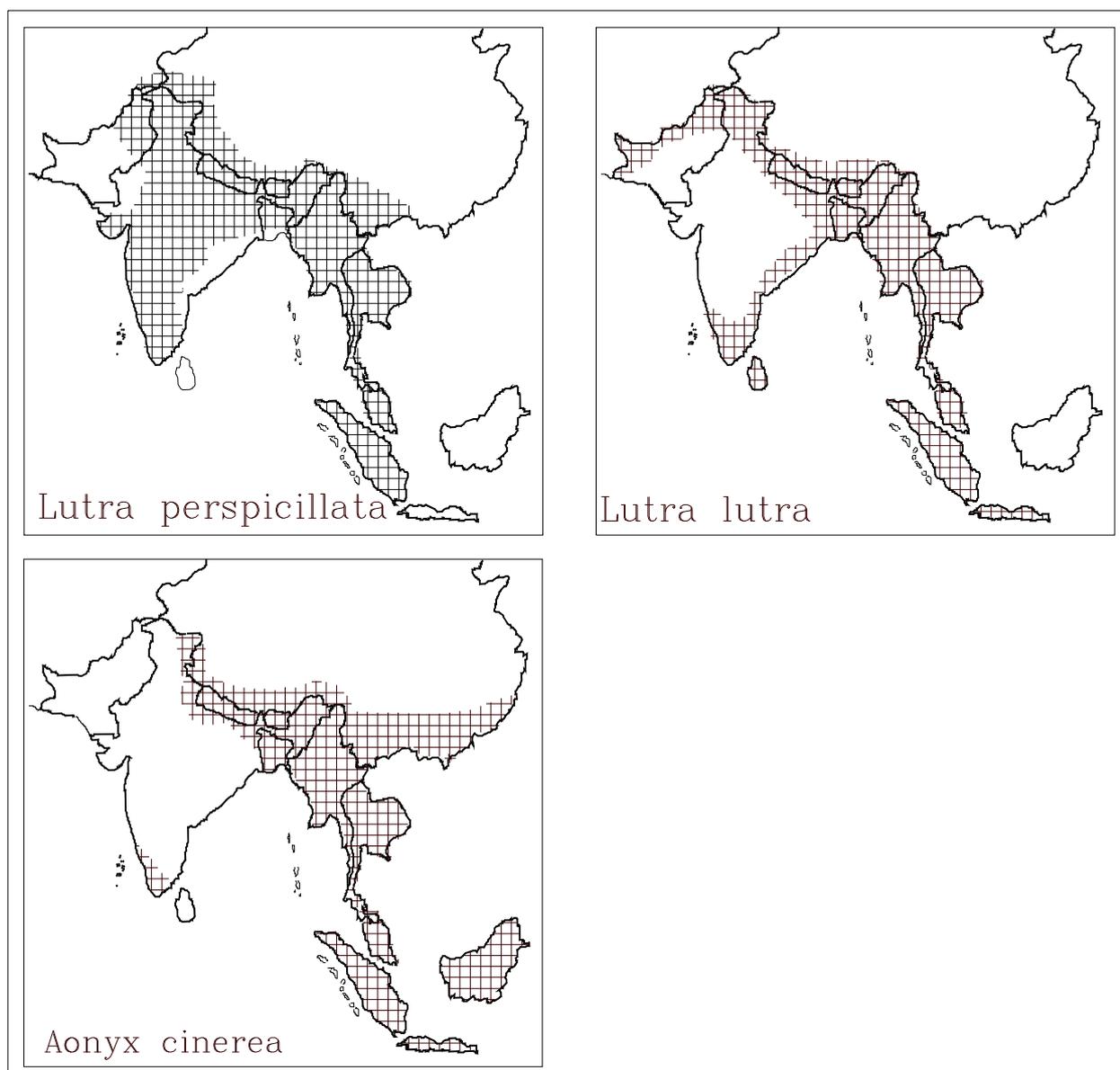

Figure 1: Distribution of otter in India and southeast Asia

The distribution of the Oriental small-clawed otter in the Indian sub-continent (then British India) is discontinuous (Figure 1). BLANFORD (1881) reported that it inhabits the Himalayas at low elevations and is found in lower Bengal, being common near Calcutta, in Assam and in Burma. Since that time and till today it has not been reported from the peninsular India except at considerable elevations on the Nilgiri hills and from some other ranges in the Madras Presidency. Since 1947 the Madras Presidency has been divided, hence due to lack of locality name the occurrence of this species from present day Tamil Nadu is uncertain. POCOCK (1941) confirmed the occurrence of *Amblonyx cinerea concolor* from Himalayas, from Kulu eastward, Assam and upper Burma, and of the other sub-species *A. cinerea nirnai* from the hill ranges of southern India.

Historical account of distribution of otters from Tarai and Lower Himalayas

The Tarai is a belt of approximately 35 km width and 400 km long stretch of land extending from northwest Uttar Pradesh State up to Bihar (Figure 2). This stretch of land is characterised by alluvial deposits with low water table, leading to marshes dominated by tall grassland communities of *Phragmites karka, Arundo* and*, Sclerostachya fusca,* and swamps dominated by *syzygium* species. The earliest authentic report of the occurrence of otters in the Tarai, Garhwal and Kumaun areas (lower Himalayas) has been given by ATKINSON (1882), BLANFORD (1881) and HINTON and FRY (1923). Atkinson described two sub-species of *Lutra*, viz. *L. lutra nair* and *L. lutra vulgaris* (monticola?), and *Aonyx leptonyx* (*cinerea?*) from the region. According to ATKINSON (1882), *L. lutra nair* was found throughout the Tarai and in all the larger streams along the foothills of the Himalayas, ascending the rivers to thirty miles and perhaps more. It usually hunts in groups of five or six, though as many as twelve have been seen together in the Ramganga river in the Patli Dun and twenty in the Suswa in Dehra Dun. He further stated that it is not clear whether *L. lutra vulgaris* occurs in the Kumaun Himalayas. As far as is known, it is restricted to the interior of the Himalayas. *Aonyx leptonyx* a small otter (*Aonyx cinerea*) species of an earthy brown or chestnut-brown above has been procured in the Sarda river at Barmdeo, above the junction of the Alkananda and Pindar rivers near Karnaparayag, in the Nandakini, above Nandprayag and in Bhilang. During 1920 and 1921, HINTON and FRY (1923) conducted a survey of mammals in the Tarai region of Nepal and confirmed the occurrence *of L. perspicillata*. From these description it could be concluded that at least three otter species *Lutra, Lutrogale* (*perspicillata*) and *Aonyx* were occurring in the present survey area in the Alaknanda valley between 1823 and 1887. During a survey conducted during 1995-96 (HUSSAIN, in this issue) occurrence of *L. perspicillata* from the Tarai region was confirmed.

Figure 2. Location of survey area

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DESIGNING A RADIO-TRACKING STUDY FOR OTTER RESEARCH: A FEW CONSIDERATIONS

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Abstract: In recent years, radio-tracking technology and its applications have increased significantly and have been tried in many otter species. The use of radio-tracking in a study depends on the objectives of the study, the type of data to be collected, and the constraints on the investigator regarding funding, equipment limitations, field conditions and the species under study. Thus, the success of a radio-tracking study depends on the careful design of the research project. This paper discusses the possible approaches while designing a research project on otter using radio-tracking. It highlights the pitfalls, and suggests some ways to improve the research methods for generating better quality data.

INTRODUCTION

Ecological information can easily be obtained by trapping, tagging and tracking individual animals closely for a considerable period of time. Radio-telemetry, a technique already tried on many species is an obvious choice (MITCHELL-JONES et al., 1984). Radio-tracking determines the location of animals through the use of a radio receiver and directional antenna that traces the source of signal coming from a radio-transmitter attached to the animal. Radio-tracking offers two main advantages of extreme importance to researchers: (a) it allows precise identification of individual animals, and (b) it allows the researcher to locate each radio-tagged individual as often as desired (MECH, 1983). With these advantages, radio-tracking is particularly useful in collecting information pertaining to the following aspects of free ranging otters.

a)   locations and movement;
b)   home range and habitat use;
c)   behaviour and activity pattern;
d)   social structure.

In general, otters are secretive, thinly distributed and largely nocturnal, and in the wild can be difficult to observe. Hence, radio-tracking is useful in observing free ranging otters, especially in locating their dens, resting and grooming sites. Radio-telemetry technology and its applications have increased significantly over the past two decades and has been successfully tried on several otter species (*e.g.* MELQUIST and HORNOCKER, 1983; REID, 1984; REID et al., 1986; SERFASS et al., 1986; SERFASS, 1994; MITCHELL-JONES et al., 1984; GREEN et al., 1984; WILLIAMS and SINIFF, 1983; HUSSAIN, 1993; ROWE-ROWE et al., 1995). Nevertheless, useful data are not easily obtained by radio-tracking. Successful studies are the result of careful design, realistic assessments of circumstances and capabilities (SARGEANT, 1980) and often the availability of sufficient funds. This paper discusses the approaches for designing a radio-

tracking study, highlights the pitfalls and suggests ways to improve the research methods for generating better quality data on the ecology of free ranging otters.

Despite widespread use of telemetry to study a variety of wild animals under natural conditions, it remains uncertain whether radio tagged animals behave normally. It has been generally assumed that the placement of a transmitter in or on the animal does not cause significant behavioural or physiological change (CORNER and PEARSON, 1972). Several studies (e.g. GARCELON, 1977; MELQUIST and HORNOCKER, 1979a,b, 1983; CLUTE and OZOGA, 1983; GARSHELIS and SINIFF, 1983; GARROT et al., 1985) have demonstrated the effect of radio-tagging on free ranging animals. Most investigators have concluded that although transmitter attachment through collars or otherwise may alter some aspects of an animal's behaviour or physiology, the changes do not significantly affect the integrity of research (WHITE and GARROT, 1990). Some of the effects of tagging using collars that have been identified are:

a)   induced behavioural change;
b)   impaired movement;
c)   reduced food intake;
d)   loss of weight;
e)   neck laceration due to collar;
f)   vulnerability to predators in the case of species which share their habitats with crocodiles.

In recent years, to avoid the effects of neck collars, transmitters (intraperitoneal and sub-cutaneous) have been implanted in many species. In the case of otter, the advantages of such transmitters, compared to the traditional neck collar fitted with a transmitter, are that:

a)   it can be retained for a desirable period;
b)   it is not an obstacle while swimming;
c)   does not catch on a snag while diving or while entering the burrow;
d)   neck collars often cause irritation and change the normal behaviour which is not likely to happen in case of implanted transmitters.

Nevertheless, a major advantage of an external transmitter over a internal one is that it provides a visible marker on the otter. This prevents confusion when the tagged otter is seen in close proximity to another individual (MITCHELL-JONES et al., 1984). Implanted, particularly intraperitoneal transmitters, were successfully used in American river otter (*Lutra canadensis*) (MELQUIST and HORNOCKER, 1979a,b), sea otter (*Enhydra lutris*) (WILLIAMS and SINIFF, 1983; HOOVER, 1984), smooth-coated otter (*L. perspicillata*) (HUSSAIN, 1993; HUSSAIN, 1996; HUSSAIN and CHOUDHURY, 1995), Eurasian otter (*L. lutra*) (RUIZ-OLMO et al., 1995) and spotted-necked otters (*L. maculicollis*) (ROWE-ROWE et al., 1995). MELQUIST and HORNOCKER (1983) observed that, in the case of American river otters, social interaction among conspecifics did not alter or disrupt, since the transmitter could not be visually detected. Similar observations were also made by HUSSAIN (1993). Physiological complications resulting from implanting transmitters were not recorded during many studies (e.g. SERFASS et al., 1986; SERFASS et al., 1993)

nor did they apparently inhibit reproduction (MELQUIST and HORNOCKER, 1983; REID et al., 1986).

PLANNING A RADIO-TRACKING STUDY

Before committing scarce time and funds to the purchase of expensive equipment KENWARD (1987) suggested that it is worth asking the following questions to examine feasibility of taking up a radio-tracking study:

a)   is radio-tracking the best approach?
b)   can I afford it?
c)   do I have time for radio-tagging?
d)   can I catch enough animals?
e)   can they be radio tagged?
f)   can I collect appropriate data?

While planning a radio-tracking study, it is also worth considering the relative advantages and disadvantages of some alternatives to radio-tracking. Animals can be tracked using signs (ERLINGE, 1967) or using visual marker tags, or injected with low activity radionuclides (KRUUK et al., 1979; JENKINS, 1980; MITCHELL-JONES et al., 1984) so that they can be tracked using spraint or scent marking sites as an indicator of their movement, dispersal, and home range. However, the author believes that incorporating radio-tracking in otter research is more advantageous than any other means of tracking, provided that there are no constraint of funds and time. Raising funds, procuring radio-tracking gear and delay in capturing animals can seriously hamper the progress of the project. In addition, perfecting field techniques such as triangulation methods, interpretation of fixes, and understanding behavioural pattern from the radio signals may also take time. It may take several months to discover that it is impossible to collect the initial data, and more time may be spent developing other ways of collecting information. By that time, the sample of tagged animals may have become too small because of death, dispersal and radio failure, with further delays before some additional animals can be trapped and tagged. Trapping sufficient numbers of animals for monitoring that could produce enough data for statistical interpretation is an important factor that affects the success of a radio-tracking study. In the author's study on the ecology of smooth-coated otter it took almost nine months to capture the first otter. Trapping success depends on many factors. It is not just a matter of how the trap works, but of where best to place it, how often to visit it and the density of animals at the trapping site. Trapping non-target animals such as juveniles or too many animals of same sex and age or other species such as beaver (POLECHLA, 1988), ratel, crocodiles and turtles (HUSSAIN, 1993) are major deterrent in otter trapping for ecological study.

Two important constraints to radio-tagging are the signal propagation conditions and the animal's size. The propagation of radio waves through water depends strongly on its conductivity. With water of low conductivity, such as rivers and freshwater lakes with a conductivity less than 0.01S m^{-1}, the surface range of a radio tag may be reduced by 50% at a depth of 10m (KENWARD, 1987). Signal strength is also influenced by the topography and vegetation

structures. The transmitter life, pulse rate and range influence the weight and the volume of the transmitter, which in turn make a transmitter package either suitable or unsuitable for a species. Ideally, for otter transmitter weight should not exceed 3% of the body weight of the animal (MELQUIST and HORNOCKER, 1979a). This puts additional strain on the budget and objective of the study, as smaller transmitter are more expensive and have less transmitting life. For otters, it is wise to use transmitters with an operating life of two years, which could help in generating data that allow comparison between years.

Collection of large amount of data leads to confusion in finding a suitable analytical technique. Effective project planning should consider all stages of the study, through to the data analysis. A key step in the implementation of any radio-tracking study depends on the careful design of the project. This is an extremely important point, which is occasionally overlooked by telemetry users. It is likely that more money and effort have been wasted on ill-conceived radio-tracking studies than on the use of any other field technique (SARGEANT, 1980). To avoid this pitfall when planning a radio-tracking study, WHITE and GARROT (1990) suggested application of five steps of the basic scientific method:

(a) defining scope of the study: some studies may have very specific objectives and, hence, a detailed definition of the problem can be formulated at the outset of the planning process (SARGEANT, 1980). Often, however, the scope of the study is broad leading to a very general definition. In such cases investigators should be sure of their reasons for using telemetry and identify the exact data sought;

(b) review of available information: study of existing information that pertains to the defined problem allows one to become familiar with the current state of knowledge and aids in the formulation of specific hypothesis;

(c) designing research methodology: this is probably the most important step in the planning process as explicitly defining each hypothesis to be tested allows the investigator to design data collection procedures and statistical tests that will optimise one's chance of obtaining conclusive results;

(d) field data collection: once the decision regarding methodology and sample size have been made, data collection can begin;

(e) analysis of the data: this allows the investigator to draw conclusions about accepting or rejecting the hypothesis tested.

Field considerations

Many factors interact to determine the quality and quantity of data obtained from radio-tracking studies (SARGEANT, 1980). Once the objectives, conceptual design, statistical procedures, and sampling scheme have been outlined, a radio-tracking system must be designed that will meet these requirements. At this point in planning, there are a multitude of technical decisions to be made that will directly affect the performance of the system and, hence, the success of the study. At this juncture it is important that the investigator know the functions of the radio-tracking system or seek advise from professionals. This will enable him/her to select appropriate transmitter frequency, optimum pulse width and length, decide transmitter life, weight, volume and shape, and type of receiving systems to be used. The most often used transmitter frequency in Europe and USA is 150-152 MHz. All these depend on the otter species under study, the

topography and heterogeneity of the study area and the kind of habitat in which the animals live. While selecting a transmitter it is important to maintain the balance between transmitter life, signal strength and size of the transmitter.

Home range shape in otters is often determined by drainage pattern (MELQUIST and HORNOCKER, 1983). Otters use a variety of habitats such as streams, large rivers, swamps and marshes, and coastal waters. Accordingly, the home ranges can be either liner or two dimensional, or both. In the smooth-coated otter it was observed that home range is also influenced by den distribution, and availability of foraging sites (HUSSAIN and CHOUDHURY, 1995). This in turn influence movement pattern and habitat use. Thus, each radio-tracking study should be site specific depending on the type of habitats, while the tracking technique such as homing on to the animal or triangulation will vary from site to site. Similarly, the method of calculating home range size, movement pattern and habitat use will be different depending on linear or two-dimensional home range. It is always better to conduct a preliminary study on habitat use pattern prior to the initiation of intensive radio-tracking.

Sampling and statistical considerations

Design of a proper sampling scheme causes the investigator to consider the definition of the statistical population being studied, sample size, and the probability that the experiment will return a successful conclusion (WHITE and GARROT, 1990). The intensive field work required to collect data limits the number of animals that can be tracked and the frequency with which data can be collected. If variability between sex and/or age class can be expected for the parameters to be estimated, and only a limited number of animals can be tracked, the investigator should consider instrumenting only one sex-age class. However, in the case of the otter it is extremely difficult to capture target animals making such definitive conclusions difficult. In such cases it becomes necessary to increase the sample size.

Appropriate statistical procedures should be selected prior to beginning the field portion of a study in order to calculate the sample size needed to gain reasonable statistical power and/or precision. Thus, determining how many data should be collected requires that the statistical test be identified and for different sample sizes, the power of the test be evaluated. Most analytical procedures also require that individual observations be independent, which is a reflection of sampling frequency. At this stage guidance from a bio-statistician may be needed. While monitoring daily movements, activity and habitat use, the investigator must not try to artificially inflate sample sizes by sampling so frequently that independence of the observations becomes questionable. All these factors must be balanced in order to determine a sampling scheme that will satisfy the requirements for a sound study. The requisite steps should be:

a)   decide number of animals to be tagged;
b)   select animals of appropriate age and sex;
c)   select appropriate statistical procedures;
d)   decide tracking intensity.

Initially trial tracking should be made for a couple of weeks and data should be consolidated to check if the tracking intensity needs to be increased or decreased. Also it is better to consolidate the data at regular intervals.

Precautions

It is important to take necessary precautions in every step of project planning, especially during field operations. It is of outmost important that prior to trapping, protocols on anaesthetic and implantation procedure be finalised with the help of an expert veterinarian. The following points should be remembered while planning a radio-tracking study for otter:

a) use smallest possible transmitters to achieve the required aims of the study;
b) select a safe and broad spectrum anaesthetic agent;
c) consult expert veterinarian during anaesthetic and implantation procedure;
d) prior to the field application, test transmitters;
e) avoid tagging operation during reproductive phase, or on lactating females;
f) avoid tagging young animals especially juveniles less then six months old;
g) before collecting data, allow few days for the animals to adapt to the transmitter; or data for the initial period of tracking should be examined carefully to detect any abnormality and if required can be truncated during analysis.
h) avoid frequent/excessive homing on to the animal, respect their privacy.

Risk factors

The process of designing a radio-tracking study is iterative. The objectives suggest the population to be sampled, which suggest the sampling procedures, which in turn suggest the statistical analysis of the data, and all of which are influenced by the field techniques (WHITE and GARROT, 1990). In however meticulous a way a project is designed it is likely that the project may get set backs due to reasons outlined below:

a) not being able to raise adequate funds;
b) not being able to capture sufficient animals;
c) risk of mortality during capture and tagging;
d) loss or malfunctioning of transmitters;
e) premature death of the instrumented animal.

Requirements of additional transmitters or extra receiving sets mid-way through the project may be necessary. Shortage of funds often demoralises the investigator. Ensure sufficient funds prior to the initiation of the project. Similarly, there is always risk of losing animal while trapping, and or after instrumentation, malfunctioning of transmitters such as decrease in range length may seriously hamper the progress of the project. One should mentally be prepared for such set backs and accept it. From the author's experience, he believes that careful planning, ingenuity and strong commitment are the foremost factors governing the success of a radio-tracking study.

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