INDIRECT METHODS OF OF IDENTIFYING MAMMALS: A CASE STUDY FROM SHIVAPURI NATIONAL PARK, NEPAL

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ABSTRACT

The main objective of this study was to explore diversity of mammalian species in Shivapuri National Park (ShNP) through indirect method. Specific objectives were (i) to identify and describe characteristic features of different signs as key to species identification, and (ii) to determine occurrence and abundance of mammalian species based on the signs. Survey was conducted by walking through fixed 11 transect lines of total 229 km long, collecting and recording of footprints, feces, scrapes, scratches, shelters or burrows, calls and quills of mammals. Altogether 344 indirect signs were collected and observed through fixed transect lines and 25 signs through random searching of mammals from Kakani, Panimuhan, Shivapuri Peak, Baghdwar, Sundarijal, Chisapani and Manichur in ShNP. Basic characteristics of identified signs of different mammals as key to their identification have been described. The occurrence of species was confirmed through indirect signs and abundance was estimated on the basis of encounter rate (number/km/day) and relative frequency percentage of the signs. Among 20 species, 18 species belonging to six orders and 14 families were recorded confirming by different indirect validation techniques. The study also identified large civet, a new record for ShNP. The highest percentage relative frequency (35%) and encounter rate (0.53 /km) of signs of wild boar and house rat implied these species were the most abundant mammals in the park. This was followed by barking deer (17% and 0.26), common leopard (17% and 0.25), jungle cat (9.6% and 0.14), Himalayan squirrel and rhesus monkey, which were intermediate in abundance. Himalayan goral (6.7% and 0.10), Indian hare (4.3% and 0.06), yellow throated marten (4% and 0.06), golden jackal (3.5% and 0.05), large civet (2.6% and 0.04), black bear (0.3% and 0.004), Chinese pangolin, hanuman langur, royel's pika, porcupine and small mongoose were the least abundant species.

Key words: Mammals, identification, footprints, scrapes, feces, shelters.

INTRODUCTION

Information on biodiversity including wildlife status, population and community interactions and their contribution to ecosystem development is essential for effective conservation of wildlife and management of protected areas (Basnet 1998). Such information is developed by regular monitoring and maintaining records collected from various scientific methods. Both direct and indirect methods are used in identification of wildlife species. Although direct observation is the most acceptable method in identifying mammalian species, in some cases, non-invasive sampling and indirect methods are efficient way of obtaining wildlife samples. Sriyanto *et al.* (1997) studied status of Javan rhinoceros (*Rhinocerus sondiacus*)

from track counts. Dawson (1990) calculated elephant density from the density of their dung along a transect-line. Thomson (1952) and Weaver (1779) showed that the wolf (*Canis lupus*) and cayotes (*Canis latrans*) could be identified by the measurement of their scat's diameter. Many biologists (Sunquist 1981, Tamang 1982, McDougal 1997) used pugmark method to estimate tiger population because it is reliable, easier, cheaper and more precise. Similarly, Fox and Chundawat (1995) evaluated the abundance of snow leopard using their sign in the upper Indus valley.

In Shivapuri National Park (ShNP), disturbance rate and fragmentation of habitat by road construction and human settlements are increasing and threatening wildlife species. However, neither this problem has been evaluated nor the status of mammalian diversity (occurrence and abundance) has been updated regularly. Therefore, the main objective of this study was to explore occurrence and abundance of mammalian species in ShNP through indirect method. Specific objectives were to (i) identify and describe characteristic features of different signs as key to their identification, and (ii) identify and determine occurrence and abundance of mammalian species based on the signs.

STUDY AREA

The research was conducted in ShNP, which is the only protected area lying entirely within Nepal's midhills ecosystem. It is located on the northern fringe of Kathmandu valley and lies about 12 km away from the capital city between $27^0 45'$ – $27^0 52'$ latitude / $85^0 15'$ – $85^0 30'$ longitude (Fig. 1). The park gazetted as the country's ninth national park in 2002, covers an area of 144 km^2. The highest point is the Shivapuri peak, which is 2,732 m above mean sea level, and represents the second

highest peak around Kathmandu valley. The lowest parts are at altitudes of approximately 1360m above mean sea level. Wild boar (*Sus scrofa*), barking deer (*Muntiacus muntjak*), Himalayan goral (*Nemorhaedus goral*), common leopard (*Panthera pardus*), jungle cat (*Felis chaus*), golden jackal (*Canis aureus*), yellow-throated marten (*Martes flavigula*) and rhesus monkey (*Macaca mulatta*) are some of the common mammalian species of the park. Four forest types of the park include lower mixed hardwood forest, Chir-pine forest, upper mixed hardwood forest, Oak-Rhododendron forest (Amatya 1993). There are about 9,432 households with a total population of 48,991 (49.7% male and 50.3% female) in and around the park (CBS 2001). Buffer zone of the park has mixed ethnic zone. Tamang accounts for 74% followed by Chhetri/ Brahmin (15%) and Gurung/ Magar/ Newar (11%) in the sample. Literacy rate is estimated to be 49.3 % (Khatri-Chhetri 1993).

METHODS

Occurrence of mammals

1. **Line transect**

A survey was conducted by walking through 11 fixed transects of total 229 km long and recording and collecting evidence of mammals during July 2003 to July 2004. In order to study mammalian diversity, the entire habitat was divided into four blocks on the basis of natural barriers and man made demarcation such as deep gullies, rivers and foot trails. Each block was surveyed by walking through transect lines of variable length, depending on the availability of tracks (Fig. 1). Besides fixed transects survey, a random search was also adopted to record the occurrence of mammalian species in the park.
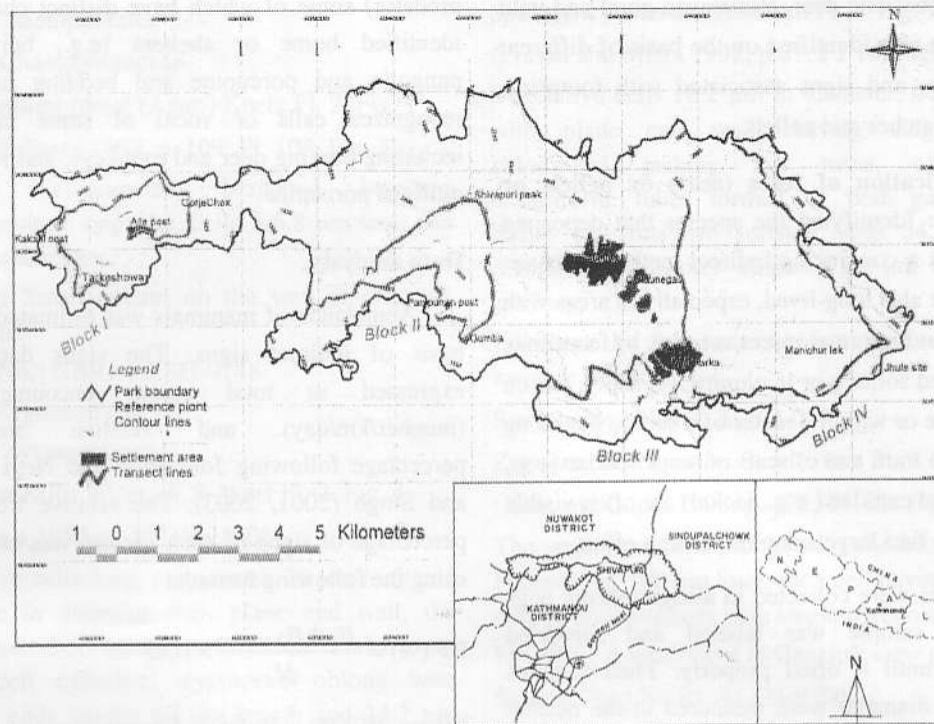
Fig. 1. Study area showing transects (survey route)

2. Indirect methods

Following indirect methods were adopted:

i) Identification of footprint (pugmarks or tracks): Footprints of different species of mammals are different with distinct characters in their shape, size and presence or absence of claws. The exact structure of footprint was obtained by using tracing and casting methods, and photography (WWF 1998). For tracing of common leopard and Himalayan squirrel, an A4 size colorless glass plate was placed over the tract and the outline of the track was traced with a free flowing permanent marker pen. For casting of common leopard, a packet of Plaster of Paris was mixed with water until the mixture was thick but pourable. Then, it was poured into the footprint and allowed it to settle for about 30-40 min. Casting was removed from soil surface with a

sharp knife. When photographing a footprint, a pen or scale was placed on the bottom and sides of each footprint to scale the size. After measuring an exact structure of the footprint, its complete identification was done by using references (Gurung and Singh 1996, WWF 1998, Singh 1999 and WWF 2001). The measurement of leopard's pugmark is one of the most important tools used to study variation in individuals. Total length (TL), total width (TW), and pad width (PW) of leopard's pugmark were measured. Sex (male or female), age group (cub, sub adult, and adult) on the basis of distinct difference in the relative length of TL, TW and PW were identified. In some cases, field circumstances (e.g. clear occurrence of large and small leopard tracks at the same time at a location indicates a female with cubs) allowed for a confident interpretation and were also included in the reference data set. The tracks or footprints of

ungulates (barking deer, Himalayan goral and wild boar) were also identified on the basis of different shape, size, and signs associated with footprints such as scratches and pellets.

ii) Identification of feces (scats or pellets or dropping): Identifying the species that deposited the feces is a convincing indirect method because: a) feces are also long-lived, especially in areas with little rain and minimal insect activity, b) feces may be deposited solitary or in clumps, typically, left on a shape pile or within a meter of a scrape but along or next to a trail, and c) scats of some felidae (e.g., leopard) and canidae (e.g., jackal) are often visible and easy to find large samples per unit effort.

Samples were collected in airtight plastic bags and each sample was labeled and sun-dried separately until it dried properly. Then samples length and diameter were measured to the nearest centimeter with calipers and it was weighed using a digital weight. The collected feces were distinguished by different size, shape, odor, color and the signs associated with feces, such as scrapes and footprints. The collected feces were also tallied with feces of mammals of the Central Zoo for further confirmation of identified feces and identification of unidentified feces.

iii) Identification of scrapes and scratches: Scraping is the most common marking activity and among long-lived signs, especially if it is made in undisturbed area. Scrapes are made when an animals scuffs the ground with its hind feet, leaving a characteristics shape. Identification of the scrapes of leopard followed WWF (2001). Length and width of the scrapes were measured by a measuring tape. Wild boar's scratches or signs (plough) were like ploughing.

iv) Other methods: We used other methods such as mammalian feeding signs (e.g., carcass left by predator) some of which have distinct characters, identified home or shelters (e.g., burrow of pangolin and porcupine and bedding of hare), recognized calls or vocal of some mammals including barking deer and monkeys, and recorded quills of porcupine.

Data analysis

Abundance of mammals was estimated on the basis of indirect signs. The signs data were expressed as total count, encounter rate (number/km/day) and relative frequency percentage following Johnsingh and Negi (2003) and Singh (2001, 2003). The relative frequency percentage of signs of each species was estimated using the following formula:

$$RF\ (\%) = \frac{n_1 + n_2 \text{.......}}{N} \times 100$$

Where, RF (%) = Relative frequency percentage

n = Total number of signs of each mammalian of each transect

N = Grand total number of signs of each mammals of total transects

Quantitative and qualitative analyses were used to examine variation within shape and size of different signs of mammals.

RESULTS AND DISCUSSION

Characteristic features of mammalian signs

Altogether 344 signs (scratches: 121, scats: 102, pellets: 55, tracks: 42, scrapes: 16, and pugmarks: 8) of ten mammals in 11 fixed transects of total 229 km long and 25 signs (burrow: 17, drooping: 3, quills: 3, shelter: 1, and pellet: 1) of six mammals were observed and collected during random searching in ShNP (Tables 1-18). Each type of the signs of individual species has been described with photograph as an identification key (Figs. 2-23).

Table 1. Characteristic signs of Leopard (*Panthera pardus*)

Scat	Pugmark	Scrape

• Shape: Cylinder, more or less blunt at tip, 3 to 9 small round shape dropping.
 • Color: Blackish in fresh, whitish after sundry.
 • Size
   • Mean lenth = 9.25 cm, SD = 2.6, range = 5.5 to 11.7 cm
   • Mean diameter = 2.85 cm, SD = 0.5 cm, range = 1.9 to 3.4 cm
   • Mean sundry wt. = 89.25 g, SD = 53.18, range = 24.3 to 168.4 g
 • Remark: Scat contains more hair of large prey species such as wild boar and barking deer. Some scats of leopard contain hoof of wild boar, barking deer and dog bone.
	Male
	 • Mean total length (TL) = 9.50 cm, SD = 0.5, range = 9 to 9.5 cm
	 • Mean total width (TW) = 8 cm, SD = 0, range = 0
	 • Mean total pad width (PW) = 5.83 cm, SD = 0.28, range = 5.5 to 6 cm
	 Female
	 • Mean total length (TL) = 8.05, SD = 0.07, range = 8 to 8.1 cm
	 • Mean total width (TW) = 7.15 cm, SD = 0.21, range = 7 to 7.3 cm
	 • Mean total pad width (PW) = 5 cm, SD = 0, range = 0
	 • Remark: All the mean measurement of male pugmark; TL, TW and PW are more than that of female. The mean total length of pugmark of a female is more or less equal to total width of a male pugmark.
		• Shape: The scrape was longer, narrower, linear in shape and shallow depression.
		 • Mean length = 29.16 cm, SD = 2.78, range 25 to 33 cm
		 • Mean width= 19.66 cm, SD=0.81, range= 18 to 20 cm
		 • Remarks: The scrapes of common leopard were observed along the trails. Sometimes the clumps of scrapes were found in linear. Scats were also found at the sites of scrapes.

Table 2. Measurement of Pugmark (back) of common leopard in ShNP.

Sex	Total length (TL) (cm)	Total Width (TW) (cm)	Pad Width (PW) (cm)
Sub adult	8.1	6.2	4.9
Female	8	7	5
Female	8.1	7.3	5
Cub	3.9	4	2.5
Cub	2.7	2.7	2
Male	8.5	8	5.5
Male	9	8	6
Male	9.5	8	6

Table 3. Characteristic signs of Wild boar (*Sus scrofa*)

Footprint/Track	Scratches
• Length = 12 cm • Width = 6 cm • Depth = Varies by soil type • Remark: Track of wild boar's were observed along the trail, inside forest and cropland.	• Maximum damage upto five meters long. • Scrathes were like ploughing the ground • Depth varied from surfacial to 60 cm deep.

Table 4. Characteristic signs of Barking deer (*Muntiacus muntjak*)

Pellet	Footprint/track	Call/vocal

• Shape: Slender in shape but sometime pointed at one end.
 • Colour: Black
 • Size
  • Mean length = 1.25 cm, SD =0, range=0
  • Mean diameter = 0.375 cm, SD=0, range=0
	• Fore foot length = 3 cm, width = 2.9 cm
	 • Hind foot length = 3 cm, Width = 2.2 cm
		• Male barked like dog when disturbed.
		 • While barking, they ran away and the call disappeared.

Table 5. Characteristic signs of Himalayan Goral (*Nemarhaedus goral*)

Pellet

- Shape: Slender in shape, more or less blunt at the end and somewhat larger than that of barking deer
- Colour: Grey with blackish in colour
- Size:
  - Mean length = 1.3, SD = 0, range =0
  - Mean diameter = 0.6, SD =0, range=0
  - Remark: Pallets contain more fine grinding of digested grass

Table 6. Characteristic signs of Jungle Cat (*Felis chaus*)

Scat

- Shape: Elongated, three or four constriction and more or less blunt at the end.
- Colour: Black
- Size:
  - Mean length = 8.07 cm, SD = 1.38, range = 6.2 to 9.5 cm
  - Mean diameter = 1.65 cm, SD = 0.12, range = 1.5 to 1.8 cm
  - Mean sun dry wt. = 20.17 g, SD = 4.62, range = 14.3 to 25.3 g

Table 7. Characteristic signs of Large Civet (*Viverra Zibetha*)

Scat

- Shape: Elongated, three or four constriction but short tapering at the end.
- Color: Black
- Size
  - Mean length = 10.07 cm, SD = 0.78, range = 9.2 to 11.1 cm
  - Mean diameter = 1.5 cm, SD = 0.37, range = 1 to 1.9 cm
  - Mean Sun dry wt. = 15.17 g, SD = 7.29, range = 10.3 to 26 g
- Remark: Fresh and old scat were found frequently at the same place.

Table 8. Characteristic signs of Golden Jackal (*Canis aureus*)

Scat	Call/Vocal

• Shape: Elongated, three or four constriction and long tapering at one end.
 • Colour: Black
 • Size:
  • Mean length = 9.12 cm, SD = 1.75, range = 6.5 to 10 cm
  • Mean diameter = 1.47 cm, SD = 0.12, range = 1.3 to 1.6 cm
  • Mean sun dry wt. = 12.2 g, SD = 4.2, range = 5 to 16.1 g
	• Howling (long loud cry) at dusk

Table 9. Characteristic signs of Himalayan Black Bear (*Selenarctos thibetanus*)

Scat

- Shape: Slender, blunt at both end
- Colour: Black
- Size:
  - Length = 12 cm, SD=0, range=0
  - diameter = 3.4 cm, SD=0, range=0
  - Sun dry wt. = 80 g
- Remarks: Scat contents were seed of fruit.

Table 10. Characteristic signs of Yellow throated Marten (*Martes flavigula*)

Scat

- Shape: Elongated, short tapering at one end.
- Colour: Black
- Size:
  - Mean length = 8.8 cm, SD = 0.69, range = 8 to 9.2 cm
  - Mean diameter = 1.13 cm, SD = 0.32, range = 1 to 1.5 cm
  - Mean sun dry wt. = 5.97 g, SD = 3.15, range = 2 to 8.3 g
- Remark: Scat Contents were more of insects and their part (eg., Wasp)

Table 11. Characteristic signs of Indian Hare (*Lepus nigricollis*)

Pellet

- Shape: Somewhat round
- Colour: grey
- Size:
  - Length = 1 cm
  - diameter = 1 cm
- Remarks: Pellets contents were more fibre

Table 12. Characteristic signs of Royal's pika (*Ochotona royeli*)

Pellet	Shelter

- Shape: Small and round
- Colour: black and soft
- Size:
  - Length = 0.5 cm
  - Diameter = 0.4 cm
	- Under rocks in open area
	- Examination of habitat in the crevices of rocks revealed interspaces, subterranean runways, and burrowed piles of stones.

Table 13. Characteristic signs of Chinese pangolin (*Manis pentadactyla*)

Burrow

- Diameter = 20 to 32 cm
- Depth (old burrow) = 0.52 to 1.5 m
- Depth (fresh burrow) = 2 m
- Habitat: Open forest comprises *schima-castonopsis* forest, *Alnus nepalensis*, *Quercus* sp. and *Lyonia* sp. with red soil type.

Table 14. Characteristic signs of Hanuman langur (*Presbytis entellus*)

Dropping

- Shape = more or less slender
- Colour: Black
- Size
  - Length: 4 cm
  - Diameter =3 cm
- Remark: Dropping contents were more fine grinding parts of insect, grass and leaves. No deep odor or odorless.

Table 15. Characteristic signs of Rhesus monkey (*Macaca mulatta*)

Call and crop damage signs

- Aggressive calls
- Crop damage (e.g., maize) signs chaos

Table 16. Characteristic signs of Himalayan squirrel (*Dremomys lokriah*)

Foot print

- Shape: More or less square, toe pads were more elongated and elliptical in shape
- Size:
  - Total Length (TL) = 4.6 cm
  - Total Width (TW) = 4.4 cm
  - Total Pad width (PW) = 2.7 cm

Table 17. Characteristic signs of Common porcupine (*Hystrix indica*)

Burrow	Quills
- Maximum Width = 45 cm - Depth = 1 m - Remarks: The main entrance was slightly arched, 30 cm in height. Their burrows were observed in the lower elevation of *Schima-Castanopsis* forest near agriculture land.	- Shape: Elongated and slender, sharp printed at the tip - Colour: White at base and tip. Only one small portion is black toward tip - Size - Total maximum length = 16.5 cm - Total maximum circumference = 2 cm

Table 18. Characteristic signs of Field rat (*Mus Cervicolor*)

Tunnel or burrow	
- Small to medium in size - Usually a pile of mud seen in front of the tunnel	Scattered in agriculture fields and forests in contract to house rats (*Rattus rattus*) m/near houses

Fig. 2. Scat of common leopard with dog's teeth.

Fig. 3. Scat of common leopard with hoof of barking deer

Fig. 4. Pugmark of common leopard
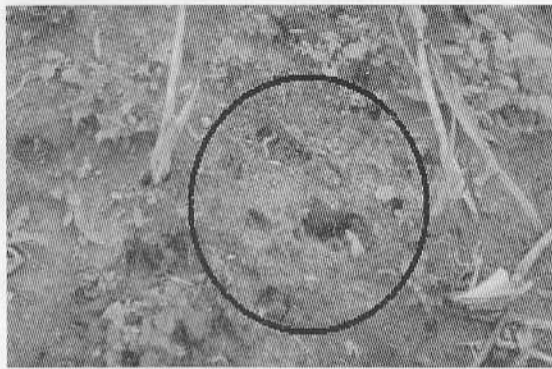

Fig. 5. Scrape of common leopard

Fig. 6. Track of wild boar

Fig. 7. Scratches of wild boar

Fig. 8. Pellet of barking deer

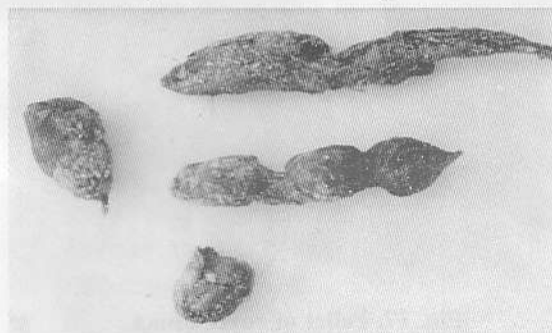Fig. 9. Pellet of Himalayan goral
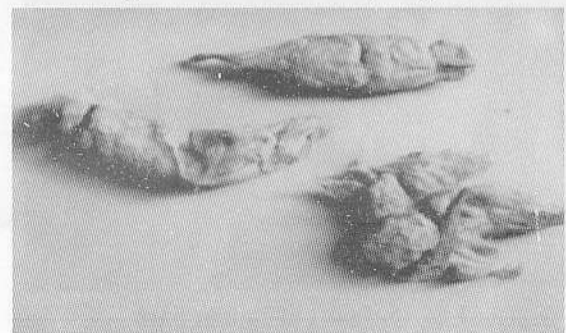

Fig. 10. Scat of jungle cat.
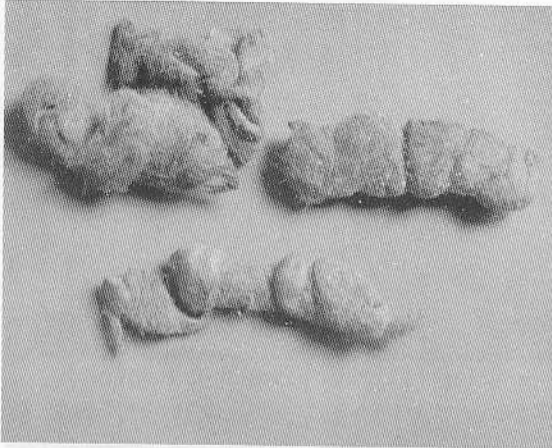

Fig. 11. Scat of large civet

Fig. 12. Scat of large civet

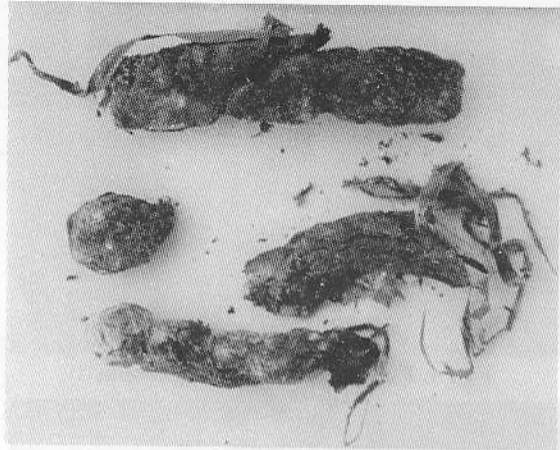Fig. 13. Scat of golden jackal

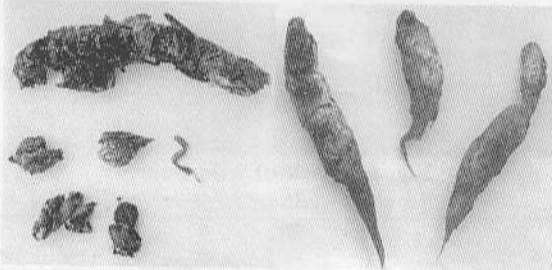Fig. 14. Scat of Himalayan black bear
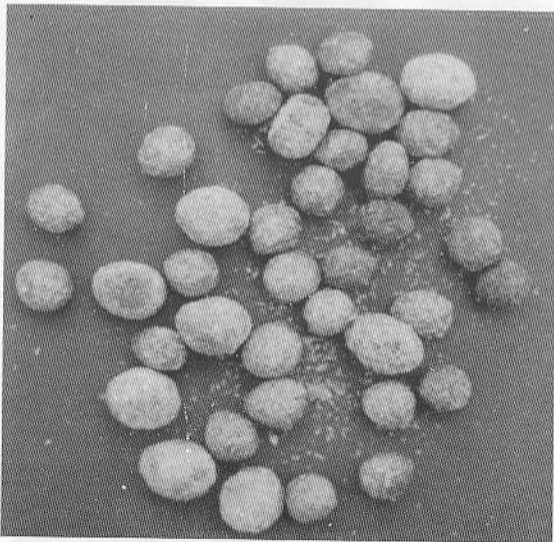

Fig. 15. Scat of yellow throated marten

Fig. 16. Pellet of Indian hare

Fig. 17. Pellet of royel's pika

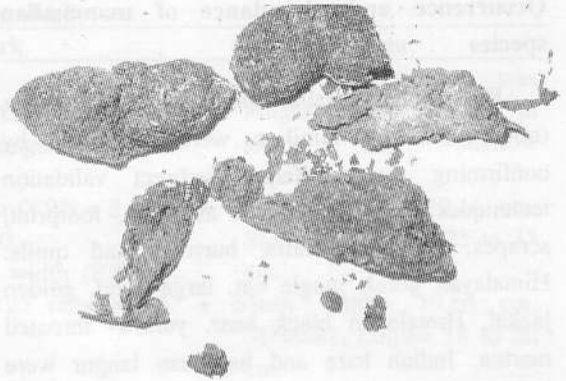Fig. 18. Burrow of Chinese pangolin

Fig. 19. Dropping of hanuman langur

Fig. 20. Crop damage by rhesus monkey

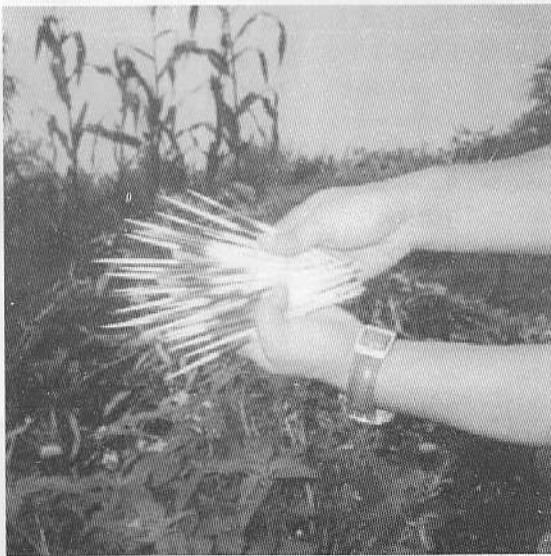Fig. 21. Footprint of Himalayan squirrel

Fig. 22. Quills of porcupine

Fig. 23. Burrow of field rat

Occurrence and abundance of mammalian species

Eighteen mammalian species belonging to six orders and 14 families were identified by confirming their different indirect validation techniques (Table 19) such as feces, footprint, scrapes, scratches, calls, burrows and quills. Himalayan goral, jungle cat, large civet, golden jackal, Himalayan black bear, yellow- throated marten, Indian hare and hanuman langur were identified by feces; common leopard by feces, footprints and scrapes; barking deer by feces, footprints and calls; Chinese pangolin, field rat and house rat by burrow; royel's pika by burrows and feces; wild boar by scratches and footprints; Himalayan squirrel by footprint; Indian porcupine by burrows and quills, and rhesus monkey by calls.

Large civet, a new record for ShNP, was confirmed during the present study (Table 19). Nine scats of this species were located (date: July 2003) at various altitudes ranging from 1740m to 2350m in Kakani, Panimuhan, Chharchhare Khola, on the way to Chagau, Nagigumba, and Manichur-Jhule. On August 29, 2003, 134 cm long (with tail) a dead body of this species was found during regular patrolling near Nagigumba, and it was sent to Natural History Museum of Tribhuvan University on September 2, 2003 for preservation (Fig. 3). Patrolling staff of ShNP also sighted the animal at the lower forest below Nagigumba on September 31, 2004. These indirect and direct evidences confirmed the presence of large civet in ShNP and added one more species to the existing list of mammalian species of the park.

Table 19. Mammalian diversity and indirect validation techniques in ShNP.

SN	Common/scientific name	Order	Family	Validation method	Remarks
1.	Wild boar (*Sus scrofa* Linneaus)	Artidactyla	Suidae	Sh, Ft	+
2.	Barking deer (*Muntiacus muntjak* Zimmermann)	Artidactyla	Cervidae	Fe, Ft, V, C	+
3.	Himalayan goral (*Nemorhaedus goral* Hardwicke)	Artidactyla	Bovidae	Fe	+
4.	Common leopard (*Panthera pardus* Linnaeus)	Carnivore	Felidae	Fe, Ft, Sc	+
5.	Jungle cat (*Felis chaus* Guildenstaedt)	Carnivore	Felidae	Fe, V	+
6.	Large civet (*Viverra zibetha* Linnaeus)	Carnivore	Felidae	Fe	New record
7.	Golden jackal (*Canis aureus* Linnaeus)	Carnivore	Canidae	Fe, V	+
8.	Himalayan black bear (*Ursus ursinus* G. Cuvier)	Carnivore	Ursidae	Fe	+
9.	Yellow-throated marten (*Martes flavigula* Boddaert)	Carnivore	Mustelidae	Fe, V	+
10.	Royel's pika or Himalayan mouse pika (*Ochotona royeli* Ogilby)	Lagomorpha	Ochotonidae	Fe, Br	+
11.	Indian hare (*Lepus nigricollis* F.Cuvier)	Lagomorpha	Leporidae	Fe, Br	+
12.	Chinese pangolin (*Manis pentadactyla* Linnaeus)	Pholidata	Manidae	Br	+
13.	Rhesus monkey (*Macaca mulatta* Zimmermann)	Primates	Cercopithecidae	C, V	+
14.	Hanuman langur (*Presbytis entellus* Dufresne)	Primates	Cercopithecidae	Fe, V	+
15.	Himalayan squirrel (*Dremomys lokriah* Hodgson)	Rodentia	Sciuridae	Ft, V	+
16.	Common porcupine (*Hystrix indica* Kerr)	Rodentia	Hystricidae	Br, Q	+
17.	Fawn colored mouse (*Mus cervicolor* Hodgson)	Rodentia	Muridae	Br, V	+
18.	House rat (*Rattus rattus* Hodgson)	Rodentia	Muridae	Br, V	+

Note: + denotes presence of species by previous literature (Kattel 1993, BPP 1995, Shrestha 1997 and Mujupuria 1998), Fe = Feces (Scat/Pellet/Dropping), Ft = Footprint (Pugmark/track), Sc = Scrapes, Sh = Scratches, C = Call or Vocal, Br = Burrow, Q = Quill, V = Visual observation.

Table 20. Counts, encounter rates (no./km/day) and relative frequency (RF %) of ten different mammal's signs in 11 transects line of the Shivapuri National Park (July 2003 to July 2004).

Transect	Km walked	No. of days	Common leopard	Jungle cat	Large civet	Jackal	Black bear	Yellow throated marten	Barking deer	Wild boar	Himalayan goral	Indian hare
I	7	5	16 (0.45, 20.5)	6 (0.17, 10.4)	00	2 (0.06, 11.3)	00	4 (0.12, 16.2)	19 (0.54, 20.3)	26 (0.74, 12.8)	00	00
II	7	4	20 (0.71, 32.4)	4 (0.14, 8.6)	2 (0.07, 11.11)	2 (0.07, 13.2)	00	1 (0.03, 4.0)	4 (0.14, 5.2)	5 (0.18, 3.1)	00	10 (0.35, 73)
III	5	2	00	00	0 0	1 (0.1, 19)	00	1 (0.1, 13.5)		0	00	00
IV	5	2	3 (0.3, 13.6)	5 (0.5, 30.6)	3 (0.3, 47.6)	0 (0,0)	00	1 (0.1, 13.5)	5 (0.5, 18.8)	3 (0.3, 5.2)	00	00
V	5	3	00	1 (0.07, 4.3)	2 (0.14, 22.2)	0 (0,0)	00	0		3 (0.2, 3.4)	00	00
VI	4	4	3 (0.2, 9.1)	1 (0.06, 3.7)	0 (0,0)	1 (0.06, 11.3)	1 (0.06, 100)	2 (0.12, 16.2)	14 (0.87, 32.7)	41 (2.56, 44.3)	23 (1.5, 100)	000
VII	5	4	00	4 (0.2, 12.3)	1 (0.05, 8)	2 (0.1, 19)	00	2 (0.1, 13.5)	0	10 (0.5, 8.6)	00	00
VIII	7	3	0 0	1 (0.05, 3.0)	0 (0,0)	0 (0,0)	00	2 (0.10, 13.5)	3 (0.142, 5.3)	16 (0.76, 13.1)	00	00
IX	7	3	3 (0.14, 6.3)	1 (0.05, 3.0)	0 (0,0)	0 (0,0)	00	2 (0.1, 3.8)	2 (0.1, 3.8)	3 (0.14, 2.4)	00	00
X	13	3	10 (0.25, 11.4)	7 (0.18, 11)	0 (0,0)	3 (0.07, 13.2)	00	00	10 (0.25, 9.4)	10 (0.25, 4.3)	00	5 (0.13, 27)
XI	7	2	2 (0.14, 6.3)	3 (0.21, 13)	1 (0.07, 11.1)	1 (0.07, 13.2)	00	1 (0.07, 9.4)	2 (0.14, 5.2)	4 (0.29, 5.0)	00	15 (0.48, 100)
	72	35	57 (2.19, 100)	33 (1.63, 100)	9 (0.63, 100)	12 (0.53, 100)	1 (0.06, 100)	14 (0.74, 100)	59 (2.66, 100)	121 (5.92, 100)	23 (1.5, 100)	15 (0.48, 100)
Average			0.25, 17%	0.14, 9.6%	0.04, 2.6%	0.05, 3.5%	0.004, 0.3%	0.06, 4%	0.26, 17%	0.53, 35%	0.1, 6.7%	0.06, 4.3%

Table 21. Status of Mammalian species in ShNP, 2004.

SN	Scientific Name	IUCN	CITES	HMG	Local
1	Barking deer	-	-	-	Intermediate
2	Brown-toothed shrew	-	-	-	NE
3	Chinese pangolin	LR/nt	II	Protected	Least abundant
4	Clouded leopard	Vu	I	Protected	Not confirmed
5	Common leopard	LR/lc	I	-	Intermediate
6	Fawn colored mouse	-	-	-	needs further confirmation
7	Golden jackal	-	III	-	Least abundant
8	Hanuman langur	LR/nt	I	-	Least abundant
9	Himalayan black bear	Vu	I	-	Least abundant
10	Himalayan goral	LR/nt	I	-	Least abundant
11	Himalayan squirrel	-	-	-	Intermediate
12	House rat	-	-	-	Most abundant
13	Indian hare	-	-	-	Least abundant
14	Jungle cat	LR/lc	II	-	Intermediate
15	Large civet	-	III	-	Least abundant
16	Leopard cat	LR/lc	I	Protected	Not confirmed
17	Porcupine	-	-	-	Least abundant
18	Rhesus monkey	-	II	-	Intermediate
19	Royel's pika	-	-	-	Least abundant
20	Small Indian Mongoose	-	-	-	Least abundant
21	Wild boar	-	-	-	Most abundant
22	Yellow throated marten	-	III	-	Least abundant

Note: LR/lc = Lower Risk/ least concern, LR/nt = Lower Risk/ near threatened, Vu = Vulnerable, Local status, Least abundant (low in number), Intermediate (Medium in number), Most abundant (High in number), NE (Not estimated)

Other mammals

Besides these eighteen mammals (Table 19), other two species and brown-toothed shrew (*Soriculus caudutus* Horsfield) and small Indian mongoose (*Herpestes auropunctaus* Hodgson) were recorded through direct observation and two species were reported during questionnaire survey such as leopard cat (*Felis bengalensis* Kerr) and clouded leopard (*Pardofelis* nebulosa Kerr). But we could not confirm these species either by observation or indirect signs. This study has confirmed 20 species of mammals in ShNP (including six species listed in IUCN threatened species category, ten species in CITES and one species in HMG list of protected mammals (Table 21).

The average signs encounter rate (number per km) of all the mammals was 1.5. The highest relative frequency (35%) and encounter rate (0.53 /km) of signs of wild boar implied this species was the most abundant mammal in ShNP. This was followed by barking deer (17% and 0.26), common leopard (17% and 0.25), and Jungle cat (9.6% and 0.14), which were intermediate in abundance. Himalayan goral (6.7% and 0.10), Indian hare (4.3% and 0.06), yellow throated marten (4% and 0.06), golden jackal (3.5% and 0.05), large civet (2.6% and 0.04), and black bear (0.3% and 0.004) were the least abundant species (Tables 20 and 21). House rat (most abundant) and Fawn colored mice were seen plenty in agriculture and open areas inside the park. Himalayan squirrel and rhesus monkey were intermediately abundance. Fifteen burrows of Chinese pangolin were observed in Sundarijal area, three fecal dropping of hanuman langur in the Shivapuri Peak and Baghdwar, two burrows of porcupine in Kakani, and one burrow of royel's pika in the Shivapuri Peak. Direct observation and questionnaire survey showed that brown toothed shrew, clouded leopard, leopard cat, and small Indian mongoose also occurred in small numbers in ShNP.

CONCLUSION

Indirect method of identifying mammals is a conventional method for studying mammalian diversity. Different kinds of signs of mammals were identified and described with photographs in ShNP. These signs included feces, footprints, scrapes, scratches, calls, burrows and quills. Among 20 species, 18 mammalian species belonging to six orders and 14 families were identified confirming by seven different indirect methods (Table 19). Two species (clouded leopard and leopard cat) were reported to have been inhabiting the study area. This study also confirmed the occurrence of large civet, a new record for ShNP (Tables 7 and 19; Figs. 11 and

12). The highest relative frequency (35%) and encounter rate (0.53 per kilometer) of sign of wild boar and house rat implied that these species were the most abundant mammals in ShNP. Barking deer, common leopard, Jungle cat Himalayan squirrel, and rhesus monkey were intermediate in abundance. Himalayan goral, Indian hare, yellow throated marten, golden jackal, large civet, black bear, Chinese pangolin, hanuman langur, royel's pika, porcupine, and small mongoose were the least abundant species in the park.

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