## **Report on**

## Estimation of population trend of Lesser Cats by Camera Trap method in Buxa Tiger Reserve, West Bengal (2015)



**Implemented by:** 



NATURE ENVIRONMENT & WILDLIFE SOCIETY (NEWS)

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#### **EXECUTIVE SUMMARY:**

The lesser cats were neither very charismatic nor posed any large threat to man and therefore, they never attracted any conservation attention in the last few decades. Over the past decade the lesser cat population has gone through a severe decline mostly because of the destruction and conversion of their prime habitats in Indian sub-continent. In a previous pilot study we have already assessed the presence and distribution of the lesser cats in Buxa Tiger Reserve (BTR). In this follow up study, an effective trapping area (ETA) of around 150 km<sup>2</sup> designed in two sampling blocks covering four ranges such as Jayanti, Gadadhar, Rajabhatkhawa (RVK) and Buxaduar of BTR were sampled with camera traps to estimate the populations of lesser cats. The total efforts of the camera-trap samplings collectively in two sampling blocks were of 4860 trap nights. Overall, 39 pictures of leopard cat were captured during the sampling session of 81 days. Thereafter, population status of the leopard cat was estimated using detection and non-detection data from repeated surveys through camera trapping following occupancy based Royle-Nichols model of individual heterogeneity in single season. Naive occupancy for leopard cat was estimated as 26.67% in the entire study area while after correcting for imperfect detection, the probability of site occurrence  $(\Psi)$  for leopard cat in the ETA was found to be 0.36±0.10. The estimated population of leopard cat was found to be 27.11±8.94 for the entire study area of BTR while the density of leopard cat was calculated as 18.27±6.02 individuals/100 km<sup>2</sup>. Conditions of habitats and other requisite resources in Jayanti and Gadadhar ranges were found more suitable for leopard cats than in RVK and Buxaduar ranges in BTR. Use of camera traps with white flash encased within fabricated wooden pole (SPG Pole) for the protection from elephant and gaur should be preferred in future camera trap studies. As management intervention strategies to protect the lesser cat population, efficient law-enforcement monitoring and maintaining the habitat heterogeneity of northern tropical forests with regulations in grazing, illicit felling and unsustainable tourism, alongwith added surveillance and vigilance especially where the border is porous, will probably result in long-term survival of these small carnivores.

#### **INTRODUCTION:**

In the lineage of feline evolution, genus *Panthera* is considered the oldest while the genus *Felis* is more recent. Phylogenetic studies have brought members of the subfamily *Pantherinae*, such as *Panthera*, *Uncia* and *Neofelis* together into one lineage (Eisenberg, 1986). The family *Felidae* is classified into two sub-families i.e. *Pantherinae* and *Felinae*, 14 genera and 40 species worldwide. Fifteen among these including five species of large and ten lesser wild felids are distributed in the Indian subcontinent. In a forest ecosystem, felids are generally the top predators in almost every food chain influencing the structure and dynamics of the subsequent descending trophic levels (Eisenberg, 1986).

During the last 50 years, the continual increase in human population and spread of settlements with the incessant exploitation of natural resources, along with illicit poaching are threatening an array of wild plant and animal species with tortuous fate of extinction. Felids or wild cats are among other carnivore species that are observed worldwide with severe population decline. Conservation initiatives were performed in every part of the world to ensure sustainable future of these threatened species. For effective species conservation and management, understanding of population ecology parameters of that species is most essential, especially if the species represents an important member of the lesser carnivore guild and regulates the population of small mammalian and avian populations. Till date only a few studies on the ecology (Distribution and abundance) and ethology of the small wild cats were carried out in India. Yet, apart from the four big cats the small ones do not feature in any major research or conservation planning. The ecological role of the lesser wild cats in the eastern Himalayan habitats is not well known and gathering such information on elusive species in remote and intricate Himalayan habitats has always been challenging since conventional sampling protocols have been proven inadequate in such areas (Sathyakumar et al. 2011).

Over the last two decades, the use of various noninvasive techniques for the sampling of animal populations has increased significantly. Technological advances have allowed practitioners to sample and monitor animal populations without invasive methods. Reducing of time, effort and expenses in the collection of scientific data with more efficiency have increased interest towards noninvasive sampling methodologies. Noninvasive sampling methods are particularly well suited to animals that are elusive, often occur at low densities, and are difficult to capture or detect.

The leopard cat (*Prionailurus bengalensis*) is one of the widely distributed lesser wild cats inhabiting an array of habitats throughout Asia (Green 1991, Nowell & Jackson 1996, Sunquist&Sunquist 2002; Bashir et al. 2013). In contrary to the other lesser wild cats of Asia whose ecology were not much investigated, different aspects of the ecology of leopard cat especially with respect to the feeding habits, activity patterns, movements and ranging behavior have been extensively studied (Inoue 1972, Rabinowitz 1990, Izawa et al. 1991, Grassman 2000, Rajaratnam 2000, Austin 2002, Khan 2004, Grassman et al. 2005, Rajaratnam et al. 2007, Watanabe 2009, Bashir et al. 2013). But, till date there is dearth of standardized technique for estimating site-specific abundance and density of leopard cat and hence reliable estimates are available only from Eastern Himalayan region (Bashir et al. 2013) among all the habitats. Census protocols for such elusive and cryptic lesser wild cat must therefore be accurate, reliable, cost-effective and reasonably easy to apply (Jackson et al. 2006). Estimates based on track observations are failure prone and unreliable while radio-telemetry is costly and constrained to a small number of individuals within a population (Karanth 1995, 1999).

Camera trapping in combination with both non-spatial capture-recapture (CR) statistical modeling (Otis et al. 1978, Karanth and Nichols 1998) and spatially explicit capture-recapture (SECR) (Efford 2004, Royle and Young 2008) have been successfully adopted to reliably estimate densities for nocturnal, elusive felids with distinct identifiable coat patterns, such as tigers *Panthera tigris* (Karanth 1995,Karanth&Nichols 1998), leopards *Panthera pardus* (Harihar et al. 2009), jaguars *Panthera onca* (Kelly 2003, Silver et al. 2004, Sollmann et al. 2011), ocelots *Leopardus pardalis* (Trolle&Kery 2003), Geoffrey's cats *Leopardus geoffroyi* (Cue' ller et al. 2006), snow leopards *Uncia uncia* (Jackson et al. 2006) and Eurasian lynx *Lynx lynx* (Blanc et al. 2012, Weingarth et al. 2012). Cheyne and Mcdonald (2011) also followed the natural variation in fur markings for identifying leopard cat individuals, but could not estimate their density due to limited sample size.

SECR density estimation techniques have emerged as a robust tool to deal with low sample size. These models first assess an individual's activity centre by using the spatial location of captures and then estimate the density of these activity centers across a precisely defined polygon containing the trap array (Gardner et al. 2009, Royle et al. 2009b), thereby avoiding the issue of estimating the effective area sampled (Sollmann et al. 2011).

The present study was actually a follow up of the pilot phase study (Dey et al, 2014) in Buxa Tiger Reserve (BTR). Therefore, this was conceptualized to assess abundance of different available lesser wild cats by using camera trapping technique and accordingly develop their conservation strategies in BTR, West Bengal. Populations of the lesser wild cats are threatened throughout their distribution range worldwide by habitat loss, poaching for wildlife trade and conflict related to human activities such as vehicular accidents. The population status of the four sympatric lesser wild cats in BTR were unknown and therefore, robust scientific investigation of their population trend with efficient conservation management are essential for these species before the situation turns beyond recovery. This present study is aimed to support the in-situ conservation of all the lesser wild cats in the study area.

#### **PROJECT OBJECTIVES:**

The present study was performed to achieve the following objectives -

- To assess abundance of four sympatric lesser wild cats in BTR,
- To identify spatial distribution of the four sympatric lesser wild cats in BTR through camera trap and

• To propose area specific conservation measures for management of BTR.

#### **STUDY AREA:**

The Eastern Himalayas Region contains 17 Tiger Conservation Unit (TCU) landscapes that have been identified to conserve metapopulations of tigers. Four of these including Buxa Tiger Reserve (BTR) are Level 1 TCUs or high priority tiger conservation landscapes (Wikramanayake *et al.* 1998), situated in India.

#### Location-

Buxa Tiger Reserve (BTR) is situated in newly formed Alipurduar district, West Bengal. It comprises of the entire erstwhile Buxa Forest Division (702.44 km<sup>2</sup>), and a part of Cooch Behar Forest Division 58.43 km<sup>2</sup> which was added subsequently to this Reserve. The Reserve lies between latitudes  $26^{\circ}30'$  and  $26^{\circ}55'$  N and longitudes  $89^{\circ}20'$  and  $89^{\circ}55'$  E (Source: Tiger Conservation Plan, BTR by West Bengal Forest Department).

#### History of foundation-

The Forest Department in the year 1866 undertook the forests of Buxa Tiger Reserve and prior to that these used to be an unoccupied wasteland. Those forests came under British rule in 1865 and the first reservations were made in 1879 according to the Indian Forest Act (Act VIII of 1878) and the process continued till 1940. Thus most of the forest areas of the Tiger Reserve enjoy the status of Reserved Forests under the provision of the Indian Forest Act (IFA), 1927 upto 1982. BTR was constituted in the Year 1983 in Jalpaiguri

District vide Govt. of India's notification No. J-11025/18/B/FRY (PT) dated, 16th February, 1983 and became the 15th Tiger Reserve of the Country. Buxa Tiger Reserve was formed over an area of 758.78 Sq. Km of Reserved forests vide Govt. of India's notification No.J-11025/18/B/FRY (PT) dated16-02-1983. District Magistrate, Jalpaiguri transferred 209.84 Ha resumed tea garden forest lands vide memo no. 346(10)/LR-C dated15.05.89 for inclusion in BTR. Thus, the total area of BTR is 760.87 km<sup>2</sup>. An area of 314.52 km<sup>2</sup> was declared as Buxa Wildlife Sanctuary vide Notification No.316-For/11B-1/86 dated 24-01-1986 under section 18 of Indian Wildlife Protection Act, 1972.

In the year 1990, an additional area of 54.47 km<sup>2</sup> was added to the Sanctuary vide Notification No.7588-For/11B-24/90 dated 06-10-90 and 12-For/11B-24/90 dated 01-01-91 under section 18(1) of Wildlife Protection Act, 1972 making the Sanctuary area of total 386.07 Sq. Km. In 1992 an area of 117.10 km<sup>2</sup> of the Sanctuary was preliminarily notified as National Park under section 35(2) of Indian Wildlife Protection Act, 1972 vide notification no.85-For/11B-42/91 dated 06-01-92 (Annexure 4) and finally constituted as Buxa National Park vide Notification No.3403-For/11B-6/95 dated 05-12-1997, under section 35(4) of the said Act. The total area of the Reserve is 760.87 km<sup>2</sup> of which the core

area 390.58 km<sup>2</sup> has been constituted as Wildlife Sanctuary (273.35 km<sup>2</sup>) and National Park (117.23 km<sup>2</sup>) and the rest of 370.29 km<sup>2</sup> area as Reserved Forests and Other Protected Forests (Source: Tiger Conservation Plan, BTR by West Bengal Forest Department).

#### Geomorphology-

The BTR lies at the foot hills of Himalayan Ranges. It consists of the Himalayan formation of Darjeeling gneiss at an altitude of 1800 m. The Great boundary fault (Gondwanas) lies just on south of it, followed by timulences of Shiwalik hills. Then follows the highly drained Bhabar tract and finally, south of 22<sup>nd</sup> mile, is the ill drained clayey Terai tract. The Reserve is mainly situated in Bhabar and Terai areas consisting of slightly undulating land with a general inclination from North to South. It extends in some places into the outer range of Himalayas and reaches an elevation of 1800 mt. The hilly tracts (Adma, Chunabhati, Tobgaon, Santrabari, Phaskhawa, Tashigaon and Hatipota blocks) are steep and precipitous. The forests of this Reserve are intersected by numerous rivers originating both from hills and plains with a general flow from North to South. The principal rivers that flow through this Reserve are Sankosh, Rydak, Jayanti, Bala, Dima and Gaburbasra. The rivers become full and fierce with torrents in the rains but are shallow and tame in the dry season (Source: Tiger Conservation Plan, BTR by West Bengal Forest Department).

#### Meteorology-

The area lies in the moist tropical zone. The average day temperature varies from  $12^{\circ}$ C to  $21^{\circ}$ C from November to February, between  $27^{\circ}$ C to  $32^{\circ}$ C from May to September, between  $24^{\circ}$ C to  $27^{\circ}$ C for the rest of the months. The highest recorded temperature was  $39^{\circ}$ C in 1899 and lowest was  $2^{\circ}$ C in 1887 (Ref: 5th Working Plan of Buxa Division). There is an appreciable variation in day and night temperature throughout the year. Sometimes winter nights are too severe. From July to September, the days and early evenings are moist and hot and indeed oppressive; however, nights are always cooler. South – West monsoon is the main source of rainfall. The Reserve receives maximum rainfall from mid June to September. The average annual rainfall in the Reserve is about 4100 mm, increasing a little towards North. Along the foot hills the rainfall varies according to the configuration of the hills; on the outer ranges of the hills it reaches around 5000 mm per year. The average

annual rainfall at Rajabhatkhawa (Altitude < 100 m) is 3750 mm while that in Buxaduar (altitude 780 m) is 5600 mm. The rainfall is very high during the month of June, July and August. It subsides from the early September and disappears during the first week of October. December is the driest month with minimum rainfall. March receives maximum of winter rain. Pre-monsoon showers accompanied by hail and thunder storm occur in the month of April to May. As the Reserve is located in the foothills of the outer Himalayas, it remains adequately humid throughout the year. Maximum relative humidity varies between 80% - 95% with maximum humidity during June to September and seldom below 75% with minimum in December to February. From November to February the nights are very cold with much frost and dew and in low lying areas a dense fog lingers often even beyond 9.00 a.m. From March to the onset of monsoon fog and frost are absent but dew is deposited until April (Source: Tiger Conservation Plan, BTR by West Bengal Forest Department).

#### Flora-

The Reserve lies in the Bio-geographic Zones of Central Himalayas (2C) and lower Gangetic Plains (7B) (Rodgers and Panwar, 1988). The lower-gangetic plain in North West Bengal, that separates the peninsula from Himalayas through a belt of Shiwalik in between, is referred as sub-montane Terai or Duars (Mani, 1974). The Buxa Tiger Reserve is a Forest of multi-tier vegetation assemblage. According to Champion and Seth (1968) classification, the Reserve sustains eight distinct vegetation types such as -

- i. Northern dry deciduous Sal, Khair, Sissoo, Simul Association (5B/IS<sub>2</sub>),
- ii. Eastern Bhabar and Terai Sal (3C/CIB and 3C/CIC),
- iii. East Himalayan Moist Mixed deciduous forest (3C/C<sub>3b</sub>),
- iv. Sub-Himalayan Secondary Wet Mixed forest (2B/2S<sub>3</sub>),
- v. Eastern Sub-montane semi-evergreen forest (2B/CIb),
- vi. Northern Tropical Evergreen forests (1B/C<sub>1a</sub>),
- vii. East Himalayan Subtropical Wet Hill forest (8B/CI) and
- viii. Moist Sal Savannah (3C/DSI) and Low alluvium Savannah woodland (3C/3/1S1).

The principal constituents of the forested areas in flat to undulated terrains are Sal (*Shorea robusta*) in an admixture of various deciduous species such as Bahera (*Terminallia belerica*), Khair (*Acacia catechu*) and Sissoo (*Dalbergia sissoo*), Simul (*Bombax ceiba*), Sidha (*Lagerstroemia parviflora*), Tantari (*Dillenia pentagyna*), Odal (*Sterculia villosa*), Kumbhi (*Careya arborea*), Chilaune (*Schima wallichii*) etc. The evergreen and semievergreen vegetations in the higher altitudes include Horse-chestnut (*Aesculus punduana*), Amboke (*Eugenia formosa*), Chalta (*Dillenia indica*), Katus (*Castanopsis sp.*), Bhalukat (*Talauma hodgsoni*), Lator (*Artocarpus chaplasha*), Gokuldhup (*Canarium sikkimense*), Lali (*Amoora wallichii*) and Malagiri (*Cinnamomum cecidodaphne*), Chilaune (*Schima wallichii*) in association with Tanki (*Bauhinia purpurea*), Toon (*Toona ciliata*), Lampate (*Duabanga grandiflora*), Maina (*Tetrameles nudiflora*), Champ (*Michelia champaca*), Chikrasi (*Chukrasia tabularis*),Gokul (*Ailanthus grandis*) etc(Source: Tiger Conservation Plan, BTR by West Bengal Forest Department).

#### Fauna-

BTR harbours a wide range of animal diversity. In total, 68 species of mammals, 41 species of reptiles and more than 246 species of birds, 4 species of Amphibian along with 33 species of fishes. Among these, there are 20 species of mammals which are endangered and are included in schedule I of Wildlife (Protection) Act 1972. Seven species of birds and 10 species of reptiles of BTR are also included within the endangered category.

The major carnivores of BTR are Royal Bengal tiger (*Panthera tigris tigris*), leopard (*Panthera pardus*), clouded leopard (*Neofelis nebulosa*), hog badger (*Arctonyx collaris*), jungle cat (*Felis chaus*), leopard cat (*Prionailurus bengalensis*), sloth bear (*Melursus ursinus*), fishing cat (*Prionailurus viverina*), small Indian civet (*Viverricula indica*), hyena (*Hyaena hyaena*), jackal (*Canis aureus*), mongoose (*Herpestes edwardsi*), Indian fox (*Vulpes bengalensis*), wild dog (*Cuon alpinus*) etc. Marbled Cat (*Pardofelis marmorata*) and golden Cat (*Catopuma temmincki*) were reported earlier but in recent years they are not sighted. Among the herbivores, the pre-dominants are elephant (*Elephus maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), chital (*Axis axis*), barking deer (*Muntiacus muntjak*), hog deer (*Axis porcinus*), wild pig (*Sus scrofa cristatus*), hispid hare

(*Caprolagushispidus*), etc. Wild Buffalo (*Bubalus bubalis*) was historically reported from BTR. The great Indian one horned rhino (*Rhinocerous unicornis*) was reported in South Bholka and Panbari blocks of Buxa Tiger Reserve upto 1968. Many other important fauna such as porcupines (*Hystrix indica*), rhesus macaque (*Macaca mulatta*), squirrels, common pangolin (*Manis crassicaudata*) and Chinese pangolin (*Manis pentadactyla*) are also frequently sighted in these forests.

The forests of BTR are also rich in avifauna and the important ones are hill maina (*Gracula religiosa*), crested serpent eagle (*Spilornis chieela*), the common red jungle fowl (*Gallus gallus murghi*), the flame backed woodpecker (*Chrysocolaptus lucidus*), nightjar (*Caprimulgus macrurus*), black francolin (*Francolinus francolinus*), green pigeons (*Treon sps*), hornbills (*Tockus sps*.) and various kinds of waterfowl. Peafowls (*Pavo cristatus*) are also seen quite frequently. Around the water pools, water birds such as darter (*Anhinga melanogaster*), grey heron (*Ardea cinerea*), little egret (*Egretta garzetta*), paddy bird (*Ardeola gravil*), Cattle egret (*Buceros bicornis*) can be sighted. The rare Bengal florican (*Eupodotis bengalensis*) was reported from the tiger Reserve though no recent sightings have been documented.

Among reptiles, tortoise, lizards, various kinds of Snakes such as king cobra (*Ophiuphagus hannah*), Russel's viper (*Vipera russeli*), black crait (*Bungarus niger*), Indian python (*Python molurus*), reticulated Python (*Python reticulatus*), Chinese pangolin (*Manis pentadactyl*) are found in this region. Gharial (*Gavialis gangeticus*) and mugger (*Crocodilus palustris*) are reported in 6<sup>th</sup> Working Plan of Buxa Division (1965-66 to 1974-75), but these have not been sighted recently.Numerous rivers and streams in the forests of this Reserve contain a variety of fish of which Mahseer is the biggest and most sought after in Rydak River near Bhutanghat. Fishes of several species like boal (*Wallago attu*), kalbaus (*Labeo calbasu*), mrigel (*Cirrhinus cirrhosus*), chital (*Notopterus chitala*), sole (*Channa striatus*) are found. There are innumerable small fishes in the rivers and streams. Most common are chela (*Chela bacaila*), hum, puti (*Puntius ticto*), boroli (*Barilius barila*), etc.

Studies on entomo-fauna by Prof. D. Roychoudhury and others of Calcutta University listed 500 species of insects belonging to 13 orders, 65 families and 229 genera. Buxa Tiger Reserve is extremely rich in terms of invertebrate such as insects, Spiders and butterflies, etc (Source: Tiger Conservation Plan, BTR by West Bengal Forest Department).

#### **METHODOLOGY:**

#### **Reconnaissance surveys-**

The whole surface of the sampling area (entire Buxa Tiger Reserve) was divided into 2 km x 2 km (4 sq. km) grids. Within each grid, sign occupancy surveys were carried out in 2-3 trails of 3-5 km length to generate baseline information on presence and distribution of lesser cats. Direct and indirect evidences of lesser cats such as pug marks, fecal samples, scrape and rake marks were recorded. These information were used to identify the most adequate site for intensive camera trapping.



Figure 1: Map of the study area "Buxa Tiger Reserve" (2015)

#### Camera trapping-

Estimating the population size of wild lesser cats in the Buxa Tiger Reserve (BTR) was carried out by grid based systematic sampling approach. 37 pairs of infra-red camera traps with both motion and thermal sensors were planned to be installed at the end of December 2014 and the sampling was proposed to be continued till May 2015. Accordingly the camera trapping session was started during the first week of January 2015. But due to various anthropogenic disturbances and adverse incidences in the forest such as theft, permanent damage of the cameras and setting the cameras in fire, the sampling had to be called off by the first week of April 2015.

Considering the large area of BTR the cameras were deployed in block shift method. Each trapping block will cover 148 Km<sup>2</sup> of geographical area. Present study was proposed to cover four to five adjacent blocks for camera trap sampling. Trapping session was carried out for short period (here in 77 days) to assure minimum or no significant changes in the population size to be sampled and hence maintain both geographical and demographic closure (Karanth1995). Cameras were deployed along natural trails and junctions where signs were abundant, indicated by sign survey. Camera traps were placed at 15-25cm above ground, attached to a rock or tree trunk at 3-5m distance from the centre of a trail or point where animal movements were expected. Cameras were set with one minute delay between successive activations and they were kept operational for 24hour-monitoring during the entire sampling session of 77 days. The functionality of the cameras were checked at every four to five days' intervals.

#### Photo-capture rate-

Photo-capture rate as an index of relative abundance was calculated for the entire trapping session and for each species. The photo-capture rate was calculated as the number of photographs divided by the number of effective trapping days per site (Carbone et al, 2001) and represented as relative abundance index (RAI) per 100 trap days (O'Brien et al, 2003).

Identification of lesser cats from spot patterns-

The dataset of captured photographs were separated species wise. Then the similar protocol of individual identification of the lesser wild cats as described by Kelly et al, 2008 and Bashir et al., 2013 was followed. Spot patterns of each lesser cat photographed from flanks, face, tail and limbs were considered to identify the individual as the technique was previously used for tiger, leopard, clouded leopard, hyena, leopard cat etc.

#### **Population Estimation-**

Generally after the individual identification, unique identification numbers used to be assigned to individual wild lesser cats (Otis et al. 1978) for each species. But due to the contemptible photo qualities of the infra-red camera traps, out of 39 photos of leopard cats only nine photos (four of left flanks and five of right flanks) were only individually identifiable for estimation of population size using closed capture models using different methods. Therefore instead of using population estimation technique based on Capture-Recapture based statistics, we had to move to occupancy based approach of population estimation.

Recent advancements in occupancy based techniques allowed to estimate population status using detection and non-detection data from repeated survey through camera trapping. We considered the home range of leopard cat as a unit area for estimating its abundance. Based on available literature, the reported average home range of the species  $(3 - 14 \text{ km}^2;$  Grassman et al, 2005, Rajaratnam et al, 2007) was taken in to consideration for the analysis of abundance of leopard cat in BTR using Royle and Nichols Model. The probable home range of leopard cat using its body size, with the formula -

 $[A = 15.14 * M^{1.26}]$  were also estimated (Swihart et al, 1988) where A = home range area in hectare and M = body weight of target species (carnivore); for leopard cat it ranges from 0.55 kg to 3.8 kg. In this way, the estimated home range of leopard cat varied from 0.72 to 8.15 km<sup>2</sup> which was well comparable to the home ranges of the species from available literature (Grassman et al, 2005, Rajaratnam et al, 2007). Accordingly, grid-cell of 2 x 2 km2 was selected as a single unit area for abundance estimation of leopard cat. Accordingly, total 37 grids were delineated in the intensive study area. Capture history matrix for a species was constructed from its detection at all sites across the sampling occasion (Royle and Nichols, 2003). We defined one sampling occasion to be comprised of 36 trap nights/block for two blocks of study for 77 days. If the species was detected at least once at a site over the entire sampling duration, it was recorded its capture history as '1', or '0' otherwise for non-detection.

The Royle and Nichols Induced Heterogeneity model (Royle and Nichols, 2003) assumes that heterogeneity in detection probability among sites primarily results from variation in animal abundance. This relationship can be explained using likelihood techniques to estimate abundance from repeated detection/non detection data at sites, by assuming abundance to be a random variable with Poisson or Negative Binomial probability distribution. The Royle and Nichols model (Royle and Nichols, 2003) relates detection probability and abundance using following formula:

 $\mathbf{pi} = \mathbf{1} \cdot (\mathbf{1} \cdot \mathbf{r})^{Ni}$ ; Where pi is the species specific detection probability at site I; r is the animal specific detection probability at site and Ni is the actual animal abundance at site i. To characterize the underlying estimation of abundances, the Poisson model can be a good starting point as it arises under a random distribution of animals in space (Royle and Dorazio, 2006.). Using this model for abundance estimation, the final likelihood equation to estimate parameters (mean abundance at site and animal specific detection probability) is as follows:

$$L(w \mid r, \lambda) = \prod_{1}^{R} \sum_{k=0}^{\infty} r C_{w_{i}} [1 - (1 - r)^{k}]^{w_{i}} [(1 - r)^{k}]^{T - w_{i}} \frac{\lambda^{k} e^{-\lambda}}{k!}$$

where, *R* is the number of sites; *T* is the number of repeated samples; *w* is the detection vector of the total number of detections from each site *i*, i.e. a vector of all the individual site-specific detections, *wi* and  $\lambda$  is the expected abundance at each site, also the Poisson mean. Parameters were estimated using camera trap capture matrices, in program PRESENCE version 2.0 (McKenzie et al, 2002).

#### **RESULTS:**

In the present study, four ranges of Buxa Tiger Reserve (BTR) such as Jayanti, Gadadhar, Rajabhatkhawa (RVK) and Buxaduar were sampled to estimate the populations of lesser cats. The effective trapping area (ETA) was estimated as 148.41 km<sup>2</sup> (Figure 2). Camera

trapping sessions were carried out in two blocks such as first block covering the Jayanti and Gadadhar ranges (First Block ETA  $-62.92 \text{ km}^2$ ) whereas the second block has covered Rajabhatkhawa and Buxaduarranges (Second Block ETA  $-69.44 \text{ km}^2$ ) (Figure 2). In the present study we have used thirty pairs of cameras with both white flash and infra-red flash, seven pairs were kept in the reserve.

Deploying of camera traps was initiated from 9th January 2015 onwards and the session in the first block continued till 20<sup>th</sup> February, 2015. Thereafter, camera trapping were continued in the second block from 26<sup>th</sup>February till 6<sup>th</sup> April, 2015 at RVK & Buxaduar Ranges. Each pair of Cameras were checked and re-checked with an interval of three days to observe the presence of Lesser Cats and other wildlife. The GPS locations, altitudinal variations and vegetation type of each spots of the deployed cameras were noted simultaneously. QGIS 2.6.1 Brighton software (www.qgis.org/en) was used to plot the camera trap locations and preparing the polygon for ETA. Simultaneously three buffer layers with buffer of 500m, 1000m and 2000m were also prepared with estimated areas of 177.68 km<sup>2</sup>, 208.37 km<sup>2</sup> and 274.02 km<sup>2</sup> respectively (Figure 2). At Jayanti and Gadadhar Ranges, the camera trapping were continued for 42 days whereas at RVK and Buxaduar Ranges, the camera traps had to be withdrawn after 39 days as 11 units of camera traps were stolen and permanently damaged in the forest by unknown miscreants.

In our previous pilot study (Dey et al, 2013) five species of family Felidae such as leopard, leopard cat, fishing cat, marbled cat and jungle cat were photo-captured whereas during the present study, photographs of leopard, clouded leopard and leopard cat were captured. Therefore, we have dedicated our efforts to the estimation of leopard cat population in the present study. In the present study, population status of the leopard cat was estimated using detection and non-detection data from repeated survey through camera trapping following occupancy based Royle-Nichols model of individual heterogeneity in single season.



Figure 2: Camera trap sampling design for population estimation of leopard cat in Buxa Tiger Reserve (BTR) 2015

#### Photo capture rate-

The total efforts of the camera-trap samplings were of 4860 trap nights where efforts of 2520 trap nights were provided in the first block and 2340 trap nights were completed in the second block (Table 1). Altogether, 39 pictures of leopard cat were captured from BTR (31 photos from the first block of Jayanti and Gadadhar ranges and 8 photos from the second block of RVK and Buxaduar ranges). Due to lack of clarity in the photographs captured by cameras with infra-red flash, individual identification could be possible for only nine photographs out of 39 pictures captured. Among these nine photos, five photographs were of right flank and rest four was of left flank. Therefore, capture-recapture statistics applied to individually identifiable species could not be utilized in this situation. The photo-capture rate of the leopard cat per 100 trap nights for the entire study area was 0.8 whereas for the first block it was estimated at 1.23 and for the second block it was 0.34 respectively (Table 1).

#### Population estimation of leopard cat-

Program *PRESENCE 3.1*(Hines, 2006) was used to estimate the population of leopard cats in BTR following the Royle-Nichols single season heterogeneity model. Naive occupancy for leopard cat was estimated as 26.67% in the entire study area while it was 36.67% in the first block and 16.67% in the second block (Table 1). Detection probability (*r*) was estimated as  $0.03\pm0.01$  for the entire study area and also for the first block while it was  $0.03\pm0.02$  in the second block. After correcting for imperfect detection, the probability of site occurrence ( $\Psi$ ) for leopard cat in the entire study area was found to be  $0.36\pm0.10$ whereas in first block it was  $0.50\pm0.15$  and  $0.23\pm0.11$  in the second block. The average abundance of leopard cat per unit area ( $\lambda$ ) was estimated as  $0.45\pm0.15$  for the entire study area while in first and second blocks, the similar parameter was estimated as  $0.70\pm0.30$  and  $0.26\pm0.15$  respectively. The estimated population of leopard cat was found to be  $27.11\pm8.94$  for the entire study area of BTR while the population status of the leopard cats was estimated in the first and second block of sampling as  $20.92\pm9.07$  and  $7.74\pm4.37$ respectively (Table 1). The density of leopard cat was calculated  $18.27\pm6.02$ individuals/100 km<sup>2</sup> in the entire study area whereas the similar population parameter for the first and second blocks of sampling was estimated as  $33.25\pm14.42$  individuals/100 km<sup>2</sup> and  $11.15\pm6.29$  individuals/100 km<sup>2</sup> (Table 1).

# Table.1: Population parameters of leopard cat estimated by camera trap sampling inBTR (2015)

Different population	Different Study Areas and Sampling Blocks		
parameters of leopard cat estimated by camera trapping study	Jayanti and Gadadhar Ranges	Rajabhatkhawa and Buxaduar Ranges	Entire Study Area of BTR
Trap Nights (no. of camera units x sampling period)	2520	2340	4860
Effective Trapping Area (ETA) in km <sup>2</sup>	62.92	69.44	148.41
Total number of Photo- captures	31	8	39
Photo Capture Rate (RAI) per 100 trap nights	1.23	0.34	0.8
Naïve Occupancy in percentage (%)	36.67	16.67	26.67
Detection Probability	0.03±0.01	0.03±0.02	0.03±0.01
Probability of Site Occurrence (Ψ)	0.50±0.15	0.23±0.11	0.36±0.10
Average abundance per unit area $(\lambda)$	0.70±0.30	0.26±0.15	0.45±0.15
Estimated Population in ETA	20.92±9.07	7.74±4.37	27.11±8.94
Individual density in ETA per 100 km <sup>2</sup>	33.25±14.42	11.15±6.29	18.27±6.02
Model Akaike Information Criterion (AIC) value	213.032	102.435	314.87

#### Relative abundance and distribution of leopard cats-

The GPS locations of the camera trap sampling design were plotted in GIS domains and the locations with photo-capture of leopard cats were marked (Figure 3). Thereafter, photocapture rates as relative abundance index (RAI) values of leopard cats were added to all the 60 camera trap sampling locations to build a vector spatial layer. Based on these vector data analyzed from 60 camera trapping point locations, raster data were interpolated by kriging technique following the Gaussian or normal distribution of wild animals to create distribution maps using ArcGIS 9.3 software (ESRI, 2008). By using geo-statistical techniques such as 'kriging', continuous surfaces incorporating the statistical properties of the measured vector data (here relative abundance from photo capture rates) were created. Since kriging technique is based on statistics, it produces not only prediction surfaces but also an estimated range of errors. Therefore, to understand the patterns of spatial distribution map (Figure 4) for the species with basic three classes such as low, medium and high relative abundance in the effective trapping area (ETA) or intensive study area (ISA) in BTR was developed.



Figure 3: Locations of camera traps with photo-capture of leopard cats in Buxa Tiger Reserve (BTR)



Figure 4: Relative abundance or distribution of leopard cats estimated by camera trapping in BTR (2015)

### Table.2: List of other wild animals photo captured in the camera traps deployed in Jainti, Gadadhar, RVK and Buxa duar Ranges of Buxa Tiger Reserve during the survey for the Lesser cats population trend study (2015)

Sl.	Common name	Scientific name	Total	Ranges
No.			captured	
1	Gaur	Bos gaurus	98	Jainti, Gadadhar,
				RVK
2	Asian Elephant	Elephas maximus	148	Jainti, Gadadhar,
				RVK
3	Dhole	Cuon alpinus	1	Jainti
4	Barking deer	Muntiacus muntjak	207	Jainiti
5	Sambar deer	Rusa unicolor	66	Jainti, Gadadhar,
				RVK
6	Large Indian Civet	Viverra zibetha	50	Jainti, Gadadhar,
				RVK, Buxa duar
7	Small Indian Civet	Viverricula indica	56	Jainti, Gadadhar,
				RVK, Buxa duar
8	Yellow-throated	Martes flavigula	20	Jainti
	Marten			
9	Indian Peafowl	Pavo cristatus	25	Jainti, Gadadhar,
				RVK, Buxa duar
10	Red Jungle fowl	Gallus gallus	60	Jainti, Gadadhar,
				RVK, Buxa duar
11	Indian crested	Hystrix indica	8	Jainti, Gadadhar,
	Porcupine			
12	Monkey	Rhesus macaque	103	Jainti, Gadadhar,
				RVK, Buxa duar
13	Himalayan Serow	Capricornis thar	1	Jainti
14	Wild boar	Sus scrofa	162	Jainti, Gadadhar,
				RVK, Buxa duar
15	Crab Eating	Herpestes urva	113	Jainti, Gadadhar,
	Mongoose			RVK, Buxa duar
16	Bengal Monitor	Varanus bengalensis	2	RVK
	Lizard			
17	Honey Badger	Mellivora capensis	1	Jainti
18	Chital	Axis axis	1	RVK

SI.	Lat. N	Lon. E	СТ	Name of the place/	Remarks
No.	(Degree	(Degree	No.	Compartment	
	decimal)	decimal)			
1	26.680490	89.604760	1	N Jainti/1 (83	Damaged by
				Glade)	elephant
2	26.630990	89.615860	17	S Jainti/9	Stolen by human
3	26.627280	89.633190	25	S Panbari/2 Cheko	Damaged by
				Jhora	elephant
4	26.613830	89.615040	29	S Panbari/7	Damaged by
					elephant
5	26.614080	89.611050	30	S Panbari/8 Patai Jhora	Damaged by
					elephant and
					memory chip stolen
					by human
6	26.700120	89.593630	32	N Jainti/5	Damaged by
					elephant
7	26.64600	89.57082	11	Rajavatkhawa(RVK)	Damaged by
					elephant
8	26.6453	89.56264	7	RVK	Stolen by human
9	26.64602	89.53218	13	RVK	Stolen by human
10	26.69485	89.57391	15	RVK	Burned by human
11	26.69263	89.55728	14	RVK	Damaged by
					elephant

Table.3: The locations of Camera traps (in pairs) damaged by Elephants and due toanthropogenic reasons during the field survey at BTR (2015)



Fig.5: Chart showing the camera traps in pairs damaged by elephants and humans in BTR (2015).

#### **DISCUSSION AND RECOMMENDATIONS:**

The minimum comprehension required for effective management of mammals especially the elusive and cryptic carnivores within a protected area includes knowing exactly which species are present, their distribution within the area, and their relative abundance across different habitat types (Sheng et al. 2010). With the maximum concentration of conservation efforts on the charismatic large predators, the ecology and population status of the lesser wild cats are poorly known in India. Specifically in Buxa landscape, our present study is one of the pioneer efforts in understanding that ecological gap for the lesser wild cat population ecology.

In the present study, an effective trapping area (ETA) of around 150 km<sup>2</sup> covering four ranges of Buxa Tiger Reserve (BTR) such as Jayanti, Gadadhar, Rajabhatkhawa (RVK) and Buxaduar were sampled with camera traps to estimate the populations of lesser cats. The sampling session was designed block wise and continued for 81 days in two blocks but it had to be stopped prematurely as 11 units of camera traps were stolen and permanently damaged by unknown miscreants in the forest. The total efforts of the camera-trap samplings collectively in two sampling blocks were of 4860 trap nights. In the previous pilot study (Dey et al, 2014) five species of family *Felidae* such as leopard, leopard cat, fishing cat, marbled cat and jungle cat were photo-captured whereas during the present

study, photographs of three wild felids such as leopard, clouded leopard and leopard cat were captured.

Therefore, during this study, we have estimated the population of leopard cat, the sole lesser cat photographed. Overall, 39 pictures of leopard cat were captured from sixty camera trap locations laid in two blocks covering the ETA. Except nine photographs captured by cameras with white flash out of 39 pictures of leopard cat, rest were found not adequately unambiguous to identify the individual leopard cat. Therefore, capture-recapture statistics applied to individually identifiable species could not be utilized in this situation. Rather both detection and non-detection data were used from repeated surveys through camera trapping following occupancy based Royle-Nichols model of individual heterogeneity in single season.

Program *PRESENCE 3.1*(Hines, 2006) was used to estimate the population of leopard cats in BTR. Naive occupancy for leopard cat was estimated as 26.67% in the entire study area while after correcting for imperfect detection, the probability of site occurrence ( $\Psi$ ) for leopard cat in the ETA was found to be 0.36±0.10. The estimated population of leopard cat was found to be 27.11±8.94 for the entire study area of BTR while the density of leopard cat was calculated as18.27±6.02 individuals/100 km<sup>2</sup>. In this study, we have found that the population of leopard cat in the first sampling block covering Jayanti and Gadadhar ranges (20.92±9.07) was much higher than that of in the second sampling block in RVK and Buxaduar ranges (7.74±4.37). Similarly the site occupancy ( $\Psi$ ) of leopard cat in the in the first block (0.50±0.15) was more than double than in the second block (0.23±0.11). Therefore, it can be stated that the habitats and other pre-requisite resources in the Jayanti and Gadadhar ranges.

Given the elusive nature of the small carnivore assemblages there are a few methodological considerations and limitations in research designs dedicated to study the ecology of the lesser carnivores. For instance, variation in the efficiency and capability to record species presence/absence among different models of camera traps can influence the results. Therefore, the use of these different brands of cameras with white and infra-red flashes would have influenced our main findings. Therefore, for future studies on lesser

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cats, use of camera traps with white flash encased within fabricated wooden pole (SPG Pole) for the protection from elephant and gaur should be preferred. Simultaneously in future studies, it would be preferable to estimate densities using actual home range of small carnivores from the region of concern. Here for the leopard cat, home range values from literature  $(3 - 14 \text{ km}^2; \text{ Grassman et al}, 2005, \text{ Rajaratnam et al}, 2007)$  exceeded the sub unit area (sampling grid of four square km) sampled. Despite intensive search efforts, low detection probabilities (0.029–0.01) presented particular difficulties in monitoring cryptic small carnivores, thus limiting the reliability of occupancy estimates in our study (MacKenzie*et al.* 2002). For future surveys (e.g. camera trap placements) it is better to cover large sample areas and reduce the inter-trap distance by installing additional number of cameras to produce more precise occupancy estimates.

The lesser cats were neither very charismatic nor posed any large threat to man and therefore, they never attracted any conservation attention in the last few decades. Therefore, lesser cats are becoming lesser and lesser all over their habitats in the Indian subcontinent (Sharma and Sankhala, 1984). The critical climatic changes, vulnerable openness of the woodland and scrubland, surging of the cross border illegal trades in wild cat skins and other body parts have been the main factors responsible for their destruction during the last two decades (Sharma and Sankhala, 1984). Over the past decade the lesser cat population has gone through a severe decline mostly because of the destruction and conversion of their prime habitats (Macdonald and Loveridge 2010). Delany &Happold (1979) stated that intensive grazing by large ungulates (especially domestic livestock) degrades the land and makes it uninhabitable for rodents because of loss of cover and food. Therefore, livestock grazing is one of the most inevitable risks for the lesser cats which are dependent on the rodent population following the trophic cascade.

It must be noted that conversion of natural vegetation into agriculture in many cases destroys cover, which is essential for hunting especially for felids. Retaining patches of bushes within agricultural fields could benefit small carnivores. BTR is also facing terrible threats due to natural habitat degradation, unimpounding cattle grazing pressure, along with infiltration problem across the border of Bhutan-Nepal and ever increasing

unsustainble tourism pressure on the river beds and forested lands of BTR as observed and recorded during the field work.

The changes in small carnivore density highlights the close relationship between these species and the vegetation structure and suggests that effective management of this assemblage could be achieved by careful management of the habitat structure. Management should aim at maintaining the habitat heterogeneity of northern tropical forests, as any management regime which reduces the habitat diversity would probably result in a decrease in the diversity of small carnivores. Effective law-enforcement monitoring would also be required to convict the poaching and illegal trade incidences across the landscape. Efficient regulation of the cattle grazing is needed. Moreover, the critical natural habitats of BTR, it being in a strategic position as a bordering state with Assam and countries like Bangladesh and Bhutan, is prone to anthropogenic pressures due to border issues, and the forest dynamics is affected (Table. 3). Hence particular protection measures during these socio-political disturbed phases have to be taken to maintain the continuity of the forest dynamics. It is also required for the long-term survival of the lesser cats in this landscape. As this was the second phase of the study a number of interesting features were observed which would require one more detailed study in the same area in the same period for conservation and management of these four sympatric species. Further studies are needed to understand the intra-guild relationships, niche separation of lesser carnivores across the entire habitats subjected to different management regimes (ranges) or disturbance gradients in Buxa Tiger Reserve.

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PLATE No. 1 (Photo capture of leopard cats-1)



**(a)** 



**(b)** 

Figure 6: (a) & (b) Photo capture of Leopard cats in camera trap at Buxa Tiger Reserve (2015)

PLATE No. 2 (Photo capture of leopard cats-2)

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(c)



(d) Figure 7: (c)&(d) Photo capture of Leopard cats in camera trap at Buxa Tiger Reserve (2015)

#### PLATE No. 3 (Photo capture of other wild animals-1)



**(e)** 



(h)



**(g)** 

Figure 8: (e) Clouded Leopard; (f) Himalayan Serow; (g) Leopard; (h) Sambar

PLATE No.4 (Photo capture of other wild animals -2)



(i)

(**k**)



**(l)** 

Figure 9: (i) Spotted Deer; (j) Barking Deer; (k) Indian Porcupine; (l) Crab eating mongoose Photo captured in camera trap at Buxa Tiger Reserve (2015).

Nature Environment & Wildlife Society (NEWS)

PLATE No.5 (Photo capture of other wild animals -3)



(m)

**(n)** 



(0)

**(p)** 



**(q)** 

# Figure 10: (m) Small Indian Civet; (n) Yellow Throated Marten; (o) Monitor Lizard; (p) Dhole; (q) Wild boar Photo captured in camera trap at Buxa Tiger

Reserve (2015)



PLATE No.6 (Photo capture of other wild animals -4)



**(s)** 

Figure 11: (r) Gaur ; (s) Elephant Photo captured in camera trap at Buxa Tiger Reserve (2015)

#### PLATE No.7 (Field team at work)



Figure 12: Field Team at work

### Appendix 1. List of Carnivorous animal of BTR

Sl no.	Common Name	Species name	Cited	IUCN Status	Jainti	Gadadhar	RVK	Buxa duar	Total
1	Indian Tiger	Panthera tigris	No	Endangered					0
2	Leopard	Panthera pardus	Yes	Near Threatened					0
3	Clouded Leopard	Neofelis nebulosa	Yes	Vulnerable					0
4	Hog badger	Arctonyx collaris	Yes	Near Threatened					0
5	Jungle Cat	Felis chaus	Yes	Least Concern					0
6	Leopard Cat	Prionailurus bengalensis	Yes	Least Concern					0
7	Sloth Bear	Melursus ursinus	Yes	Vulnerable					0
8	Fishing Cat	Prionailurus viverina	Yes	Endangered					0
9	Civet Cat	Viverricula indica	Yes	Least Concern					0
10	Hyaena	Hyaena hyaena	Yes	Near Threatened					0
11	Jackal	Canis aureus	Yes	Least Concern					0
12	Mongoose	Herpestes edwardsi	Yes	Least Concern					0
13	Fox	Vulpes bengalensis	Yes	Least Concern					0
14	Wild dog	Cuon alpinus	Yes	Endangered		1			1
15	Marbled Cat	Pardofelis marmorata	Yes	Vulnerable					0
16	Golden Cat	Catopuma temmincki	Yes	Near Threatened					0
17	Crab-eating Mongoose	Herpestes urva	Yes	Least Concern	20	23	63	7	113
18	Small Indian Civet	Viverricula indica	Yes	Least Concern	10	21	19	6	56
19	Large Indian Civet	Viverra zibetha	Yes	Near Threatened	6	24	19	1	50

Sl no.	Common Name	Species name	Cited	IUCN Status	Jainti	Gadadhar	RVK	Buxa duar	Total
1	Asiatic elephant	Elephus maximus	Yes	Endangered	44	55	40	9	148
2	Gaur	Bos gaurus	Yes	Vulnerable	16	12	59	11	98
3	Sambar	Cervus unicolor	Yes	Vulnerable	17	36	10	3	66
4	Chital	Axis axis	Yes	Least Concern			1		1
5	Barking deer	Muntiacus muntjak	Yes	Least Concern	82	66	50	9	207
6	Hog deer	Axis porcinus	No	Endangered					0
7	Wild Bore	Sus scrofa cristatus	Yes	Least Concern	29	31	82	20	162
8	Hispid hare	Caprolagus hispidus	No	Endangered					0
9	Wild Buffalo	Bubalus bubalis	No	Least Concern					0
10	Indian one horned rhino	Rhinocerous unicornis	No	Vulnerable					0
11	Indian Crested Porcupines	Hystrix indica	Yes	Least Concern	0	3	1	4	8
12	Rhesus macaque	Macaca mulatta	Yes	Least Concern	20	37	43	3	103
13	Common Indian Pangolin	Manis crassicaudata	No	Endangered					0
14	Chinese Pangolin	Manis pentadactyla	No	Critically Endange	red				0
15	Himalayan Serow	Capricornis thar	Yes	Near Threatened	1				1
16	Yellow Throated Marten	Martes flavigula	Yes	Least Concern	16	2	2		20
17	Bengal Monitor Lizard	Varanus bengalensis	Yes	Least Concern			2		2

# Appendix 2. List of Herbivores animal of BTR



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Appendix 3. Map showing the forest Ranges in BTR.



Appendix 4. Locations of cameras in BTR.

# Report on Pilot Phase

Nature Environment & Wildlife Society (NEWS)

# Estimation of Population Trend of Lesser Cats in Buxa Tiger Reserve (BTR), West Bengal

(A Pilot Phase Study Report)



Implemented

&

# **Report Submitted by**

Nature Environment & Wildlife Society



Estimation of population trend of Lesser Cats in Buxa Tiger Reserve (BTR), West Bengal-

Report of the pilot phase -

Principal Investigators:

Ajanta Dey

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#### Abstract

Lesser wild cat populations are widely threatened with habitat loss, human-wildlife conflict and wildlife trade throughout their extant range in the world. Until now, for the most part information on small cats in India has been in the form of natural history notes on distribution and habits, ad-hoc records on sightings and behavior or short studies on diet and habitat use. Our study was conceptualized to assess population trend of lesser wild cats in Buxa Tiger Reserve (BTR) in Duars, West Bengal. We investigated on their ecology through three fold survey strategies 1) Questionnaire survey, 2) Sign survey and 3) Camera trapping. n=11 single camera units were used for 160 days study in three different ranges (Jayanti, Hatipota and Kumargram) of BTR with effort of 1760 trap nights. We obtained photo captures of 10 different mammalian families with 17 different species. Of them 4 species were of endangered (EN) in IUCN (International Union for Conservation of Nature and Natural Resources) category of threatened taxa. Camera trapping revealed the existing distribution of four sympatric wild lesser cats in BTR; Leopard cat

*Prionailurus bengalensis,* Fishing cat *Prionailurus viverrinus,* Jungle cat *Felis chaus* and Marbled cat *Pardofelis marmorata.* Calculated RAI (Relative abundance index) revealed that for the entire occasion leopard cats were found the most abundant species (0.85) among all the existing lesser wild cats, followed by other sympatric species, fishing cat (0.06), marbled cat (0.06) and jungle cat (0.06). All the four species of lesser wild cats were found only in Kumargram Range and in other two ranges only leopard cat was photo captured. More research needs to be done and the continuation of the study has a scope to reveal the population status of lesser wild cat population in BTR landscape for developing conservation management and firm scientific planning to ensure the long term survival of these four existing sympatric species.

#### Introduction

There are existing 28 species of lesser wild cats in the world among them 10 species are thriving in India, the highest number any country has (Nowell and Jackson 1996). The increasing human population, the spread of settlement and the exploitation of natural resources of wild lands, together with persecution, are threatening some species with extinction. For other cat species we observe worldwide population decline. Conservation initiatives were taken in every part of the world to ensure survival of threatened species. For effective species conservation and management, an understanding of species ecology with population trend is vital, particularly if the species forms an important constituent of the lesser mammalian guild and regulates small mammal and bird populations. Few studies on their ecology (Distribution and abundance) and ethology were carried out in India. Yet, apart from the four big cats the small ones do not feature in any major research or conservation planning. The ecological role of the lesser wild cats in the eastern Himalayan habitats is not well known and gathering such information on elusive species in remote and intricate Himalayan habitats has always been challenging since conventional sampling protocols have been proven inadequate in such areas (Sathyakumar et al. 2011). Over the last two decades, the use of various noninvasive techniques for the sampling of animal populations has increased significantly. Technological advances have allowed practitioners to sample and monitor animal populations without invasive methods. Reducing of time, effort and expenses in the collection of scientific data with more efficiency have increased interest towards noninvasive sampling methodologies. Noninvasive sampling methods are particularly well suited to animals that are elusive, often occur at low densities, and are difficult to capture or detect. Arguably, the most popular noninvasive sampling technique among those reviewed by Long et al.

(2008) is remote photography using camera traps. Camera trapping has emerged as an efficient noninvasive monitoring tool with wide applicability in ecological studies in varied habitat conditions and proved very effective in this kind of study. Much attention also has been focused on using camera-trapping to detect otherwise elusive species, including charismatic examples such as tigers (*Panthera tigris*) (Karanth et al. 1995), snow leopards (*Panthera uncia*) (Jackson et al. 2006), giant pandas (*Ailuropoda melanoleuca*) (Li et al. 2010), Jaguar (*Panthera onca*) (Silver et al. 2004) and others.

The project was conceptualized to assess abundance of different available lesser wild cats by using camera trapping technology and accordingly develop their conservation strategies in Buxa Tiger Reserve (BTR), West Bengal.The Reserve lies in the Biogeographic zones of Central Himalayas (2C) and Lower Gangetic Plains (7B) (Rodgers & Panwar, 1988). We assessed the species occurrence, population status and activity pattern of lesser wild cats in the study area, part of Buxa Tiger Reserve, India, based on questionnaire survey, sign surveys and camera trapping.

Lesser wild cat populations are threatened throughout their extant range in India by habitat loss, conflict and wildlife trade. For BTR where the population status of the four sympatric lesser wild cats are unknown there conservation management and firm scientific planning are essential for these species before the situation reaches the point, of beyond recovery. This current project is designed to promote the *insitu* conservation of all the lesser wild cats in the study area.



Objectives

To assess abundance of four sympatric lesser wild cats in BTR

To identify spatial distribution of the four sympatric lesser wild cats in BTR



#### Study Area

Buxa Tiger Reserve is situated between 26° 40' 30" N, 89° 44' 30" E coordinates of Alipurduar sub-division of Jalpaiguri District, West Bengal. The location of the Reserve is in the tri-junction of three major bio-geographic zones viz. Lower Gangetic Plains, Central Himalayas and Bramhaputra Valley. Representation of multi strata vegetation assemblage from the plains to an elevation of 1750m in the hills, coupled with a good number of perennial water streams, enables this Reserve to be an excellent harbour for various wild animals.

The Tiger Reserve covered 760.87 Sq. Km of multi strata vegetation assemblage. In the plains the forest is composed of Sal (*Shorea robusta*) along with its associates like Champ (*Michelia champaca*), Chilaune (*Schima wallichi*), Chikrasi (*Chukrasia tabularis*), Bahera (*Terminalia belerica*), Sidha (*Lagerstroemia parviflora*), Toon (*Toona ciliata*), Lali (*Amoora wallichi*), Lasuni (*Aphanomixis polostachea*), Lampati (*Duabanga grandiflora*), Simul (*Bombax ceiba*). In the river banks Simul, Sisoo and Sirish are commonly found , while in the hills Katus (*Castanopsis indica*), Mandane (*Artocarpus fraxinifolius*), Bhalukath (*Talauma hodgsoni*), Phalame(*Walsura tabulata*) associated with Kimbu (*Morus laevigata*), Panisaj (*Terminalia microcarpa*), Gokul (*Ailanthus grandis*) are common. The grasses mostly used by the wild ungulates and other herbivores are *Imperata cylindrica*, *Arundo donax*, *Themeda arundinacea*, *Phragmites karka*, *Paspalidium punctuatum*, *Panicum maxima*, *Seteria glauca*, *Oryza sp.*, *Saccharum sp.*, *Andropogon sp.*, *Thysanolana sp*.



Buxa Tiger Reserve (BTR) West Bengal

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Altitudinal variations with its geographical position in the tri-junction of the biogeographical zones eventually develop high floral diversity which in turn elevates faunal species variation in Buxa Tiger Reserve (BTR). The existing large carnivores of Buxa Tiger Reserve are Bengal tiger (Panthera tigris), leopard (Panthera pardus), clouded leopard (Neofelis nebulosa). Other lesser carnivores are hog badger (Arctonyx collaris), jungle cat (Felis chaus), leopard cat (Felis bengalensis), fishing cat (Felis viverrina), wild dog (Cuon alpinus), jackal (Canis aureus), mongoose (Herpestes edwardsi), fox (Vulpes bengalensis). Among herbivores, predominant are Asian Elephant (Elephas maximus), Gaur (Bos gaurus), Sambhar (Rusa unicolor), Chital (Axis axis), Barking deer (Muntiacus vaginalis), Hog deer (Axis porcinus), Wild pig (Sus scrofa) and Hispid hare (Caprophagus hispidus). Many other animals like Porcupine (Hystrix indica), Rhesus macaque (Macaca mulatta), Common Pangolin (Manis crassiculata) also frequent in these forests. Varieties of fishes are present in the rivers and streams flowing inside the forest, most commonly found are Chela, Boroli, Puti, Hum, Sole etc. Among reptiles tortoise, lizards, gecko, various kinds of snakes such as King cobra (Ophiophagus hannah), Russell's viper (Daboia russelii), Black krait (Bungarus niger), Indian Python (Python molurus) and Reticulated Python (Python *reticulatus*) are found in this region.

#### Avifauna

More than 227 bird species were reported from this IBA site by Allen et al. (1996). But, if we include the birds seen earlier by Inglis et al. (1918-1920), Stevens (1923-1925), Inglis (1952-69), Law (1953) and Sanyal (1995), the total comes to 359 species for the IBA. During a one-year BNHS study, 221 species were sighted by Prakash et al. (2001). The Greater Adjutant *Leptoptilos dubius*, an Endangered

(EN) species, was earlier seen by Inglis et al. (1918-1920) but not by Allen et al. (1996) or Prakash et al. (2001). Similarly, the following species were not sighted in recent surveys: Manipur Bush Quail *Perdicula manipurensis*, Pallas's Fish Eagle Haliaeetus leucoryphus, Bengal Florican Houbaropsis bengalensis, Lesser Florican Sypheotides indica, White-bellied Heron Ardea insignis, Wood Snipe Gallinago nemoricola, Jerdon's Babbler Chrysomma altirostre and Finn's Weaver Ploceus megarhynchus. A part of Buxa Tiger Reserve lies in the Eastern Himalayas Endemic Bird Area (EBA 130) where Stattersfield et al. (1998) have listed 21 restricted range species. Red-breasted Hill Partridge Arborophila mandelli, Yellow-vented Warbler Phylloscopus cantator, Hoary-throated Barwing Actinodura nipalensis and White-naped Yuhina Yuhina bakeri are found in the higher reaches of Buxa. Most parts of Buxa are plains and would come under the Assam Plains Endemic Bird Area (EBA 131) where three species are considered restricted range. Only the Black-breasted Parrotbill Paradoxornis flavirostris has been reported from this IBA, although earlier even the Manipur Bush Quail was found at the foot hills. Prakash et al. (2001) recorded 32 species of raptors, including the two Critically Endangered *Gyps* vultures. Allen et al. (1996) report five species of hornbills (Indian Grey Ocycercos birostris, Oriental Pied

Anthracoceros albirostris, Great Pied Buceros bicornis,Rufous-necked Aceros nipalensis and Wreathed Aceros undulatus).Some species of conservation interest seen by them are: Chestnut- breasted Partridge Arborophila mandellii (5 individuals), Rufous- necked Hornbill (one pair), Beautiful Nuthatch Sitta formosa (2-4 birds), Long-billed Wren-Babbler Rimator malacoptilus (one pair), Black-headed Shrike-Babbler Pteruthius rufiventer (small numbers), Yellow-throated Fulvetta Alcippe cinerea (small party), White-naped Yuhina Yuhina bakeri (small flocks) and Greater Rufous-headed Parrotbill Paradoxornis ruficeps (flocks of

>30). Thirteen species belonging to the Vulnerable (VU) category and 11 belonging to the Near Threatened category are found in Buxa, some with significant numbers.

## Methodology

#### Reconnaissance survey

The survey was strategized into three consecutive phases; 1) First phase was questionnaire survey, 2) second phase sign survey and 3) third phase was camera trapping. The survey team initially has carried out the first phase, interview based survey in the villages present in and around Buxa Tiger reserve (BTR), on Forest staffs of BTR and daily field labourers to generate secondary presence absence data on lesser wild cats. It was an attempt to prioritize zones from where to start the pilot sign survey on the lesser felids.



Survey team interviewing Forest staffs and field labor at Buxa tiger Reserve (BTR)

Based on the interviews, sign survey (Second phase) was carried out with prime focus on leopard cat, jungle cat, marbled cat and fishing cat. Dart roads, animal trails, river and stream beds were searched for indirect signs of the target species. Multiple trails were walked to get signs of lesser cats in Jayanti, Hatipota and Kumargram range. Generating data points on indirect signs were carried out to obtain the most possible camera trap locations where capture probability of the concerned species were high that was essential for third phase. In the month of January 2012 and December 2013 three Ranges of Buxa Tiger Reserve (BTR) were surveyed to record presence of lesser wild felids in the landscape with the help of indirect signs such as scats and pugmark. Based on the observed probability of obtained indirect signs, potential trap locations were identified and camera traps were installed accordingly (Fig.2). Lesser wild cat scats were collected during the sign survey to carry out DNA analysis for species level identification.



Few field instances during the sign survey on lesser wild cats of BTR

#### Camera trapping

Camera-trapping has long been used to survey for and monitor the occurrence of wildlife species around the world (Carbone et al. 2001; Jackson et al. 2006; Moruzzi et al. 2002). Much attention has been focused on using camera-trapping to detect otherwise elusive species. Over time, these efforts have been replaced by more systematic sampling approaches, often centered on identifying individual animals in a mark-recapture framework (Carbone et al. 2001; Jackson et al. 2006) to estimate their population abundance in the study areas. For species that cannot be individually identified from photographs, indices are often used to make inference about differences in abundance across time, space and species (O'Brien

et al. 2003; O'Brien, 2011). While Indices can rarely be used for inference about absolute population size under certain conditions they can provide information on relative differences in abundance or density (Williams et al. 2002; O'Brien, 2011). The pilot camera trap survey was carried out from December, 2013 to May, 2014 for all the sympatric lesser wild felids of the Buxa Tiger Reserve with very limited resources (Camera trap, n=11).



Few field instances of camera trap installation in BTR

The study area was divided into three Ranges named as Jayanti (5.96 sq. km, ETA), Hatipota (5.44 sq. km, ETA) and Kumargram (3.90 sq. km, ETA) (Fig.3), where in total ETA (Effective trapping area) covered 15.03 sq. km of the entire Buxa Tiger Reserve. Effective trapping area was calculated by joining the outer most camera traps of the trapping surface to form a polygon and the area of trapping polygon was considered as ETA. A total of 11 passive (Single unit) camera traps (Spypoint I6, Spypoint BF-6 and Spypoint FL-8) were deployed in the locations, identified as most probable capture points from the sign survey. Due to limitations of camera units (n=11), traps were deployed opportunistically in each range to record species and their occurrence in the area. Trapping was attempted to make systematic as per as possible by placing the cameras in 1x1 km grid system

(Fig.2). All the camera trap units were functional for 160 days (5 months 10 days) consecutive occasions resulting into 1760 trap nights. Consecutive photo captures of same species were obtained by the same camera more than once within 1 hour were excluded (Bowkett et al. 2007) and declared as an event. Relative abundance index (RAI) was calculated for each species of lesser wild cats from captured photographs. The time and date printed on the photographs has been used to determine the daily activity pattern of individual species (Pei 1998). DAI (Daily activity index) formula was not used for this small data set. Here a simple representation was made up to indicate the activity pattern of lesser wild cats.



Fig.2 Deployment of camera traps opportunistically in the study area for recording lesser wild felid presence and abundance

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Fig.3. Map showing synchronization among Indirect signs of lesser wild cats and deployed camera trap (n=11) points in Jayanti, Hatipota and Kumargram Ranges of Buxa Tiger Reserve (BTR), West Bengal, 2014



Fig.4. Map showing the effective camera trapping areas (ETA) covered by the camera traps in Jayanti (5.96 sq. km), Hatipota (5.44 sq. km) and Kumargram (3.90 sq. km) ranges respectively of Buxa Tiger Reserve (BTR), West Bengal

Result

Sign Survey

Total 42 signs of wild felids were found in different points during the pilot survey, of these 3 signs were of leopards. Two of those were scats and rest was a pugmark. 39 total signs were obtained of lesser wild cats, among those indirect signs, scat was 64.29%, pugmark, 26.19% and direct sighting contributed only 2.38% (Fig.5).



Fig.5. Sign abundance index for lesser wild cats in Jayanti, Hatipota and Kumargram Range of Buxa Tiger Reserve (BTR) during the pilot sign survey in January, 2013 and December, 2013

Results of sign survey indicated that among the study areas relative abundance of lesser wild felids were highest in Jayanti Range (57.14%) and followed by

Kumargram (30.95%) and Hatipota (11.90%) range. Only single sighting was recorded of a leopard cat from NRVK 13 compartment.



Fig.5. Comparable Sign abundance of lesser wild cats among Jayanti, Hatipota and Kumargram Range of Buxa Tiger Reserve (BTR), West Bengal during the pilot sign survey in January, 2013 and December, 2013

#### Camera Trapping

Camera trap sampling has successfully photo captured lesser wild cats along with several other associated species in the study area. Definite evidence of 17 mammalian species from 10 different families was observed from the captured photographs. Felidae contributed 5 species, cervidae 3 species, viverridae 2 species and all other families contributed one species each. Among these 17 identified species, 4 species (Dhole, fishing cat, hog deer and elephant) belonged to IUCN endangered category (EN) (Table1).

Common name	Scientific name	Family	IUCN Status
Leopard	Panthera pardus	Felidae	NT
Leopard cat	Prionialurus	Felidae	LC
	bengalensis		
Fishing cat	Prionialurus	Felidae	EN
	viverrinus		
Marbled cat	Pardofelis	Felidae	VU
	marmorata		
Jungle cat	Felis chaus	Felidae	LC
Dhole	Cuon alpinus	Canidae	EN
Crab eating	Herpestes urva	Herpestidae	LC
mongoose			
Large Indian civet	Viverra zibetha	Viverridae	NT
Small Indian civet	Viverricula indica	Viverridae	LC
Gaur	Bos gaurus	Bovidae	VU
Yellow throated	Martes flavigula	Mustelidae	LC
martin			
Barking deer	Muntiacus vaginalis	Cervidae	LC
Hog deer	Axis porcinus	Cervidae	EN
Sambar	Rusa unicolor	Cervidae	VU
Wild pig	Sus scrofa	Suidae	LC
Asian elephant	Elephas maximus	Elephantidae	EN
Rhesus macaque	Macaca mulatta	Cercopithacidae	LC

Table1. List of wild species, camera trapped in Buxa Tiger Reserve during the survey

EN\* Endangered, VU\* Vulnerable, NT\* Near Threatened, LC\* Least Concerned



Fig.6. Capture of existing sympatric lesser wild cats of Buxa Tiger Reserve (BTR), December 2013 to May 2014



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Fig.7. Captures of other wild mammals in Buxa Tiger Reserve (BTR) in 160 days of camera trapping from December 2013 to May 2014

Camera traps recorded 36 photographs of lesser wild felids. 18 individual events were counted for the entire occasion. For the entire trapping occasion leopard cats' capture percentage was highest (83.33%) and followed by fishing cat (5.56%), marbled cat (5.56%) and jungle cat (5.56%). Capture data among the study areas showed measurable detection differences during trapping. The events were highest in Kumargram Range (0.51%) where all the captures of existing sympatric lesser wild felids were obtained and followed by Jayanti (0.45%) and Hatipota (0.06%) where only leopard cats were captured for the entire occasion (Fig.8).



Fig.8. Captured events (n=18) of lesser wild cats in Jayanti, Hatipota and Kumargram Range of Buxa Tiger Reserve (BTR), West Bengal during the pilot camera trapping (n=11) from December, 2013 to May, 2014

Scat DNA analysis work is in progress at ZSI (Zoological Survey of India) Laboratory, whereby a MOU has been signed to this effect. So the result on species level identification from scat DNA is not explained yet.



Fig.9. Relative abundance index (RAI) of lesser wild cats in the sampled area of Buxa Tiger Reserve (BTR), West Bengal during the pilot camera trap (n=11) survey from December, 2013 to May, 2014 (1760 trap nights)

Calculated RAI for lesser wild cats reflected that for the entire occasion leopard cats were found the most abundant species (0.85) among all the existing lesser wild cats and followed by other sympatric species like fishing cat (0.06), marbled cat (0.06) and jungle cat (0.06) (Fig.9).


Fig.10. Combined activity pattern of lesser wild cats in Buxa Tiger Reserve (BTR), West Bengal during the pilot camera trapping from December, 2013 to May, 2014

All the species of lesser wild cats were observed active during the crepuscular time and during the night. The activity peaks were observed among 0-2hours to 2-4hours and again in 18-20hours onward in the evening (Fig.10). Leopard cat showed 72.22% nocturnal and crepuscular activity.

## Discussion

According to the present context demographic knowledge of lesser wild cats is insufficient and therefore implementing conservation plans with strong scientific methodologies, is the greatest challenge. Due to the limited resource constraints we are not in a situation to estimate lesser wild cat population rather result was generated to know population abundance index of the available species of lesser felids. Obtained abundance index indicated that except leopard cat other existing sympatric cats are least abundant in the area. In Kumargram range all the species of lesser wild cats were photo trapped and showed the best result in comparison to Jayanti and Hatipota in terms of trapping success. Photographic events were just n=18 in 160 days occasion with 11 camera traps, so in this session the data set is just to describe the simple observations from it. Information on the Activity pattern of the leopard cat (n=14) of our study synchronizes with the findings of Cheyne and Macdonald (2011) (camera trapping) Rajaratnam (2000) (radio telemetry) and (Bashir et al. 2013) reporting 65, 85% and 87% nocturnal activity, respectively. For further discussion more data set will be required on the matter and can be covered in the next session of camera trapping in BTR.

In the Protected Areas (PA) and outside the PA few studies were made in the recent times but more research needs to be undertaken to gain knowledge of current distribution pattern. All the observed lesser wild cats from the present study area are threatened with conflict and wildlife trade in different parts of India (Jungle cats in Rajasthan, Sharma et al. 1984; Marble cat in Arunachal Pradesh, Selvan et al. 2013; Fishing cat in Rajasthan, Sharma et al. 1984; Leopard cat in Sikkim, Bashir et al. 2013). Recorded evidences of killing or trading of marbled cats are rare; killing was recorded in Arunachal Pradesh by Apatini tribe for their rituals (Selvan et al. 2013). Ecological and behavioral studies indicated that lesser wild cats are well adapted in human dominated landscape, where chances of conflict are automatically high. They are known to be considered as conflict species when some farmers pointed the jungle cat as a pest which takes poultry (Abu-Baker et al.2003), for fishing cat the situation is also the same esp where the fishery industries or private fisheries exist in vicinity .Furthermore, the fishing cat is known to prey on poultry (Sunquist & Sunquist 2002, Cutter & Cutter 2009, IUCN 2010) and have the possibilities to face the same threat in BTR. Buxa is a Tiger Reserve which sustains several villages inside and around its premises (Table 2) with the human population over 3 lakh, which may act as potential threat to the study species referring to the accentuated conflict risks involved in other parts of India.



	BTR (E)		BTR (W)		BTR	
	Number	Population	Number	Population	Number	Population
Forest Village	17	4801	21	10919	38	15720
FD Holding	2	1315	2	1468	4	2783
Tea Gardens	12	46285	28	130188	40	176473
Revenue village	26	53523	22	80416	48	133939
Total	57	105924	73	222991	130	328915

Table2. Demographic and other data on forest villages, FD holdings, tea gardens and revenue villages in and around PA

The ecology and population status of the lesser wild cats are poorly known in India. Specifically in Buxa landscape this study is not carried out before. In BTR studies using methodology like camera trapping will be beneficial for the purpose to develop improved species conservation and management plan. From this effort we have already obtained indications on population trends of lesser wild cats in BTR. Hence, from this comprehensive understanding of the pilot survey, it could be inferred that, further study on population monitoring and survival studies in Buxa Tiger reserve (BTR) will help in terms of conserving lesser wild cats with more definite strategies.

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Appendix 1: Map showing the locations of camera.

Appendix 2: List	of species sighted	and also captured in camera.
		1

	Photographs captured for 160 days							
		Jainti		Hatipota				
Common name	Scientific name	range	Kumargram range	range	Sighted (Yes/No)	<b>IUCN status</b>		
Leopard cat	Prionialurus bengalensis	12	9	1	No	Least Concern		
Fishing cat	Prionialurus viverrinus	1			No	Endangered		
Marbled cat	Pardofelis marmorata		1		No	Vulnerable		
Jungle cat	Felis chaus		10		No	Least Concern		
Wild boar	Sus scrofa	248	89	45	Yes	Least Concern		
Leopard	Panthera pardus	7	6	1	Yes	Near Threatened		
Dhole	Cuon alpinus		1		No	Endangered		
Large indian civet	Viverra zibetha	218			Yes	Near Threatened		
Crab eating mongoose	Herpestes urva	112	46	28	Yes	Least Concern		
Small indian civet	Viverricula indica	165	76	17	No	Least Concern		
Sloth Bear	Melursus ursinus	1			No	Vulnerable		
Yellow-throated Marten	Martes flavigula	22	22		Yes	Least Concern		
Barking deer	Muntiacus vaginalis	306	59	31	Yes	Least Concern		
Spotted deer	Axis axis		19		No	Least Concern		
Hog deer	Axis porcinus		2		No	Endangered		
Gaur	Bos gaurus	79	200		Yes	Vulnerable		
Asian elephant	Elephas maximus	86	98	15	Yes	Endangered		
Sambar deer	Rusa unicolor	18			Yes	Vulnerable		