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Research Article

Carnivore and herbivore densities in the immediate aftermath of ethno-political conflict: The case of Manas National Park, India

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Abstract:
Many biodiversity hotspots experience high political volatility and armed conflicts. But their impacts on wildlife conservation are poorly understood. In this study we analyze the influence of fifteen years of armed conflict and subsequent peacetime interventions on wildlife populations in Manas National Park, India. Camera trapping and line-transect surveys were carried out to estimate the densities of carnivores and herbivores respectively. Using relative abundance index, the estimated densities of the three large felids were: tiger, *Panthera tigris* (1.86 animals/100 km^2), leopard, *Panthera pardus* (1.68 animals/100 km^2), clouded leopard, *Neofelis nebulosa* (0.58 animals/100 km^2). Among the ungulates, which are the principal prey species of tigers, wild-buffalo, *Bubalus arnee* was most abundant (22.88± S.E. 11.63 animals/km^2). The combined density of the ungulate species was 42.02 animals/km^2. Our data and observations from the field indicate that except for the rhino, *Rhinoceros unicornis,* most wildlife species survived the conflict. Relationships between ungulate and tiger abundances indicate that Manas can support more tigers than are currently present. The ongoing restoration efforts seem to have an uplifting effect on the overall profile of the park, particularly on tourism and in engaging local communities. Our baseline estimates for the large cats and their prey species will enable future evaluation of the recovery process with respect to change in species abundance over time.

Keywords: Manas National Park, tiger, herbivore densities, carnivore abundances, ethnic conflict, India.

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Introduction

Many biodiversity hotspots in the world are currently in areas of great political volatility and armed conflicts [1], while many others are at high risk of becoming conflict zones in the future[2]. Such conflicts often result in intentional and unintentional abuse of wildlife and natural areas by conflicting parties [3]. With human security concerns taking priority, financial resources and international aids are diverted to peacekeeping, rehabilitation and humanitarian efforts, thereby marginalizing conservation activities and priorities [4-6]. In such cases, Protected Areas (PAs) are left without paid staff, equipment or infrastructure, jeopardizing short-term and long-term conservation goals [4]. Reduced protection increases the presence of soldiers, refugees and extremists, who rely on forest for their sustenance [7] increasing the burden on local natural resources [8; 9].

In conflict areas, access, scientific monitoring, protection and management of the park are the worst affected, making it difficult to assess the impact of armed conflicts on local biodiversity. For instance, a post-conflict assessment of Afghanistan's Wakhan Corridor, which was a war zone for 22 years [10], recorded decimation of wildlife due to loss of wetlands, deforestation, and hunting [11]. Studies of armed conflicts on biodiversity are restricted to USSR [12], Africa [7; 13; 14] and Afghanistan [10; 11; 15], and only a few studies exist on the impacts of political conflict on wildlife and conservation activities in the biologically rich regions of Asia [11; 16]. India has many forest areas and PAs that experience ethnic and cultural clashes and socio-political and environmental conflicts [16], but no study has attempted to assess their impacts on biodiversity and its conservation efforts.

Manas National Park (henceforth Manas), in the northeastern region of India, is a world heritage site known for tigers (*Panthera tigris*) and rhinoceros (*Rhinoceros unicornis*). Manas experienced a fifteen year-long ethnic and political conflict starting in the mid-1980s that disrupted ongoing conservation and management activities until fledgling peace was restored in 2003. During the conflict, administrative and protective mechanisms in the park ceased to exist and forest personnel abandoned the area. Anti-poaching camps were destroyed, and arms meant for enforcing park protection were stolen and used by anti-government forces in their violent struggle. This left the park vulnerable to logging, local hunting, and poaching of economically important animal species, particularly the rhino, tiger and swamp deer (*Rucervus duvaucelii*),causing habitat degradation [17] and rapid loss of wildlife [18].

Manas was believed to harbour good populations of tiger, rhino and swamp deer prior to the conflict [19]. In the absence of scientifically reliable empirical studies on the animal populations before and after the conflict, it was difficult to assess its impact on wildlife population of Manas. To overcome this limitation, we compared the densities of the animals in Manas from the present study with other conflict-free PAs of the Indian subcontinent. Notwithstanding the limitations of this approach viz. not controlling for other forms of anthropogenic and habitat differences, we nevertheless expected the prey densities to provide clues to the probable tiger densities of Manas. That is because the primary driver for tiger density is their prey density [20]. The severe conflict in Manas could have reduced prey numbers, which would then be much lower than in other PAs with high tiger densities. On the other hand, if prey densities are high in Manas, selective poaching of economically important species like tiger and leopard may have occurred during the conflict period.

With these broad limitations in mind, we have focused on the following objectives: 1) Estimate the relative abundance of tiger and other carnivores in Manas. 2) Estimate the density of tiger prey species in the park. 3) Compare and contrast ungulate and tiger densities of Manas with comparable conflict-free PAs of the subcontinent.

Methods

Study area

The study was carried out within the 500 km^2 Manas, a UNESCO World Heritage Site which is the core area of the 2,840 km^2 Manas Tiger Reserve. The Tiger Reserve lies in the Kamrup, Barpeta, Baksa, Chirang, Bongaigaon and Kokrajhar districts of Assam (26°37'-26°50'N, 90°45'-91°15'E), India. The Manas and Beki rivers run through the Tiger Reserve which is bordered by Bhutan in the north. Manas is also contiguous with Royal Manas National Park (658 km^2) (henceforth RMNP) of Bhutan.

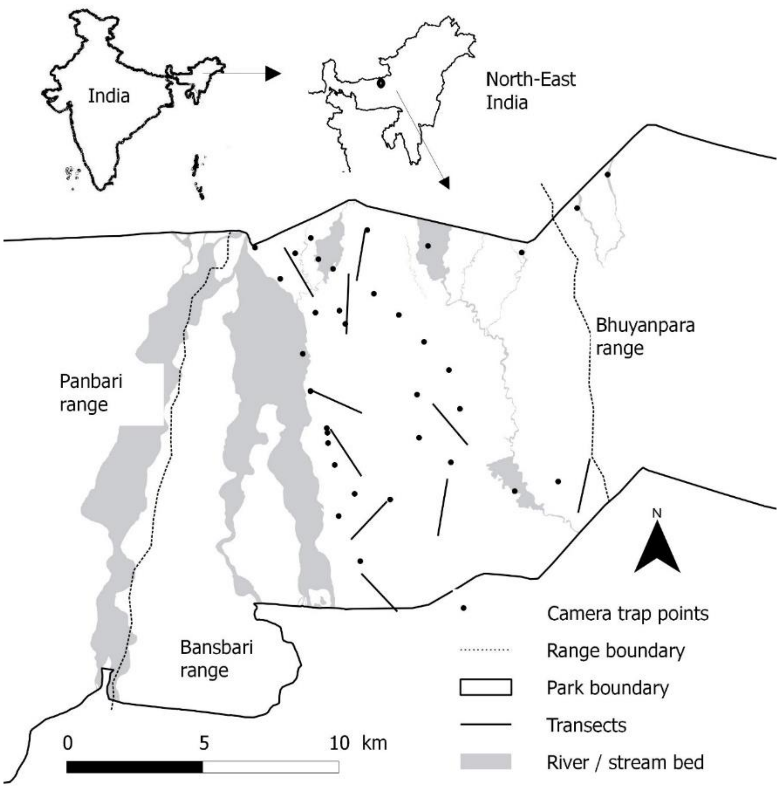

Fig. 1. Map indicating the camera trap locations (n=34), line transects (n=10) and the three ranges of Manas National Park.

Manas falls within the Himalayan biodiversity hotspot [21; 22] and is situated in the Brahmaputra plains landscape complex, which is an important tiger habitat [23]. It lies on the borders between the Indo-Gangetic and Indo-Malayan biogeographical realms with sub-Himalayan bhabar terai formation and riverine succession leading up to sub-Himalayan mountain forest habitat mosaic. There are three main types of vegetation: sub-Himalayan alluvial semi-evergreen forest, east-Himalayan mixed moist and dry deciduous forests and grasslands. Much of the riverine dry deciduous forest is at an early successional stage, being constantly renewed by floods and fire. It is replaced by moist deciduous forest away from watercourses, succeeded by semi-evergreen climax forest in the northern part of the park.

In the mid-1980s the administrative districts of the lower Assam area, within which the park was located, were embroiled in political turmoil between the state and a section of the Bodo community, the largest ethnic group of Assam, who demanded greater political rights and powers[24]. The violence that followed caused large-scale damage to Manas, adversely affecting its habitat, wildlife, management, and protection activities[25]. Consequently, the site was placed on the World Heritage Danger list in 1992 [26]. After a strenuous period of political negotiation, the ethnically-led Bodo Territorial Council (BTC) was formed in 2003, signaling the return of peace and normalcy to the area. The field work for this study was conducted from January- May 2008, after a preliminary survey in 2006.

Camera Trapping

We first carried out an extensive reconnaissance survey in all three forest ranges within Manas: the central range (Bansbari), the eastern range (Bhuyanpara) and the western range (Panbari). During the survey, signs of tiger viz. scats, pug-marks, claw marks, scraps and scent marks, were recorded and geo-referenced using a GPS.

Based on the reconnaissance survey we used the pre-existing road, trail and stream bed network to install the camera traps (Fig. 1). The camera trapping was biased towards capturing tigers and other carnivores, according to field protocols of the capture-recapture models [27]. Our effort was spread over approximately 200 km^2 covering Bansbari and parts of the Bhuyanpara,. We couldn't cover Panbari due to logistical issues such as possible theft of camera traps, because of relatively less surveillance by the forest department in that area. The camera trap survey duration was chosen after considering the demographic closure periods of large carnivores [28] and previous studies of large felids [29; 30]

At each location, a pair of traps on either side of the path facing each other was set up to photograph simultaneously both flanks of the tiger passing between the cameras. The camera traps (film-based) were fixed to sufficiently large trees wherever possible or on a custom built camera trap stand in places where no such trees were available, to meet the protocol of adequate sample points within the demarcated area. The traps were placed approximately 0.45 m above the ground. Each unit was programmed to take pictures every 30 seconds and operate only at night to minimize the monitoring costs [27], as the paths were used in daytime by tourists, armed paramilitary troops, vehicular traffic from the adjoining country of Bhutan, as well as by cattle and their herders.

All animals captured (photographed) in the camera traps were identified to the species level and the time and date of the capture (inbuilt in the camera) were noted. Consequently, each photo was rated as a dependent or independent event. Independent event was defined as (1) consecutive photographs of different individuals of the same or different species, (2) consecutive photographs of individuals of the same species taken more than 0.5 hours apart, (3) non-consecutive photos of individuals of the same species [31].

Since we didn't get both the flanks of all the captured tigers and had a small sample size, we couldn't use the capture-recapture model to estimate tiger density. Instead, we used the number of independent photographs of tigers and other carnivore species to calculate a relative-abundance index (RAI) following Carbone et al. [32], $y= 133.89x^{-0.971}$ where y is tiger density and x is the RAI. The RAI method is appropriate for rapid assessments, and has proven useful in estimating the density of animals which cannot be individually identified. In our case, since the tigers couldn't be individually identified, we felt it was justifiable to use Carbone et al's RAI [32] method. Datta et al. [33] and O' Brien et al. [31] have earlier applied the RAI based index in the south Asian region to estimate and predict tiger and prey densities in areas where they occurred sparsely.

Transect Sampling

We estimated prey densities using line transects [34-36]. A total of 10 transects, each 2 kms long, were walked by three trained observers in the mornings (6 a.m. - 9 a.m.) and afternoons (3:30 p.m. - 5:30 p.m.). The transects were selected to ensure adequate coverage of the sampled area and representation of the habitat types in which herbivore densities were expected to differ [37] (see Fig. 1). The two main habitat types in the study area are the grasslands (alluvial and savanna), which occupied about 47% of the total area, and semi-evergreen woodland forest patch which occupied about 44% of the total area [17]. Our distribution of the transect lines corresponded to the habitat attributes of Manas to eliminate the possibility of habitat bias in the sampling. Each transect was walked four times, except one which could be walked only thrice. We recorded total length of transect walked and, for each species, number of clusters detected. For each cluster, we noted the number of animals, distance, and sighting angle. Sighting distances were measured using optical range finders, and the bearing was recorded using a liquid-filled compass. The field protocols were followed as described by Kumar [38]. Prey densities and standard errors were estimated from line transect data using the program Distance 6.0 [36; 39].

Comparing the ungulate and tiger densities of Manas with other PAs of the Indian Subcontinent:

No comparable data on animal abundances were available from Manas prior to the conflict. Therefore, to evaluate the current status of tiger and prey abundances of Manas, we compared our estimates with those from other tiger habitats of the subcontinent, for both tiger and prey densities. The comparisons were made considering several parameters, viz. methods used and similarity to the habitat of study areas that were relatively peaceful. This has limited our comparison to only a few sites for which such data were available. Manas is located in a geographically unique terai landscape, which is a narrow belt of marshy grasslands, savannas and forests. They are currently confined to the south of the outer foothills of the Himalaya, the Siwalik Hills, the north of the Indo-Gangetic plain of the river Ganges, and along both banks of the Brahmaputra floodplains and its tributaries in Assam. Since we could use data only from those studies which had followed field protocols and methodologies similar to ours, we included PAs beyond terai landscape.

Results

Carnivore Abundances

Thirty-two species of mammals were recorded during the survey through camera traps, line-transect surveys and direct opportunistic sightings. A total camera trapping effort of 817 trap nights yielded 12 tiger images, of which there were 10 independent detections. Table 1 shows the RAI based density of the three greater cat species found in the study area: the tiger, the common leopard (*Panthera pardus*), and the clouded leopard (*Neofelis nebulosa*). The density of tiger is estimated to be 1.86 tigers/100 km^2 followed by common leopard and clouded leopard.

Table 1. RAI based density of tigers and other carnivores trapped during the study.

Carnivores	Scientific name	Independent detections	Total effort	RAI	Density (animals/100km^2)
Tiger	*Panthera tigris*	10	817	81.7	1.86
Leopard	*Panthera pardus*	9	817	90.78	1.68
Clouded leopard	*Neofelis nebulosa*	3	817	272.33	0.58

Herbivore Abundances

We recorded a total of 13 mammal species in the line transects. The three species of squirrels -- the hoary bellied squirrel (*Callosciurus pygerythrus*), the Himalayan striped squirrel (*Tamiops macclellandii*) and the Malayan giant squirrel (*Ratufa bicolor*) -- were excluded from the analysis because of their small size and exclusive arboreal habit. The density estimates of other herbivores are shown in Table 2. The combined ungulate density was 42.02 animals/km^2.

Comparison of Manas' tiger and ungulate densities with other PAs

The tiger and ungulate density estimates of Manas were compared with four PAs of India and one of Nepal (Chitwan National Park). While the estimated tiger density was much lower in Manas compared to the other PAs, the density of the ungulates were comparable (Table 3). In terms of species, density of wild buffalo was highest in Manas compared to the other sites, while that of other ungulate species were similar [40]. No swamp deer or the once abundant rhinoceros were recorded in the study.

Table 2. Density of prey species in Manas National Park.

Prey Species	Scientific name	Density (animals/ km^2)	Standard error	% Coefficient of variation	95% Confidence interval		n=sample size; n(o)= no. of observation
					UCL	LCL	
Wild buffalo	*Bubalus arnee*	22.88	11.63	50.85	8.53	61.37	n=10, n(o)=15
Gaur	*Bos gaurus*	5.79	3.262	56.32	1.96	17.06	n=10, n(o)=12
Hog deer	*Axis porcinus*	4.59	2.54	55.36	1.51	13.95	n=10, n(o)=24
Sambar	*Cervus unicolor*	3.95	2.51	63.56	1.14	13.68	n=10, n(o)=13
Wild boar	*Sus scrofa*	2.75	2.47	90.18	0.40	18.53	n=10, n(o)=4
Muntjac	*Muntiacus muntjak*	2.06	1.42	69.16	0.54	7.81	n=10, n(o)=7
Cattle	*Bos taurus*	5.29	7.35	138.81	0.54	51.83	n=10, n(o)=5
Capped langur	*Trachypithecus pileatus*	27.73	16.61	59.92	8.89	86.49	n=10, n(o)=16
Elephant	*Elephas maximus*	10.37	5.48	52.91	3.79	28.33	n=10, n(o)=20

Discussion

Carnivore and herbivore recovery

Our survey showed that all major carnivores survived the ethnic conflict *(see appendix)*. A previous camera-trapping survey of 2006 recorded a capture rate of 0.009 tiger/trap night [41] compared to our 0.015 tiger/trap night, indicating possible recovery in the tiger population. Emerging results from the ongoing carnivore survey also suggest a possible recovery [42].

Rhino, swamp deer and tigers were known to occur in sizeable numbers in Manas prior to the conflict period [19]. However, while rhinos went locally extinct [18], swamp deer were almost exterminated [26], and our estimates show that the tiger occurs in extremely low numbers. Rhino and tigers are two of the most 'poached' species of India, owing to high demand in the global market [43-45], and swamp deer are hunted locally for their ornamental antlers and meat. During the conflict, these species may have been selectively targeted by opportunistic poachers and anti-government forces.

Dudeley et al. [46] Nietschmann [3] and Draulans and Van Krunkelsven [7] have shown that during conflicts, economically valuable wildlife species are often targeted both by commercial poachers and by the warring parties, to meet warfare expenses [4-6]. This may be why other herbivore species managed to survive the conflict in relatively higher densities (Table 2). Applying Karanth et al's [20] model, which used prey abundance to predict tiger densities, we estimated that at current levels of density, the ungulates of Manas can support up to 8.2 tigers/100 km^2, much more than our RAI-based density estimate of 1.86 tigers/100 km^2. Thus if selective poaching can be controlled, Manas can support much higher densities of tigers. Ongoing re-introduction of the locally extinct rhinos, recovery of swamp deer in Manas [47], reduction in poaching, restoration of management, and protection measures for the tiger's preferred prey species like the muntjac (*Muntiacus* *muntjak*) , gaur (*Bos gaurus*), sambar (*Cervus unicolor*) and wild buffalo (*Bubalus arnee*) can help recover tiger population fairly rapidly [48].

Table 3. Comparison of ungulate and RAI-based tiger densities of Manas with five PAs of the Indian subcontinent. (Data source: For ungulates: Kaziranga, Kanha, Nagarhole, Pench from Karanth and Nichols [40] and Chitwan from Thapa [49]; For tiger: Carbone et al. [32]; Manas- this study.) NP=National Park; TR= Tiger Reserve MP= Madhya Pradesh; SE=Standard Error.

Sites	Forest type	Combined density estimates for ungulate prey species animals/km^2(SE)	RAI based tiger density animals/100 km^2
Chitwan NP	Alluvial grassland and moist woodland	99.9 (10.49)	29.79
Kaziranga TR	Alluvial grassland	58.1 (6.51)	17.56
Kanha TR	Moist forest	57.3 (4.07)	13.28
Nagarahole TR	Moist forest	56.1 (3.95)	10.05
Pench-MP TR	Moist forest	63.8(3.14)	6.69
Manas TR	Alluvial grassland and moist woodland	42.02 (7.39)	1.86

Limitations

Detections of all herbivores during the survey were lower than the minimum 40 recommended by Burnham et al. and Buckland et al. [34; 35]. This was due to the limited number of temporal replicates, which also resulted in high variance in the estimates. Our survey was carried out during the dry season, soon after the burning of the tall grasses by the management authorities; because it is impossible to carry out transect walks in the grasslands prior to burning. This fact also limited our sampling to 10 transects that could be adequately run during the three-month period with available manpower. Both the line transects and the camera trapping were carried out in relatively better managed and protected parts of Manas. Thus, extrapolating our results to the entire National Park or the Tiger Reserve is not recommended. In addition, because the camera trapping was primarily designed to capture tigers, other carnivores might have been under-captured during the study.

Implication for conservation

Baseline information on carnivores and herbivores:

Our study provides baseline density estimates of the herbivores and the large felids of Manas in the immediate aftermath of the ethno-political conflict. Our results can be used for evaluation of management interventions and for estimating recovery trends of animals over time. The convenient and relatively cheaper RAI-based index of tiger density might be relevant in the Indian subcontinent where funds for monitoring activities are highly inadequate [50].

Priority Areas for Recovery

We conducted this study in the Bansbari range, which is less than 1/3 of the park area and is the most effectively protected region. The remaining ranges of Panbari and Bhuyanpara still remain susceptible to illegal activities detrimental to forest conservation. Severe limitations in funds, staff, protection infrastructure, and the lack of all-weather roads and paths exacerbate the situation further [51]. We therefore recommend that management and protection efforts be focused only in the manageable areas of the park until adequate funds and infrastructure are in place. In what we call ‘Priority Areas for Recovery’ (PAR), intensive and sustained protection should be focused on small, manageable areas with the current allocation of resources for the reserve.

Nested within the larger zones, such PARs, by encompassing a good initial source population, would serve to initiate recovery by natural migration and dispersal of the source populations [52]. Bansbari, the central range of Manas where most of the protection and management activities are concentrated, could be one such PAR and extend to other areas to enhance recovery after adequate protection mechanisms are in place in these areas. Since dispersal in most vertebrates is linked to density [53], PARs could eventually function as source pools for re-colonization of outlying lower-density areas. This would complement the overall population recovery efforts in the larger region. On a larger spatial scale, the RMNP of Bhutan, which was buffered from the ethnic strife, was probably critical to the survival of some mammals during the conflict and might have helped in species re-colonization of Manas.

Conclusion

The case of Manas showed that violent political conflict had an overall negative impact on the wildlife populations, particularly on economically valuable species. However, cessation of conflicts and resumption of protection and management interventions appeared to have helped the recovery of depleted animal populations. Continued monitoring of the existing populations of wildlife species and protracted support for conservation will be critical for the future ecological health of the park.

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APPENDIX

Mammals recorded during the field-work with their current IUCN status and type of encounter (CT=Camera Traps, LT=Line Transects, DOS= Direct Opportunistic Sightings).

Sl #	Common name	Scientific Name	Family	IUCN Staus	Encounter type		
					CT	LT	DOS
1	Gaur	*Bos gaurus*	Bovidae	Vulnerable	X	X	X
2	Wild buffalo	*Bubalus arnee*	Bovidae	Endangered	X	X	X
3	Wild dog	*Cuon alpinus*	Canidae	Endangered			X
4	Rhesus macaque	*Macaca mulatta*	Cercopithecidae	Least Concern		X	X
5	Golden langur	*Trachypithecus geei*	Cercopithecidae	Endangered			X
6	Capped langur	*Trachypithecus pileatus*	Cercopithecidae	Vulnerable		X	X
7	Hog deer	*Axis porcinus*	Cervidae	Vulnerable	X	X	X
8	Sambar	*Cervus unicolor*	Cervidae	Vulnerable	X	X	X
9	Muntjac	*Muntiacus muntjac*	Cervidae	Least Concern	X	X	X
10	Elephant	*Elephas maximus*	Elephantidae	Endangered	X	X	X
11	Clouded leopard	*Neofelis nebulosa*	Felidae	Vulnerable	X		
12	Leopard	*Panthera pardus*	Felidae	Near Threatened	X		X
13	Tiger	*Panthera tigris*	Felidae	Endangered	X		
14	Leopard cat	*Prionailurus bengalensis*	Felidae	Least Concern	X		
15	Crab eating mongoose	*Herpestes urva*	Herpestidae	Least Concern	X		X
16	Himalayan crestless porcupine	*Hystrix hodgsoni*	Hystricidae	Least Concern	X		X
17	Hispid hare	*Caprolagus hispidus*	Leporidae	Endangered			X
18	Indian hare	*Lepus nigricollis*	Leporidae	Least Concern	X		X
19	Indian pangolin	*Manis crassicaudata*	Manidae	Near Threatened			X
20	Chinese pangolin	*Manis pentadactyla*	Manidae	Critically Endangered			X
21	Smooth-coated otter	*Lutrogale perspicillata*	Mustelidae	Least Concern			X
22	Himalayan yellow-throated marten	*Martes flavigula*	Mustelidae	Least Concern			X
23	Pallas' squirrel	*Callosciurus erythraeus*	Sciuridae	Least Concern		X	X
24	Hoary-bellied squirrel	*Callosciurus pygerythrus*	Sciuridae	Least Concern		X	X
25	Flying squirrel	*Hylopetes sp.*	Sciuridae	Least Concern			X
26	Malayan giant squirrel	*Ratufa bicolor*	Sciuridae	Near Threatened		X	X
27	Himalayan striped squirrel	*Tamiops macclellandii*	Sciuridae	Least Concern		X	X
28	Orange-bellied Himalayan squirrel	*Dremomys lokriah*	Sciuridae	Least Concern		X	X
29	Pygmy hog	*Porcula salvania*	Suidae	Critically Endangered	X		
30	Wild pig	*Sus scrofa*	Suidae	Least Concern	X	X	X
31	Large Indian civet	*Viverra zibetha*	Viverridae	Near Threatened	X		
32	Small Indian civet	*Viverricula indica*	Viverridae	Least Concern	X		