

THE FAUNAL COLLAPSE OF LARGE MAMMALS IN THE RESERVES OF THE NEPALESE TERAI

by Joel T. Heinen

Introduction

The primary objective of the management of nature reserves in World Conservation Union (IUCN, 1990) Categories I through V is to maintain native biotic diversity (see also Pyle, 1980), and it is therefore important to understand the ecological factors that influence diversity. MacArthur and Wilson's (1967) island equilibrium model states that diversity on islands is a function of two dynamic processes, colonization and extinction. The model states that the rate of colonization to an island is greater for nearby than for far islands, and that the rate of extinction on an island is a function of island size in that smaller islands have higher extinction rates. Consequently, small islands which are located far from a continent (which acts as a source area of immigrants) should have low diversity, large islands located far from a source area or small islands located near a source area should have intermediate diversity, and large islands located near a source area should have high diversity.

The application of this theory to reserve management has been discussed by Wilcox (1980) and Shafer (1990). Like islands surrounded by water, wildlife reserves are areas of potential habitat

for terrestrial organisms surrounded by areas which are not viable habitat, such as urban or agricultural land uses. In the case of nature reserves, other protected natural areas can be considered potential source areas. For these reasons, qualitative predictions about diversity based on this model can be made for reserves of varying sizes and distances from other reserves, which are in similar physiographic regions. In this case, these qualitative predictions are based on the historical and current presence of species native to an area, and thus the amount of faunal collapse a given area has undergone. Faunal collapse is simply the reduction of species richness due to the extirpation (locally) of native taxa (Wilcox, 1980).

Methods

The subtropical lowlands of Nepal (referred to as the Terai) contain five reserves of varying sizes. They are, from east to west: Kosi Tappu Wildlife Reserve, Parsa Wildlife Reserve, Chitwan National Park, Bardia National Park, and Sukla Phanta Wildlife Reserve. Their dates of establishment, sizes and distances to other reserves are found in Table 1.

Table 1. Names, areas, distances from source areas, and predicted diversity for the reserves of the Nepalese Terai.

Name	Date Established	Area (km ²)	Distance (in km)	Predicted Diversity
Sukla Phanta (SP)	1976	155	15	low
Kosi Tappu (KT)	1976	175	5	low, higher than SP
Parsa (PA)	1984	499	0	intermediate
Chitwan (CH)	1973	932	0	high
Bardia (BA)	1976	968	10	high

From these data, the equilibrium model predicts that diversity will be lowest in Sukla Phanta, higher in Kosi Tappu, higher still in Parsa, and highest in Bardia and Chitwan. To test these predictions, the presence or absence of large carnivores and ungulates for each area was tallied using various published sources of information (Table 2, Bolton 1975, 1976; McDougal, 1980; Majupuria, 1981; Shreshta, 1981, Gurung, 1983; Corbet and Hill, 1992; Heinen and Yonzon, 1994; Anonymous, 1995). In addition to these sources, several wardens provided valuable information about the current presence or absence of various taxa during the author's many trips to these areas (see Acknowledgements).

Historical records for the species in each area are based on these sources, known range in the last 50 years, and habitat requirements for the species (from Prater, 1980 and Corbet and Hill, 1992). All species native to the Nepalese lowlands in the orders Artiodactyla, Perissodactyla and Proboscidea are used in the analysis, with the exception of the pygmy hog (*Sus salvanius*), a small species of Artiodactyla thought to be extirpated from all areas of occurrence in Nepal. In the case of the Carnivora, only larger species are included because the information available for them is more complete than for other taxa. The only exception to this is the cheetah (*Acinonyx jubatus*), which is thought to have occurred in southwestern Nepal historically in the region of Sukla Phanta Wildlife Reserve and Bardia National Park, but its former presence in Nepalese territory is not well known and it is therefore not included in this analysis. This species was presumably extirpated from the Indian sub-continent in the 1940s (Prater, 1980; Corbet and Hill, 1992).

Results and Discussion

The results show that, in general, the predictions based on the equilibrium model are met in that the size of a reserve relates to the number of species present. The distance criterion, however, cannot be assessed using the reserves in the Nepalese Terai because they are all located relatively close to other natural areas. In the case of Kosi Tappu, the nearest fully protected area is

approximately 150 km distant, but a large forested area, Trijuga Forest, proposed as a hunting reserve (Wegge, 1976), is located nearby and several more common mammal species are thought to travel between the two areas on occasion (e.g. spotted deer *Axis axis*). This area was proposed again as a hunting reserve in the mid-1980s, but no action has been taken to date (G.R. Singh, personal communication).

The diversity prediction based on size is not met in the case of Kosi Tappu, which is expected to have a higher density than Sukla Phanta. This is doubtlessly influenced by several factors. Kosi Tappu is located entirely within the floodplain of the Kosi River, and is subject to extensive flooding during the monsoon. This is the largest single source of mortality for one species (wild buffalo *Bubalus bubalis*) which has been studied in that reserve (Dahmer, 1978; Heinen, 1993). Furthermore, unlike the other reserves, Kosi Tappu is entirely surrounded by human habitation, whereas Sukla Phanta is bordered on three sides by district forest. The effective area of Sukla Phanta is therefore much greater than its actual area, and a recent proposal calls for the extension of that reserve by another 150 km² (B.B. Thapa, personal communication). Nearly complete corridors of natural forest connect Sukla Phanta with Dudwa National Park in the state of Uttar Pradesh, India.

In addition to these factors, Kosi Tappu is dominated mostly by grasslands and riverine forests characteristic of Gangetic floodplains. The habitat of Sukla Phanta, which included upland sal forest (*Shorea robusta*), is more diverse (see Storrs and Storrs, 1984, for a description of forest types in the region). This suggests that habitat diversity may influence species diversity independent of area in some cases, but since the two factors covary in this case, the data are inconclusive. Recent sightings of leopard (*Panthera pardus*), tiger (*P. tigris*), sambar (*Cervus unicolor*), and gaur (*Bos gaurus*) have been made in the Trijuga Forest, which is considered the source area for Kosi Tappu in this analysis, but none of these species have been regularly recorded in Kosi Tappu since the reserve was created. All prefer forest and grassland adjacent to forest, but these species are also unlikely to travel across

several kilometers of agricultural fields, so these factors cannot be separated given the physical nature of Kosi Tappu.

A similar comment can be made for the higher diversity reserves. Parsa, Chitwan and Bardia all contain elevations over 600 m, and some pine and bamboo forest areas, as well as lowland riverine habitats and sal forests. In addition to greater size, therefore, they also have greater habitat variability. The presence (historical or current) of species characteristic of the mountains, such as goral (*Nemorhaedus goral*), serow (*N. sumatraensis*) and Himalayan black bear (*Selenarctos thibetanus*), attests to this. It is doubtful that these organisms ever occurred in the exclusively lowland areas of the other two reserves, although Shrestha (1981) suggested that Himalayan black bear may have historically been a seasonal migrant to the Terai of Nepal.

Chitwan and Parsa are contiguous, so they can be considered as one reserve. Chitwan is also contiguous with Valmiki Natar Wildlife Sanctuary in Bihar, India. The three reserves, together, represent one of the largest effective protected areas in the lowlands of the Indian sub-continent (almost 2,000 km² in total area), and the model would predict that diversity in these areas combined should be substantially greater than diversity in Bardia. This is not the case, and one reason may be the abundance of unprotected and semi-protected district forest in Bardia District compared to that in Chitwan and Parsa Districts. The areas of forests in these districts should be inversely related to population densities of the districts. The human population densities of the districts which contain parks and wildlife reserves are presented in Table 3. These data show that in general, human population density in the district is inversely related to present species diversity of each reserve.

The rate of immigration of animals can be enhanced through translocation and reintroduction of species. This was done on two occasions in Bardia National Park. Blackbuck (*Antelope cervicapra*) and rhinoceros (*Rhinoceros unicornis*) have both been reintroduced, which has the effect of increasing diversity in Bardia over Chitwan. Several

reintroductions have been proposed for Chitwan, and both wild buffalo (*Bubalus bubalis*) and swamp deer (*Cervus duvauceli*) could be included in the Chitwan fauna in the future. Both species were extirpated from the park in the early 1960s (Heinen and Yonzon, 1994).

If Chitwan and Parsa are considered together, the faunal collapse in these reserves (measured by the percent of species no longer present) is less than if the reserves are kept separate in the analysis (Table 2). This is because different species are no longer present in each reserve. Wild elephants (*Elaphus maximus*), for example, are recorded as present in Parsa and absent in Chitwan. Elephants are occasionally reported in Chitwan as well, but less frequently than in Parsa. This species poses a special problem with respect to all reserves because the elephant herds reported in Nepal are not completely resident in any protected area, and most are probably not completely resident in the country. The herds which concentrate their activities (>50% of the time) in Parsa, Bardia, and Sukla Phanta, for example, are all thought to leave these reserves regularly and cross the Indian border (Santiapillai, 1987). It seems likely that no reserve in the area is large enough to contain a viable population of elephants.

Using the presence/absence criterion given here, the apparent diversity of most reserves is probably higher than the actual diversity if the viability of populations were accounted for. This is especially likely to alter the results for some carnivores, about which very little is known. Wild dogs (*Cuon alpinus*), for example, have been recorded in most areas recently, but it seems unlikely that any area supports a viable population because of the exceedingly large home ranges required by packs of this species. Similarly, the populations of tigers in Chitwan and Bardia are thought to be viable, but the persistence of tigers in Sukla Phanta can be attributed to the forested corridors leading to Dudwa National Park, as there are only an estimated eight to ten breeding animals resident in the reserve (G. Upadaya, personal communication).

The clouded leopard (*Neofelis nebulosa*) is

an interesting case in point. The species was thought to be extirpated in Nepal (Majupuria, 1981), but there are several records in the central part of the country from the late 1980s (Dinerstein and Mehta, 1989). One was from Chitwan Park, another from Pokhara to the north and west of Chitwan, and another from Janakpur to the east of Chitwan. This raises the distinct possibility that there is a small population persisting throughout the central and western hills and Terai of Nepal, but nothing is known of its density of distribution. Furthermore, the western extent of the species range is not known; the recent sightings extended it somewhat into western Nepal, and this raises the possibility that the species occurred historically into the mid- and far-western development regions in the vicinity of Sukla Phanta and Bardia, though such has not been confirmed.

The data for ungulates are much better than those for carnivores. Presence in most cases is based on regular records, and there are population estimates for many species in several areas. Several of these species, such as spotted deer, hog deer (*Axis porcinus*), barking deer (*Muntiacus muntjak*), and wild boar (*Sus scrofa*), are abundant game animals, and several other species, such as rhinoceros, swamp deer and wild buffalo, have been closely studied. There is little known about the four-horned antelope (*Tetracerus quadricornis*), which has been rarely recorded in the country recently, but is thought to persist in the areas indicated in Table 2. The nilgai or bluebull (*Boselaphus tragocamelus*) is another interesting case in point. Anonymous (1995) lists it as currently present in all five reserves, but Khatri (1994) considered it absent from Chitwan, and present in very low numbers in Parsa and Kosi Tappu. This species has declined appreciably since these reserves were created, and the reasons for this are not known (Upreti, 1994).

Conclusions

Several important conclusions can be drawn from this analysis. All the reserves of the Nepalese Terai have undergone some degree of faunal collapse, and probably none is sufficiently large enough to support viable populations of certain organisms such as elephants. However, there have

been no known extinctions of native large mammals from the entire region, with the exception of the cheetah - a species whose former occurrence in Nepal is questionable, and the pygmy hog - a small species that has been extirpated from most of its former range. Neither was included in this analysis. The Himalayan black bear, currently listed as absent from all the lowland reserves, probably never was common in that region, and populations persist in all of Nepal's mountain reserves (Anonymous, 1995). Most of the remaining species of large mammals (except elephants and wild dogs) have what are thought to be viable populations in and around at least one reserve, with the caveat that little is known about several others discussed above.

The creation of a number of reserves has doubtlessly helped to maintain this diversity, and the location of reserves relatively close to each other is also beneficial. Of the five reserves, four are located close or adjacent to other fully protected areas in Nepal or India, Kosi Tappu being the exception. The two reserves which are located close, but not adjacent, to other reserves have semi-continuous tracts of forest leading to the nearest protected area (Bardia and Sukla Phanta), and movement patterns throughout these landscape-level mosaics are in need of much further study.

Several other factors may also be important in maintaining animal diversity. Habitat diversity is one such factor, and the human population densities within the districts that contain parks and reserves - which inversely relates to the amount of natural forest present outside of the reserve to act as a natural corridor - is another potentially important factor. Kosi Tappu is the poorest reserve in all cases, and the relative importance of individual factors cannot be assessed. Some factors covary intrinsically (areas with high population density also have less district forest acting as corridors) and other factors covary in this case (Kosi Tappu is small and also has less habitat diversity).

The information presented here also suggests that the data for ungulates are much more complete than those for carnivores. There is good reason to believe that in most cases where ungulates are recorded as present, the reserve supports a

viable population of the species. This is not the case with carnivores. Tiger is the only carnivore species which has been studied in depth in the Terai, though studies on sloth bear are currently underway in Chitwan (A. Joshi, personal communication), and the sightings for several other species (e.g. wild dog, striped hyena *Hyaena hyaena*) may represent rare vagrants. These results are therefore inconclusive, and it is almost certain that the overall diversity of carnivores in all reserves would be lower if population viability were assessed for individual species known to occur in each protected area.

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Table 2. The former (F) and current (C) presence (1), absence (0), and suspected presence (?) of large carnivores and ungulates in the reserves of the Nepalese Terai.

	SP		KT		Reserve Name PA		CH		BA		Notes (see codes)
	F	C	F	C	F	C	F	C	F	C	
Carnivores	F	C	F	C	F	C	F	C	F	C	
Tiger	1	1	1	0	1	1	1	1	1	1	Protected (P, no harvest)
Leopard	1	1	1	0	1	1	1	1	1	1	P
Clouded Leopard	?	0	1	0	1	1	1	1	?	0	P
Sloth Bear	1	1	1	0	1	1	1	1	1	1	P
Him. Black Bear	0	0	0	0	1	0	1	0	1	0	P
Wild Dog	1	1	1	0	1	1	1	1	1	1	Furbearer (F, Harvested)
Jackal	1	1	1	1	1	1	1	1	1	1	F
Striped Hyena	1	1	1	0	1	1	1	1	1	1	P
<i>Sub Total</i>	7,6		7,1		8,7		8,7		8,6		
<i>Faunal collapse of carnivores</i>	14%		86%		12%		12%		25%		
Ungulates											
Sambar	1	1	1	0	1	1	1	1	1	1	P
Swamp Deer	1	1	1	0	1	0	1	0	1	1	P
Spotted Deer	1	1	1	1	1	1	1	1	1	1	G (Game, Harvested)
Hog Deer	1	1	1	1	1	1	1	1	1	1	G
Barking Deer	1	1	1	0	1	1	1	1	1	1	G
Goral	0	0	0	0	1	0	1	0	1	1	G
Serow	0	0	0	0	1	1	1	1	1	0	
Four-horned Antelope	1	0	1	0	1	1	1	1	1	1	P
Bluebull (Nilgai)	1	1	1	1	1	1	1	1	1	1	P (very rare in KT, CH,PA)
Blackbuck	1	0	0	0	1	0	1	0	1	1	P
Wild Buffalo	1	0	1	1	1	0	1	0	1	0	P
Gaur	1	0	1	0	1	1	1	1	1	0	P
Wild Boar	1	1	1	1	1	1	1	1	1	1	G
Rhinoceros	1	0	1	0	1	1	1	1	1	1	Recently released in BA from CH/PA
Wild Elephant	1	1	1	0	1	1	1	0	1	1	Herds resident >50% of time
<i>Sub Total</i>	13,8		12,5		15,11		15,10		15,12		
<i>Faunal collapse of ungulates</i>	39%		58%		27%		33%		20%		
<i>Percent total Faunal Collapse</i>	30%		68%		22%		26%		22%		

Table 3. The human population densities of districts bordering wildlife reserves in the Nepalese Terai (from HMG, 1987)

Reserve	Location	District Name	Density (per km ²)
Kosi Tappu	Eastern Terai	Sunsari	274.1
Parsa	Central Terai	Parsa	210.2
Chitwan	Central Terai	Chitwan	117.0
Bardia	Midwest Terai	Bardia	98.3
Sukla Phanta	Farwest Terai	Kanchanpur	105.0

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MIGRATORY AVIFAUNA IN THE DESERT OF BALUCHISTAN

by Mohammad Nawaz

Baluchistan is the largest of the four provinces of Pakistan, covering an area of 347,059 km². This province is an arid zone tract and lies outside the monsoon area. The desert plains of this region support more winter visitors or migratory birds than any other province of Pakistan. Very little is known about bird migration in this area, particularly of the desert avifauna.

A systematic survey was conducted by the author during the winter and summer months of 1986-1989 on the Haematozoan parasites of migrant birds in Baluchistan. Most of these birds migrate from Central Asia and Russia for wintering. The following birds were found in the desert of Baluchistan:

1. Family: PTEROCELIDAE

Imperial Sandgrouse (*Pterocles orientalis orientalis*) visits the desert habitat at Zhob, Qila-Saifulla, Muslimbagh and Loralai regions during the winter season from November to January. This species is under pressure of indiscriminate hunting by poachers.

2. Family: STURNIDAE

A large number of Rosy pastors (*Sturnus roseus*) and European starlings (*S. vulgaris*) roost in this area. The former species feeds voraciously on orchard fruits and the latter on insect larvae. These