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Editorial

One of the central tasks of the Deer Specialist Group is to be part of the IUCN Global Mammal Assessment providing our input regarding all deer species (including *Tragulus*) when the IUCN calls for an update of the Red List.

The last assessment was completed 5 years ago (2008) and it is time for each species to be revaluated. Those of you who were members during the past assessment realize how large this task is. In addition we have 2 new Red List Authorities (Eveline Zanetti (eveline_zanetti@yahoo.com.br) for the New World species and Sarah Brook (sarahmbrook@gmail.com) for the Old World species) who are just getting acquainted with the criteria for each listing.

To add to this we are already behind schedule, as some groups with smaller species lists are already completing their reassessment. In consultation with our RLAs and with the SSC staff, we have decided to shorten the process. We will not reassess species whose status we do not feel has changed significantly in the past 5 years.

We will only reassess species who meet the following criteria:

a) species that we know have shown dramatic changes in distribution and numbers over the past five years;

b) **species where increased knowledge on their populations and distributions** might lead to changes in IUCN Red List status;

c) **or new species that were elevated from sub-species** based on new genetic information (and therefor the old species must also be reexamined).

We have decided to follow the taxonomy criteria of the Handbook of Mammals of the World the chapter by Stefano Mattioli as our species list and this decision results in new species to be assessed and a few species downlisted to sub-species. As in the previous assessment, we will not evaluate sub-species.

As a point of order, if a species is not reviewed then the original assessor will stay for the species description at the Red List. If a species is reassessed during this period, then the new team will be attributed for the assessment even if their changes are minor.

We plan to complete the new assessments in the next 6-8 months, so the assessments can be reviewed and completed by fall-winter 2014. This timeline is reasonable if everyone assists the RLAs when needed.

Thank you all for engaging in this important task. The Red List is increasingly used by decision makers in setting their priorities and actions. Your activities over the next few months will make the difference for deer species throughout the world.

In this issue we are including eight interesting original articles that update the knowledge of endangered deer and methods for research in the field and laboratory. Also two abstracts from new deer projects. We also included a tribute to the DSG member Bruce Banwell. The News section includes the announcement of "***The 8th International Deer Biology Congress"*** this year in China.

We want to acknowledge to all who contribute in this edition, also we extent our thanks to all of you for being part of the DSG and we invite to submit articles to the next issue.

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Global Mammal Assessment -Old World deer species

We have 51 Old World deer species for re-assessment. Volunteers who will assist with the process include Rob Timmins, Tom Gray, Noam Werner, David Saltz, Erik Meijaard, Gordon Dryden, Jan Pluhacek, Simone Ciuti, Ruth Carden, Olga Pereladova, Ann Gunn, Rakesh Shukla and Kae Kawanishi. Several of the Old World genera currently have no-one to assist with the assessments (we are still looking for volunteers), including *Moschiola* (2 species) *Moschus* (7 species) and *Tragulus* (6 species) and *Hydropotes inermis*.

Dr. Sarah Brook
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Global Mammal Assessment -New World deer species

Our highest priorities to the update of the Red List have been selected (based on criteria explained above): a) species that we know have shown dramatic changes in distribution and numbers over the past five years; b) species where increased knowledge on their populations and distributions might lead to changes in IUCN Red List status; c) or new species that were elevated from sub-species based on new genetic information (and therefore the old species must also be reexamined). We indicated the species we know we will review (A) and species that we hope to review if sufficient volunteers step forward to assist the RLAs (criteria B and C).

We have 18 New World deer species; and are classified as:

A) Three as prioritaria to do the assessment *Hippocamelus antisensis*, *Hippocamelus bisulcus*, *Mazama nana*,

B) 11 of them *Blastocerus dichotomus, Mazama americana, Mazama bricenii, Mazama chunyi, Mazama nemorivaga, Mazama pandora, Mazama rufina, Mazama temama, Ozotoceros bezoarticus, Pudu mephistophiles, Pudu puda*

C) and four of them *Mazama bororo, Mazama gouazoubira, Odocoileus hemionus, Odocoileus virginianus*).

Until this moment we have eighteen volunteers (José Maurício Barbanti Duarte, Alexandre Vogliotti and Fernanda Braga from Brazil, Susana Gonzalez from Uruguay, Pepe Cartes from Paraguay, Paulo Corti and Eduardo A. Silva-Rodriguez from Chile, Hernán Pastore, Juan Pablo Juliá JoAnne Smith, John Jackson, Mariano Gimenez Dixon and Norma I. Díaz from Argentina, Luis Pacheco from Bolivia, Heiko Wittmer from New Zealand, Donald E. Moore and Jaime Jimenez from USA, Javier Barrio from Perú,) to assist the RLA.

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Conservation of huemul in the future Patagonia National Park: a call for immediate management intervention

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Abstract:
Huemul on the privately owned Estancia Vallé Chacabuco in Chilean Patagonia have been negatively affected by management associated with the conversion of the property into the future Patagonia National Park. Specifically, the removal of abundant livestock together with abrupt cessation of predator control has resulted in increased predation rates of both fawns and adult huemul. High predation rates now threaten the viability of this population of huemul. We outline a framework for implementing necessary management to reduce predation and simultaneously call for future research to further our understanding of the causes underlying the decline of huemul. Our management recommendations include the targeted removal of pumas known to selectively prey upon huemul and also the reduction of culpeo foxes. Given the reluctance of the landowners to implement such management, we call for CONAF to take over huemul management in the future Patagonia National Park to avoid further population declines and subsequent local extinction.

Resumen:
En la Estancia Vallé Chacabuco en la Patagonia chilena, de dueños privados, huemules han sido impactados negativamente por el manejo asociado con la conversión de la propiedad al futuro Parque Nacional de Patagonia. Específicamente, la remoción de numeroso ganado, en conjunto con la cesación de control de predadores, han resultado en un aumento en las tasas de depredación tanto de adultos como crías de huemules. Altas tasas de depredación ahora amenazan la viabilidad de esta población de huemules. Esbozamos un marco para implementar el manejo necesario para reducir la depredación y simultáneamente pedimos que haya investigación en el futuro para avanzar nuestro entendimiento de las causas subrayando el declive de las poblaciones de huemules. Nuestras recomendaciones de manejo incluyen la remoción selectiva de pumas que depredan selectivamente a los huemules y también a zorros colorados. Dado las pocas ganas que tienen los estancieros de implementar tal manejo, exigimos que CONAF se encarguen del manejo de huemules en el Parque Nacional de Patagonia del futuro para evitar más disminuciones en la población y una subsecuente extinción local.

Keywords: Conservación Patagonica, culpeo fox, huemul, predator control, puma

Introduction

Huemul (*Hippocamelus bisulcus*) (Figure 1) are among the most threatened deer species in the world. The estimated 1,500 remaining individuals are currently fragmented into >100 small and disjunct populations and are found only

in Chile (totalling ca. 1000 individuals) and Argentina (totalling ca. 500 individuals) (Jimenez *et al*. 2008). One of the largest remaining huemul populations in Chile can be found in Patagonia both on private property owned by Conservación Patagonica, an NGO registered in California, USA, and neighbouring public lands. Conservación Patagonica began acquiring land in 2004, when it purchased the *Estancia Valle Chacabuco*, one of Chilean Patagonia's largest sheep farms. The primary goals of Conservación Patagonica are to restore degraded agricultural lands on the Estancia into productive wildlife habitat and then integrate these lands into the future Patagonia National Park (hereafter referred to as PNP) (Conservación Patagonica 2013). The roughly 2,650 km^2 PNP (Figure 2) is scheduled to open in 2014, and will encompass and protect approximately 120 huemul (roughly 10% of the remaining huemul in Chile) (Wittmer *et al*. 2013a).

From late 2007 until 2010, we conducted research aimed at understanding the consequences of policy changes associated with the establishment of the PNP for the viability of huemul. Management changes were implemented immediately following the acquisition of the Estancia by Conservación Patagonica and were meant to prepare the ranch for conversion to a National Park. Management changes included the cessation of predator control and the commencement of a 4-year program to remove approximately 30,000 domestic sheep and 3,800 cattle (Conservación Patagonica 2013). As previous research (e.g., Courchamp *et al*. 2003) has indicated that there may be unanticipated risks associated with abrupt changes in predator or prey abundances, we were concerned about the potential negative effects of the above -described changes in local management on the viability of huemul. More specifically, given that previous research had identified predation from pumas (*Puma concolor*) and culpeo foxes (*Lycalopex culpaeus*) as a significant concern for huemul in the future PNP (Corti *et al*. 2010), we anticipated that the recovery of predator populations associated with cessation of predator control simultaneous with the reduction of available prey (i.e., domestic sheep) would result in increased and potentially unsustainable predation of huemul (both fawns and adults).

Figure 1: Male and female huemul (*Hippocamelus bisulcus*) in the future Patagonia National Park, Chile (photograph by L.M. Elbroch).

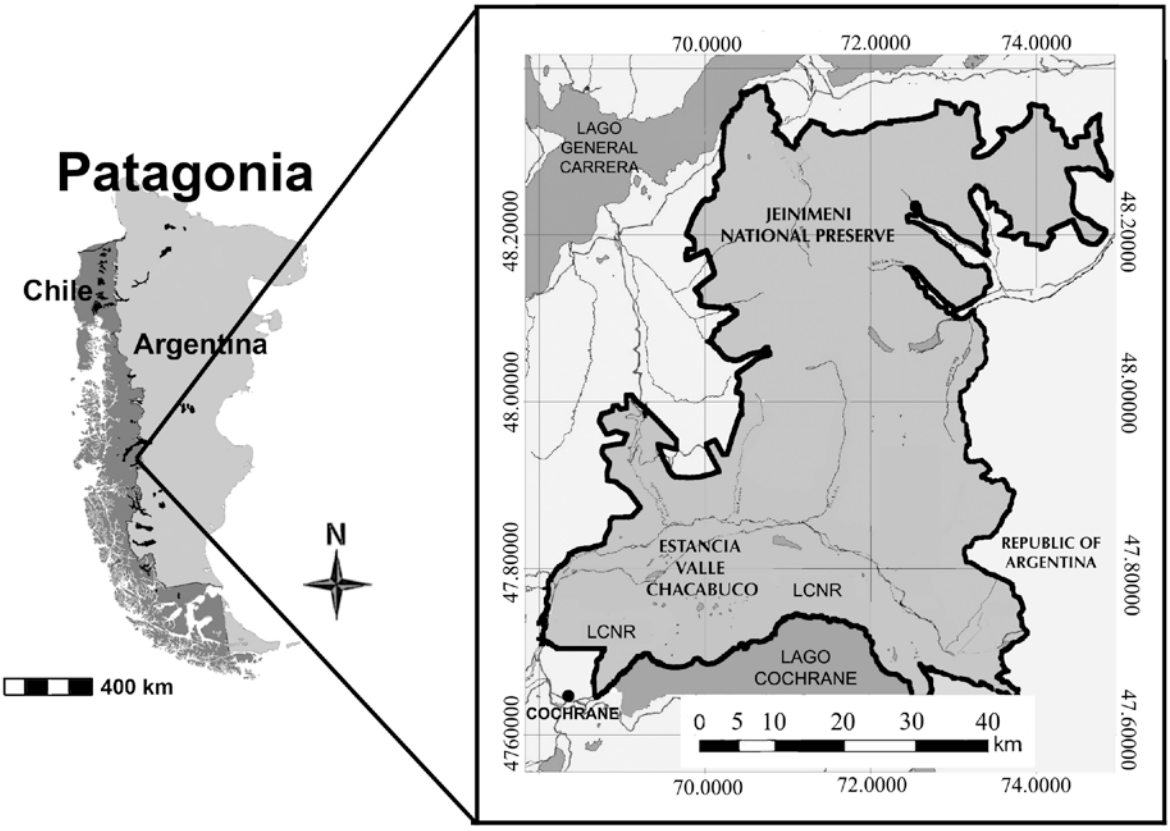

Figure 2: Location of the future Patagonia National Park (PNP) in Chile. The PNP will encompass ca. 2,650 km^2 and consist of both public (i.e., Jeinimeni National Preserve & Lago Chochrane National Reserve (LCNR) and private lands (i.e., *Estancia Valle Chacabuco*).

Four results from our research on the foraging ecology of pumas and their predation of huemul raised serious concerns about the future viability of the small huemul population in the PNP. First, pumas in the PNP currently occur at densities comparable to unhunted populations in other parts of their range (Elbroch & Wittmer 2012a) including Patagonia (Rinehart *et al. in press*) and are primarily preying on species other than huemul; >98% of puma diets were comprised of guanaco (*Lama guanicoe*), sheep, and European hares (*Lepus europeaus*) (Elbroch & Wittmer 2013a). Second, observed kill rates of pumas in the primarily open grasslands of Chilean Patagonia, where most of the available prey biomass can be found, appear almost 50% higher than kill rates observed in the more forested habitats of North America (Elbroch & Wittmer 2013a). These increased kill rates were at least partly due to

competition from scavengers, particularly Andean condors (*Vultur gryphus*) (Elbroch & Wittmer 2012b, 2013b), but also new research methods that have improved detection of puma kill sites (Elbroch & Wittmer 2013a). Third, during our study, pumas killed huemul almost twice as often as expected based on total prey availability in the PNP (Elbroch & Wittmer 2013a). When we used our results to adjust estimated survival probabilities of huemul based on identifiable individuals (Corti *et al*. 2010), we found that predation rates on both adults (from pumas) and fawns (from culpeo foxes) were unsustainable (Wittmer *et al*. 2013a). Finally, based on outcomes of a Population Viability Analysis (PVA), we predicted that huemul in the PNP are at risk of extinction (Wittmer *et al*. 2014). Ultimately, our results provided further support for the apparent competition hypothesis as the underlying cause responsible for current declines in the PNP first proposed by Corti *et al*. (2010).

Management strategies required to conserve species affected by apparent competition are complex but likely require some level of active predator control, at least temporally (Wittmer *et al*. 2013b). Consequently we proposed to cull individual pumas that have been confirmed to select huemul, defined as killing huemul disproportional to their availability, to reduce adult huemul mortality rates and reverse the current population decline (Elbroch & Wittmer 2013a). More recent analyses from our PVA (Wittmer *et al*.2014) indicate that both puma and culpeo foxes may have to be controlled to achieve population growth of huemul. Controlling predator species, even to protect endangered prey, is controversial (see references in Wittmer *et al*. 2013b). However, we believe that management aimed at addressing causes of decline of huemul in the future PNP ought to be based on best scientific understanding of limiting factors rather than policies based on personal values.

Therefore we propose the following actions to *Corporación Nacional Forestal* (CONAF), the agency responsible for managing protected areas in Chile:

1) Instead of waiting until the proposed opening date in 2014, CONAF should resume responsibility for management of huemul in the future PNP immediately.

2) Immediately hold a workshop, inclusive of all stakeholders as well as independent researchers, to develop a recovery strategy for huemul. Such a recovery strategy should be based on all available data, including those collected by staff of Conservación Patagonica.

3) Immediately administer wildlife monitoring and research programs within an adaptive management paradigm (Walters and Holling 1990). Conservation actions should involve the following individual components:

a. Reinstate an intensive monitoring study of individual pumas using GPS satellite technology to facilitate the identification of their kills and the proportion of huemul in their individual diets. Pumas shown to select huemul should be removed. Our previous results suggest that a limited number of individual pumas specialize on huemul (Elbroch & Wittmer 2013a), so such intervention would be highly targeted. Prior to deployment of GPS collars, capture protocols for pumas in the PNP need to be reviewed and addressed to reduce injuries (Elbroch *et al*. 2013).

b. Initiate a detailed study of fawn predation by culpeo foxes in order to further our understanding of fox predation on huemul fawn survivorship (Corti *et al*. 2010, Wittmer *et al*. 2013a). Remove resident culpeo foxes from known fawning locations as a precautionary measurement and to quantify possible increases in fawn survivorship associated with fox removal.

c. Implement an effective monitoring program for huemul across their distribution in the PNP using marked individuals as described by Wittmer *et al*. (2010). Such a monitoring project is essential to provide accurate yearly estimates of huemul abundance and thus population growth in the PNP needed to assess outcomes associated with predator control within the adaptive management framework outlined above. Ultimately data on changes in huemul abundances in the PNP are also needed to further test our hypothesis that apparent competition is currently the most significant threat to the viability of huemul in the PNP.

d. Further assess the role of domestic dogs in the decline of huemul, particularly around the township of Cochrane (Corti *et al*. 2010) and, if necessary, address this issue through education or dog control.

e. Initiate a comprehensive study to evaluate other potential effects associated with the establishment of the Park. For example, an extensive trail system is currently being established in the PNP (Conservación Patagonica 2013). While tourism is an important mandate of all National Parks, research in other systems has shown that trails may provide ease of travel for predators, subsequently resulting in increased mortality of endangered prey (e.g., wolf (*Canis lupus*) predation on caribou (*Rangifer tarandus*); Whittington *et al*. 2011).

During our study we observed significant positive changes associated with the restoration measures implemented by Conservación Patagonica. The removal of fences together with the increased access to low elevation grasslands appears to have benefited species such as guanacos (Wittmer *et al.* 2013a). In addition, charismatic species such as condors are benefitting from a healthy population of pumas providing access to carcasses (Elbroch & Wittmer 2012b). Unfortunately, our results also indicated that current management is threatening the viability of huemul in the PNP. Our proposed actions are controversial as they may require killing charismatic and protected carnivores, both pumas and culpeo foxes, and, due to the scale of the proposed monitoring projects, will also be expensive. Further, since Conservación Patagonica holds to a no-predator-kill policy, huemul management falls to CONAF to ensure that huemul will remain a vital part of the future PNP and an opportunity for all people, both Chilean and foreign, to enjoy and experience. Given that Conservación Patagonica unintentionally created new community dynamics, costs for implementing future restoration actions should be covered by the landowners. Because if we cannot maintain huemul inside protected areas such as the PNP, their future as a species in Chile indeed looks bleak.

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Conservation of Pampas deer *Ozotoceros bezoarticus celer in San Luis Province*

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Abstract
The Environmental Department of San Luis has proposed, through the Provincial Plan for Pampas Deer Conservation, a series of guidelines for the management and conservation of this species in the Province. The most advanced lines of work so far include estimates of population abundance from aerial surveys, agreements with landowners to protect the main population centers and hiring rangers to monitor the area. Simultaneously, we are working on the creation of private protected areas and promoting incentives and compensation to owners who maintain favorable environments for the species. As for diffusion, proposed action lines include declaration of the specie as a natural provincial monument, as well as education and outreach activities about the status of pampas deer and the need to preserve it.

Resumen
El Ministerio de Medio Ambiente de San Luis ha propuesto, a través del Plan Provincial de Conservación de Venado de las Pampas (*Ozotoceros bezoarticus celer*), una serie de directrices para el manejo y la conservación de la especie en la Provincia. Las líneas de trabajo más avanzadas hasta el momento incluyen las estimaciones poblacionales por censos aéreos, los convenios con propietarios de campos para la protección de los principales núcleos poblacionales y la contratación de guardaparques para la zona. Simultáneamente, se trabaja en la creación de áreas protegidas privadas y la promoción de incentivos y compensaciones para propietarios que conserven ambientes favorables a la especie. En cuanto a la difusión, las líneas de acción propuestas comprenden la declaración de la especie como monumento natural provincial y actividades de educación y divulgación sobre la situación del venado y la necesidad de conservarlo.

Key words: pampas deer (*Ozotoceros bezoarticus celer*), aerial survey, private protected areas

Introduction

The Pampas deer (*Ozotoceros bezoarticus*), is a medium-sized deer that inhabits savannas and grasslands of southern South America. In Argentina two subspecies are currently recognized, divided into four populations. The largest population for the subspecies pampeana *Ozotoceros bezoarticus celer*, endemic to Argentina, inhabits semi-xeric grassland environments of south-central San Luis (Dellafiore 1997; Dellafiore *et al.* 2003; Demaria *et al.* 2003). Internationally, the species is listed in Appendix I of CITES and categorized as Near Threatened by the IUCN (Gonzalez & Merino, 2008); although the populations are declining, this does not occur at a high enough rate to be categorized as Vulnerable. Nationally, it is categorized as Endangered (Ojeda *et al.* 2012). INTA studies,

through aerial surveys during the 90's, showed that the main population centers of San Luis are found in ranching areas which have not been greatly modified by human activities. The absence of roads, the difficulty for agriculture due to climatic constraints, large paddock sizes, low livestock densities and the vast grasslands with few significant changes favor the survival of the species in the region. Historically, this population was estimated at between 500 and 1200 individuals (Dellafiore *et al*. 2003), located within private fields, with a total distribution area of 450,000 hectares, although the highest concentration occurs in approximately 145,000 hectares (Demaria *et al*. 2003). However, these conditions have changed dramatically in recent years due to significant development of the area. Incorporation of new tillage technologies and introduction of African grasses, along with construction of two new paved roads, have caused a significant change in the social and productive profile of this area. Studies using satellite images show, in the period 1985-2001, a decrease of 92.6% to 43.8% for the area covered by natural grasslands, further increasing landscape fragmentation, especially in the area of greatest agricultural potential. Although this intensification of agriculture seems not to adversely affect the deer (Merino *et al*, 2009; Merino *et al*, 2011), the species is exposed to a number of factors that affect it to a greater or lesser degree, such as illegal hunting, road accidents, predation by dogs, competition with livestock and transmission of diseases (Miñarro *et al.* 2013).

Periodic monitoring of distribution and population size of key groups, as well as further studies of factors -ecological, biological, health and social- that affect these, are priority actions in the short and medium term (Miñarro *et al*. 2013). To implement these studies, the San Luis government elaborated the Provincial Plan for Pampas Deer (*Ozotoceros bezoarticus celer*) Conservation, a document that provides a framework for planning and implementation of studies and actions to increase the protection of the species and promoting good management of resources in the area to conserve it. This article aims to disseminate the work done by the Province for the conservation of the species within the framework of the Provincial Deer Conservation Plan.

Objectives and Methodology

The Provincial Deer Conservation Plan aims to recover and conserve local populations of pampas deer, ensuring the maintenance of viable wildlife populations. For that purpose, a set of action lines was defined, each of which proposes a number of activities aimed at improving management and conservation of the species in the province. These include the following actions:

Identify and implement conservation and management actions of the specie and its habitat	
	Within conservation area: protect core populations; promote creation of private protected areas, ensuring their protection by hiring provincial rangers with infrastructure and control means.
	Livestock management in private fields: regulate livestock management; regulate presence of dogs in livestock management, coordinate an appropriate system of epidemiological surveillance
	Exotic species: prevent introduction of exotic herbivores in the area, control and possibly kill bighorn, wild boar and dog populations; control domestic dogs.
	Poaching: effective and permanent checks by assigned rangers; encourage hunting event reporting, promote joint work with the Province Police, Attorney Health Control (COSAFI), Field Department and Provincial Rangers.
Increase available information about distribution, population status and conservation	
	Distribution: update the distribution map in south of province.
	Populations: estimate the relative population abundance using aerial surveys and compare with aerial survey data from 1997; estimate population trends; establish the causes that limit population growth and the potential for mitigation; assess health status of deer and livestock in areas of sympatry to determine important pathologies; stimulate the universities to develop research related to the deer and their habitat.
Develop a strategy for education and awareness about the status of the species and the importance of its conservation.	
	Perform education and outreach activities about the status of pampas deer and the need to preserve it; develop a didactic document for rural teachers; conduct workshops with rural people in order to involve them in the species´ conservation.
Promote policies and legislative actions which support the protection of the species and its habitat.	
	Promote the pampas deer species as a Natural Monument; boost declaration of the zone as a protected area; encourage the signing of agreements with owners of fields with deer and provide incentives/compensation; regulate activities affecting deer.

For owners of fields with deer, the realization of meetings was projected to discuss the conditions for the creation of private protected areas; evaluating agreements, actions and management possibilities that benefit both owners and deer.

For relative abundance estimations, the aerial surveys method was chosen, with transects at regular intervals and 2 observers, making 20 transects at an average height of 80 meters. The samplings cover most of the area inhabited by the species, from: 33º 54´ 4.7´´ S; 65º 34´ 44.8´´ W to 34º 37´ 21.1´´S, 66º 15´ 29.1´´W. To carry out the flights, support is provided by the *V Brigada Aérea de Villa Reynolds* which provides planes and pilots, and also by Dr. Manuel Demaria, who was involved in the 90's surveys.

Results

Since approval of the Provincial Plan, all proposed measures show some progress. In September 2013 the Nº IX-0852-2013 Law of Private Protected Areas was enacted in order to provide incentives to the owners to create them. In this context, a memorandum of agreement between the Environment Department and "*Antiguas Estancias Don Roberto S.A.*" ranch was signed, in order to work together for conservation and care of deer that live within the limits of the property. This agreement is very important because it represents an example to imitate by other owners in the area, but mostly because this ranch area was considered by studies as an active and historic core of the population of pampas deer.

To ensure effective protection, two provincial rangers were hired, to provide a permanent presence in the area, thereby facilitating greater control over poaching and conflicts with pets.

The estimation of relative population abundance and the location of main centers is being done by aerial surveys. So far, following the approved methodology, three flights have been made. A fourth flight will be conducted soon, completing the first cycle of samples covering the 4 seasons, and the first analysis of the data obtained will be compared with historical information. Preliminary data collected so far indicate an average presence of 70 deer in the sampled area (Figure 1).

Regarding dissemination activities, we are printing a brochure for spreading information about the importance of the species, its conservation status, threats and measures to contribute to its protection. Also, the statement of the pampas deer as a Provincial Natural Monument is to be treated by the provincial legislature, a category established by Provincial Law Nº IX-309-2004 of the Protected Areas System of San Luis.

Figure 1. Pampas deer from and livestock in "*El Centenario*" ranch 2007 (Top) and females in "*El Centenario*" ranch. 2007 (botton) taken by Diego Meier

Conclusion

From the writing of the Provincial Plan for Pampas Deer Conservation, we began working on the different lines of proposed action, achieving different levels of progress in each of them. Considering everything done so far, two essential actions for the protection of the species should be especially highlighted: population estimates through aerial surveys and effective protection of the main populations through the agreement with the "*Antiguas Estancias Don Roberto S.A*" ranch with the recruiting of exclusive Provincial Rangers for the area.

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Predicting the density and abundance of white-tailed deer based on ecological niche theory

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Abstract

Based on the theory of ecological niche modeling, a novel approach known as the Distance to the Niche Centroid (DNC) method was recently proposed for mapping the abundance/density of species. To illustrate the utility of this approach, we present the application of DNC, to predict white-tailed deer *Odocoileus virginianus* distribution, density and population size in the Tehuacán-Cuicatlán Biosphere Reserve (TCBR), Mexico. Using a distribution map based on occurrence data, estimation of DNC, and regression analysis between DNC and 14 independent sites containing local density information pertaining to this species from 2010 to 2011, we generated a map of the potential distribution of white-tailed deer density in the 4,906 km^2 that comprise the TCBR. Abundance (total number of deer) in the TCBR was calculated using both field estimations and the predicted map of density. We briefly discuss some biological, management and conservation implications of this novel conceptual and methodological approach.

Resumen

Con base en la teoría de nicho ecológico, recientemente se propuso un nuevo método conocido como la distancia al centroide del nicho (DNC) para mapear la abundancia de las especies. Para ilustrar la utilidad de este enfoque, en este trabajo se presenta la aplicación del método con el venado cola blanca *Odocoileus virginianus* en la Reserva de la Biosfera Tehuacán-Cuicatlán (RBTC), México. Empleando el mapa de la distribución potencial del venado en la reserva basado en datos de presencia, cálculo del DNC, y una análisis de regresión entre el DNC y las estimaciones de la densidad de venados de cola blanca en 14 localidades obtenidas en 2010-2011, generamos un mapa de la distribución potencial de la densidad (D, ind/km^2) del venado cola blanca en las 4,906 km^2 que abarca la RBTC. La abundancia (número total de venados) en la RBTC fue calculado empleando tanto las estimaciones de la densidad obtenidas en campo así como las predichas por la modelación. Brevemente, discutimos las implicaciones biológicas, de manejo y conservación de esta nueva aproximación conceptual y metodológica.

Key words: MaxEnt, distance to centroid niche, potential density, conservation, management.

Introduction

Ecological niche modeling is used to predict the potential distribution of a species (Peterson *et al.* 2011, Franklin 2012). Distribution models are used not only to understand the ecological requirements of the species, but also to determine aspects of biogeography, predict the existence of unknown species and populations, identify sites for translocations and reintroductions, select areas for conservation, and mitigate the effects of climate change, among others (Peterson *et al.* 2011). Niche modeling has limitations in its ability to predict patterns in spatial variation of the abundance of species within their geographic ranges (Vanderwal *et al.*, 2009, Jiménez-Valverde 2011, Torres *et al.* 2012).

According to Hutchinson (1959), the ecological niche of a species can be conceptualized as an *n*-dimensional hypervolume, in which each axis represents a key variable for the survival of the species populations without the need for immigration. Based on these ideas, Maguire (1973) proposed that the niche has an internal structure within which there is a point, or centroid, where the suitability of the species is maximized because the conditions are optimum (Fig. 1a), and also that the suitability of an area for a species decreases inversely proportional to the distance from this centroid within the ecological space (Fig. 1b). Despite its significance, however, the hypothesis of the centroid did not have much impact in subsequent years, although the idea persisted (without being proven) that abundance reflects the degree to which the environment satisfies multiple requirements of the ecological niche of each species (Brown 1995, but see Van Horne 1983). Recently, Martinez-Meyer *et al.* (2013) tested the hypothesis of Maguire (1973) and proposed that the distance to niche centroid (DNC) represents a novel approach with which to predict the density and abundance of a species. In this paper, we implement the DNC method to predict the potential population density and abundance of the white-tailed deer *Odocoileus virginianus* in the Tehuacán-Cuicatlán Biosphere Reserve, Mexico.

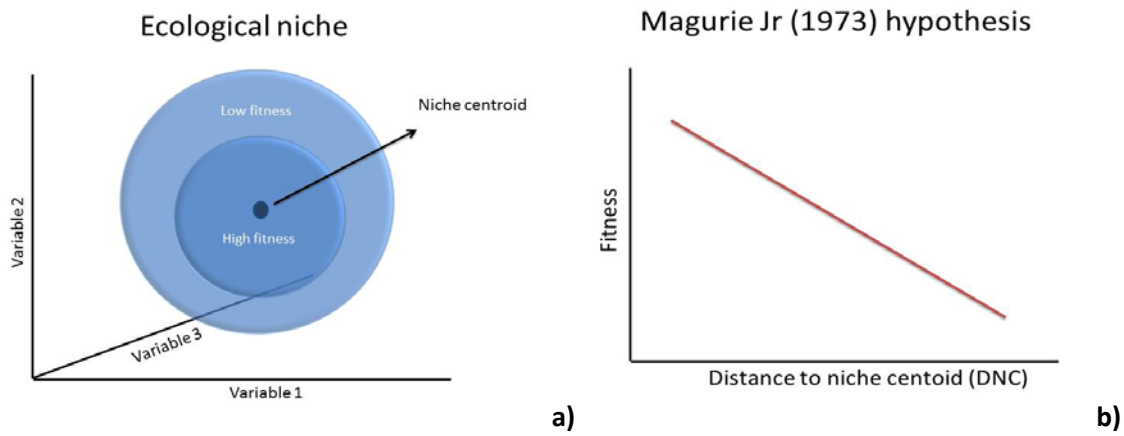

Figure 1. A) Graphical representation of the fitness along three environmental variables where the optimal is the centroid of the three-dimensional ecological niche of a hypothetical species. B) Hypothesis proposed by Maguire (1973) and tested by Martinez-Meyer *et al*. (2013). The fitness of species is inversely proportional to the distance from the niche centroid (DNC).

Methods

The study was conducted within the Tehuacán-Cuicatlán Biosphere Reserve (TCBR), a 4,906 km^2 reserve located in the states of Puebla and Oaxaca (17° 39' - 18° 53' N and 96° 55'- 97° 44' W) (Fig. 2). The TCBR contains a complex physiographic mosaic featuring internal valleys separated by numerous mountains. Altitude ranges from 600 to 2950 m asl, with annual mean temperatures varying from 18 to 22 °C and annual precipitation from 250 to 500 mm. Vegetation types are tropical dry forest (33%), semi-arid shrub land (30%) and temperate pine-oak forest (20%). The incidence of deforestation and fragmentation in the TCBR is considerably lower than in other Mexican tropical dry forests.

To model the spatial distribution of white-tailed deer density in the TCBR, we followed the protocol described by Martinez-Meyer *et al.* (2013), Yañez-Arenas *et al*. (2012a) and Escalante and Martínez-Meyer (2013).

Step 1.We gathered information on the presence and density of the white-tailed deer from systematic fieldwork from 2010 to 2012. Presence records were obtained via tracks, fecal pellets and direct observations. Additionally, we obtained records from the Global Biodiversity Information Facility (http://data.gbif.org/species/), and the Global Network on Biodiversity Information (www.conabio.gob.mx/remib/doctos/remib_esp.html) databases. Environmental variables were used to build the ecological niche model and represent climatic and non-climatic distributional controls.

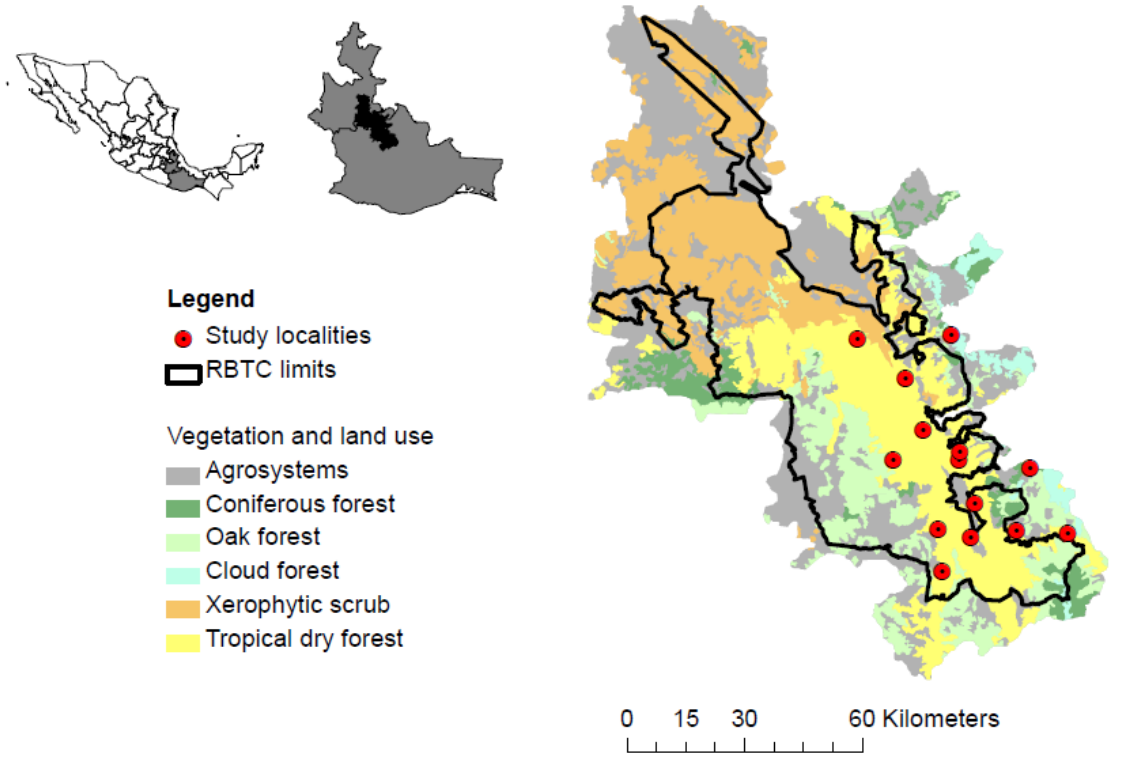

Figure 2. Geographic location of the Tehuacá Cuicatlán Biosphere Reserve, principal vegetation types, and the 14 studied sites.

Step 2. We used a modification of the previous potential distribution model of white-tailed deer in the TCBR (Ortiz-Garcia *et al*. 2012). Variable selection was made following Shi *et al*. (2006), based on Pearson's correlation tests and stepwise regressions. We used six climatic layers drawn from the Worldclim data set (Hijmans *et al.* 2005), two representing temperature (bio1 = annual mean temperature, bio2 = mean diurnal temperature range), and four representing water availability (bio12 = annual precipitation, bio14 = precipitation of driest month, bio15 = precipitation seasonality, bio19 = precipitation of coldest quarter). The non-climatic variables were a categorical layer of vegetation types and land use generated from the National Forest Inventory III (Palacio-Prieto *et al*. 2000), slope and aspect, derived from the SRTM elevation model (http://srtm.csi.cgiar.org). In total, we used nine environmental layers in geographical coordinates (Datum WGS-84) resampled to a grain size of 30 arc seconds (~ 1 km^2). Ecological niche and distribution modeling was carried out using the maximum entropy approach (Maxent; Phillips *et al*. 2006). We used 80% of the presence records as training data and the remaining 20% for evaluation; all other settings were default values. Maxent's logistic output was converted into binary maps using the minimum

training presence threshold value (Pearson *et al*. 2007). We evaluated Maxent predictions using the area under the receiver-operating characteristic curve (AUC) considering its limitations (Lobo *et al*. 2008).

Step 3. To estimate Euclidean distances calculated in GIS, we first extracted values of each environmental variable for all pixels where the species was predicted present according to the binary distribution maps. To allow direct comparisons among dimensions and avoid biases introduced by differences in scale among ecological dimensions, we standardized each dimension by subtracting each value to its mean and dividing by its standard deviation, producing a *Z*-standard normal variable (mean = 0, variance = 1). Therefore, the multidimensional niche centroid was actually the point in which the value of all variables was 0. Multidimensional Euclidean distance from each point with a density datum to the niche centroid was calculated as follows:

$$DNC = \sqrt{\sum \left(\bar{\mu}_j - a_{ij}\right)^2}$$

where DNC is the distance to niche centroid, μ is the mean of variable *j* and *a* is the value of the variable *j* in population *i*. This DNC was our predictor variable and the white-tailed deer density the response variable.

Step 4. Estimates of white-tailed deer densities (D, ind./km^2) were obtained in 14 sites in the TCBR from 2010 to 2011 (Fig. 2). We used the pellet-group count method in eight strip transects (500 x 2 m) per site (total of 120 transects) (see details, Camargo-Sanabria and Mandujano 2011, Ramos-Robles *et al.* 2013). A linear regression model was employed to fit DNC and density. An important aspect is that DNC and local density estimations were independent data in this model.

Step 5. We superimposed the map of density over that of the TCBR, classifying density into three categories: low, medium and high, according to the lowest and highest field estimations of density. Finally, we estimated abundance (N, total number of deer) in the TCBR, considering the area (number of pixels) in each density category obtained with the DNC method, and the mean and variation estimates of density in each category.

Results

We estimated the white-tailed deer's potential distribution covered 92% of the TCBR (Fig. 3). Estimates of white-tailed deer densities in the 14 sampled sites in TCBR ranged from 0.01 to 3.5 deer/km^2, with an average of 1.9 deer/km^2. As we predicted, deer density decreased with increased distance to the centroid niche (Fig.4, $y = -0.653x + 5.006$; $r^2 = 0.76$, $p < 0.005$). A validation test suggested that the regression model had a predictive capacity of 62%

in the studied area. Following the DNC approach, a map of predicted density categories (low, medium, and high) was produced for the TCBR (Fig. 3). We estimated TCBR contained 10,004 deer (range 7,788 to 12,649) (Table 1). These data clearly suggest that the TCBR can potentially maintain an important population of white-tailed deer.

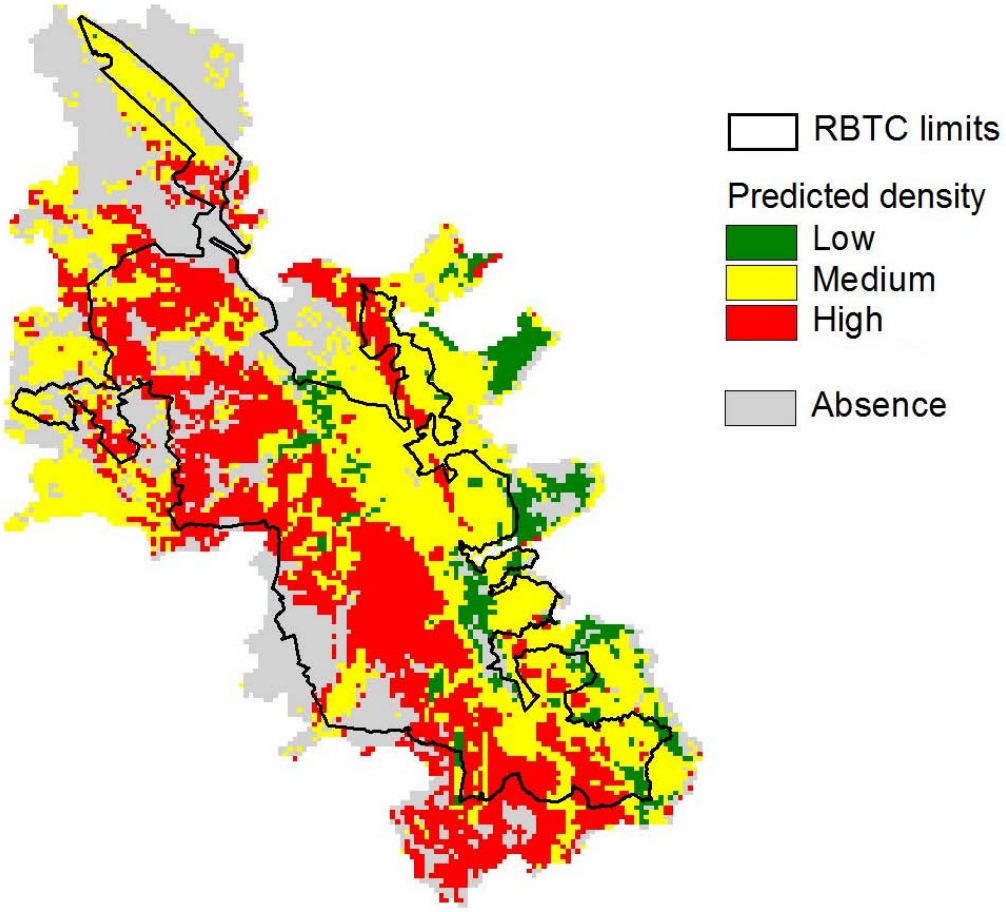

Figure 3. Map of predicted white-tailed deer density in the Tehuacán-Cuicatlán Biosphere Reserve produced using the DNC approach.

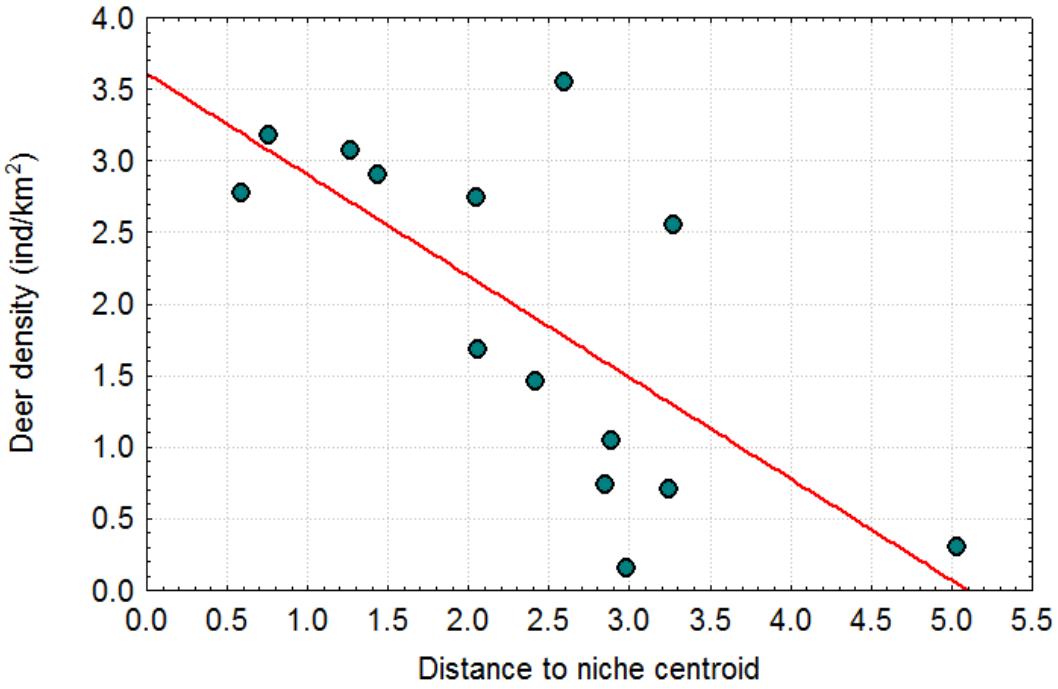

Figure 4. Relationship between white-tailed deer density and distance to niche centroid (DNC). Points represent field density estimation at 14 locations in the Tehuacán-Cuicatlán Biosphere-Reserve, Mexico.

Discussion

Ecological niche modelling has become the strongest approach for modeling species distributions when only basic information, such as species occurrence data, is available (Peterson *et al.* 2011, Franklin 2012). We used a DNC approach to predict the spatial distribution of white-tailed deer density in the TCBR. This approach presented a higher explanatory power and yielded much better results compared to density predictions from Maxent suitability values, geographic distances (Yañez-Arenas *et al.* 2012a) and other approaches to predicting abundances in a variety of species (Shi *et al.*2006, Vanderwal *et al.* 2009). The DNC approach has further advantages in that it has a solid ecological basis, the math of the approach is simple because it is based on the relationship between a single response and predictor variables, the input data required for developing the DNC method are relatively simple and the DNC method is useful for any species at different spatial scales (Martinez-Meyer *et al.* 2013). However, some limitations have also been detected in this approach (see details in Yañez-Arenas *et al.* 2012a).

Table 1. Estimation of white-tailed deer abundance in the Tehuacán-Cuicatlán Biosphere Reserve according the density distribution modeling using the distance to the niche centroid (DNC) method.

Density category	Surface (km^2)	Density (deer/km^2) mean (min – max)	Abundance (N, total deer) mean (min – max)
Absence	49	0	0
Low	124	0.7 (0.01 – 1.1)	87 (1 – 136)
Medium	2,103	1.9 (1.2 – 2.3)	3,996 (2,524 – 4,837)
High	2,193	2.7 (2.4 – 3.5)	5,921 (5,263 – 7,676)
Total	4, 906		10,004 (7,788 – 12,649)

Recently, different approaches have been used to map suitable areas for ungulate species in Mexico, such as MaxEnt (Ortiz-Garcia *et al.* 2012, Yañez-Arenas *et al*. 2012b, Pérez-Solano and Mandujano 2013), habitat suitability index models (Delfín-Alfonso *et al.* 2009, Ortiz-Garcia and Mandujano 2011, Bolívar-Cimé and Gallina 2012) and modeling the potential distribution of principal food plant species (Flores-Armillas *et al*. 2013). In this context, the DCN constitutes an alternative and/or complementary method with which to determine the spatial structure of white-tailed deer or any other species, and provides valuable information with which to identify environmental conditions that can explain the distribution and abundance of populations/species.

As a result of these characteristics, the DCN approach has interesting management and conservation implications. In this context, we agree with the view of Escalante and Martinez-Meyer (2013) that DCN can be a starting point from which to establish institutional standards for the management of species in wildlife management units. Moreover, integration of this approach with population and habitat viability analysis could help determine minimum critical areas for sustaining viable populations in natural protected areas (Mandujano and González-Zamora 2009). From the perspective of regional management and conservation, the DNC approach could be of particular value in the identification of possible source-sink populations (Naranjo and Bodmer 2007).

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Observations on killings of sambar (*Rusa unicolor*) by wild dogs (*Cuon alpinus*) in Periyar Tiger Reserve (PTR), Kerala – India

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Abstract:

The sambar is the largest and most widely distributed deer species in India. During a study on the ecology and biology of barbets (*Megalaima* spp) between 1978 and 1980 and on several other occasional visits to the PTR, encounters of sambar and wild dogs (dholes) were observed. Most kills were seen near lakeshores. The wild dogs try to isolate the target sambar and then attack in a group. In one instance a single wild dog tried to kill a fawn but it was unsuccessful. The sambars defend themselves by running either to the forests or towards the lake. It appears that the lake environs are a more convenient place for the wild dogs to capture their prey. Despite being much larger in size and weight, sambar are easily killed by the dogs as the latter mostly attack in groups. In this note one observation of such events is reported which was recorded from start to finish.

Resumen:

El sambar es la especie de ciervo más grande y con la distribución más extendida de la India. Durante un estudio sobre la ecología y biología de *Megalaima* spp entre 1978 y 1980 y en otras visitas al PTR, encuentros entre ciervos sambares y perros salvajes (dholes) fueron observados. La mayoría de los ciervos fueron matados cerca del borde del lago. Los perros salvajes tratan de aislar al blanco y después atacarlo en grupo. En un caso, un solo perro salvaje trató de matar a un cervato, pero no tuvo éxito. Los ciervos se defienden corriendo hacía los bosques o hacía el lago. Los alrededores del lago son los lugares más convenientes para que los perros capturen su presa. A pesar que los ciervos son mucho más grandes en tamaño y peso; debido a que estos generalmente atacan en grupos logran matarlos. En esta nota, se describe la observación completa de un ataque de perros.

Key words: Sambar deer, Periyar Tiger Reserve, Wild dog, predator-prey interaction.

Introduction

'Eat and be eaten' is a normal feature in the animal kingdom, and that is how the cycle of energy conversion is largely maintained in an ecosystem. During my almost four decades of venturing in the wilderness I have met with several such encounters

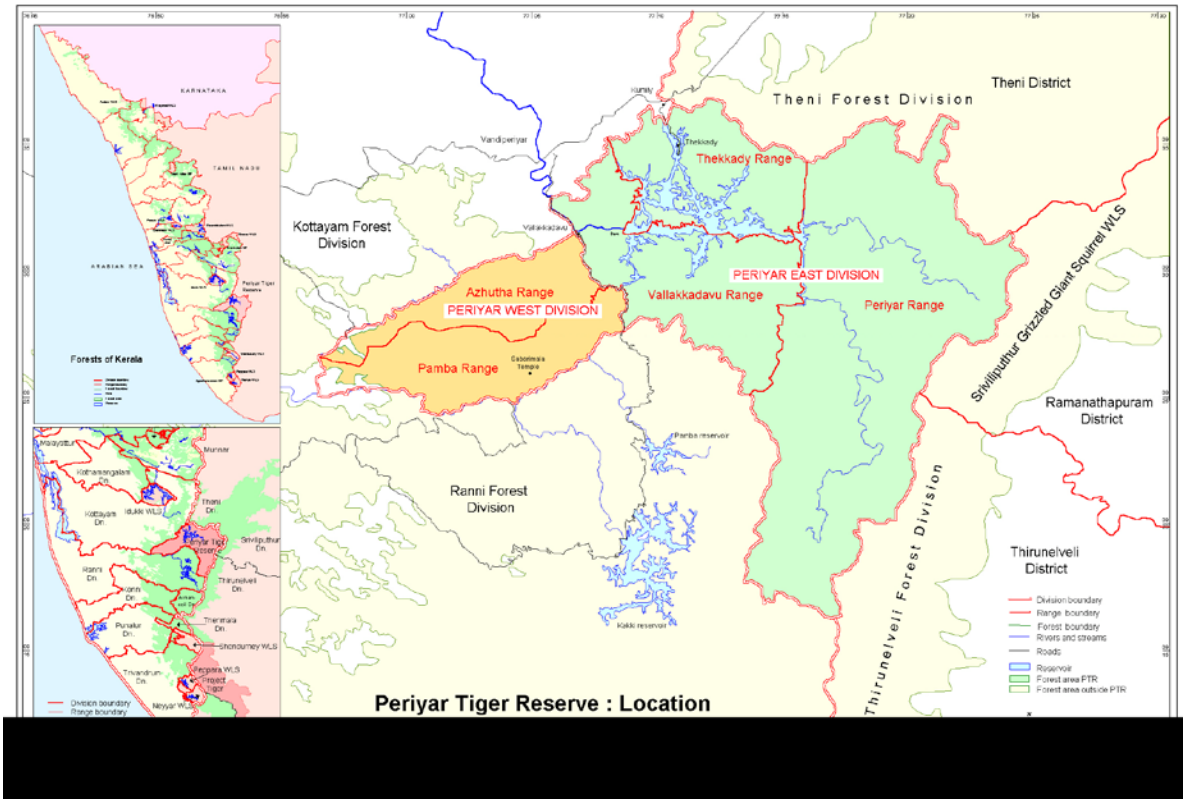

Figure 1. Map of Periyar Tiger Reserve:Kerala Forest Department

that reveal the mystery of nature. While conducting a long term study on the ecology and biology of Indian barbets *(Megalaima* spp) between 1977 and 1980 in the Periyar Tiger Reserve (PTR) (Map 1, Photo 1), and thereafter during certain occasional visits, I have had the opportunity of observing encounters between the sambar and Indian wild dogs (dholes) several times. The PTR lies between 9.18 and 9.41 N & 76.55 and 77.25 E, comprising 777 sq km area. The terrain is undulating hill slopes of savanna type grasslands with altitudes varying from 900 to 2000 meters asl. The main entrance at Thekkady is about 4 km from the nearest township, Kumli, which has convenient road connections from Kotayam (115 km) and from Madurai (145 km). There are 7 different types of forests and scores of microhabitats in the PTR. The Periyar Lake, which resulted from the construction of a dam on Periyar River, comprises 26 sq. km of reservoir. Other details of topography of the Reserve have been given by Ali (1935), Yahya (1988, 2001). The environs of the PTR are an ideal habitat for elephants (*Elephas maximus*) and therefore, besides being a Tiger Reserve (estimated population 35), it has also been duly designated as an Elephant Reserve (estimated population 700).

Although sambar (Figure 2) is the largest deer species in India (Prater, 1980, Schaller 1967), the male adult being almost 4 times larger and weighing 10 times more than a wild dog, it is amazing how easily and successfully the

latter preys on the former. As described by Israil & Sindair (1987) the wild dogs can kill even a buffalo (*Bobalus bobalis*), Indian bison *(Boss gaurus)* or tiger (*Panthera tigris)* . The population of sambar in the PTR is apparently quite good, and therefore its predation by wild dog is quite normal from a wildlife management point of view. Presently, thus, it does not require any special attention for the conservation of either species. Based on a 2002 census, the population of sambar in Kerala state is estimated to be 30414 while that of wild dogs is 365 (KFWD 2002). However, as the wild dogs are smaller and more secretive and their direct or indirect counting is difficult, this number might be underestimated. Details of physical dimensions, population estimation and distributions of the two animals are given in Table 1.

Figure 2: A full grown male Sambar in Ranthambore Tiger Reserve, Rajasthan

Out of several encounters of dogs killing sambars that I have witnessed in the Reserve, the following is the most interesting event that I was able to observe from start to finish. Most such encounters in the Reserve take place near the lake. In the present observation, the dogs killed a young sambar in the water, and literally one of the dogs swam a considerable distance to attack it, standing confused in the water: I was observing a herd of 6 sambars grazing opposite to the Edaplyam guest house near the lakeshore. Suddenly a pack of five wild dogs arrived and sat about

200 meters away from them. One of the dogs even lay down on the ground for a few minutes. By then the sambars had not seen the dogs and were busy grazing peacefully. After a few minutes the dogs got up and moved towards the sambars, dividing themselves in 2 - 3 groups. Then the sambars saw them and panicked. Three of them ran towards the forest and three ran into the water. The dogs also moved into the water from two sides and cornered a sub-adult sambar. I was observing this interesting phenomenon from the other side of the lake, along with my four students, through our binoculars. One of the dogs attacked the sambar from behind and another from the front. We were wondering why the sambar did not try to run away or swim.

Table 1: Physical dimensions and other features of Sambar and Wild dog; after Prater (1980). As provided by Wildlife Conservation Officer, PTR.

Species	**Height Cm**	**Length Cm**	**Weight Kilogram**	**Population density in PTR***	**Remark**
Sambar	150	Body Length 180-210; length of antlers 65-70	320	3.63 sq/km	Indian sub species is *R .u. niger*. Widely distributed in wooded forests.
Wild dog	43-55	90	20	0.6 sq/km	Three distinct races in India: Trans Himalayan, Himalayan and Peninsular

It appeared quite confused and frightened, only defending itself by moving its neck up and down. The dogs then pounced on the sambar and dragged it about 100 meters to the shore, and then up to about 10 meters to the grassland; then all of them joined the feast. We quietly continued watching, amazed. We could not hear any sound from either prey or predator at this site. But while the wild dogs usually remain silent during killings, except for some gushy sounds, the sambar often give hooting alarming calls on first sight of a predator or other danger such as a human. Similarly barking deer *(Muntiacus muntjcak*) also give alarm calls by barking on the approach of any

threat. Within about 45 minutes they finished eating almost the entire sambar and moved away; one of the dogs carried some part of the sambar in its mouth. After a while when we saw that the dogs had left and all was over; we drove to the scene on a bamboo raft. Except for the skin and a portion of the head there was nothing left! We measured the skin, left it there, and returned to the guest house.

Table 2: Details of observations of close proximity of sambars and wild dogs in PTR

No	Date	Time	No Sambar	No dhole	Killed Y/N	Remarks
1	22 -03-1978	3.45 pm	7	3	N	The dogs while passing by glanced at deer grazing at lakeshore and went away; one male sambar gave an alarm call. No attempt of killing was observed.
2	24-12-1978	3.30 pm	2	3	Y	The fawn was killed; but at the approach of a tourist boat the dogs moved away.
3	02-01-1979	11.30 am	5	2	N	The dogs glanced at sambars grazing and passed by; one sambar raised its head, spread ears but did not show much apprehension.
4	03-02-1980	2.45 pm	3	4	N	Sambars and wild dogs were seen at opposite banks of the lake near Manakawalla guest house; I am not sure they saw each other
5	11-12-2002	11.30 am	6	5	Y	See text

Recently Nikhel Bhopale (2013) has described a similar encounter between sambars and a wild dog from the Parambikulam Tiger Reserve, Kerala. In this instance the fawn sambar could escape unhurt probably because, in this exceptional case, there was only one dog.

On several other occasions I have seen interactions between sambar and wild dogs (Table 2). On some occasions, I had seen wild dogs just walking along the shore where herds of sambars were feeding, but they showed no intention of attacking. It appears that the dogs wait for the right place and look for an isolated sambar herd to attack them. There are barking deer also in the Reserve but I have never seen any wild dogs attacking them; neither have I heard any such story from locals. On another occasion I had witnessed the killing of a young sambar by the wild dogs but because a tourist boat approached close and some of the tourists were making noises, the dogs dispersed without eating their prey (Table 2). They might have returned later to enjoy the feast but since it was a time bound tourist boat, we had to return. Barnett et al. (1980) have discussed the diets of wild dogs in Mudumalai Wildlife Sanctuary (Tamil Nadu). According to them, the sambar constitute 9% of the diet of wild dogs, whereas spotted deer (*Axis*

axis), 78%; and the mouse deer or Indian chevrotain (*Tragulus meminna*) only 0.7%. However, one reason for the spotted deer's comprising such a large part of the wild dogs' diet in Mudumalai could be their much larger population there, while no spotted deer are found in the PTR. Therefore, a long term study on prey and predatory behaviour of wild dogs in PTR would be quite revealing.

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Kashmir Red deer or Hangul *Cervus elaphus hanglu* at the Brink of Extinction- Conservation Action, the need of an Hour

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Abstract

The Kashmir Red deer or Hangul *Cervus elaphus hanglu*, a subspecies of Red deer is endemic to Kashmir and was once distributed widely in the mountains of Kashmir. Hangul deer are presently largely confined to the 141 km² of Dachigam National Park although some relic Hangul populations also occur in adjoining areas. Our intensive study (2001-2013) results on the population ecology of this deer indicate that the major factors affecting the long term survival of the Hangul deer are the following: declining population trends and distributional range, very low adult sex ratio (23.18 males: 100 females) and fawn to female ratio (29.85 young: 100 females), excessive predation by common leopard (*Panthera pardus*), predation on fawns by black bear (*Ursus thibetanus*), meso-carnivores and shepherd's dogs, continued Hangul summer habitat loss and degradation due to excessive livestock grazing in the upper Dachigam, biotic interferences in the winter habitats and loss in heterozygosis. The current population trends indicate that the subspecies could go extinct if the necessary serious interventions are not made immediately. We propose urgent measures to counter-arrest the low sex ratio and fawn to female ratio of Hangul and strengthen the conservation breeding programme to repopulate the good habitats in the former Hangul range, imperative for the revival of the population and its distributional range. International conservation support particularly from the IUCN and DSG and need for assessment of this subspecies in the appropriate threat category by the IUCN Red list are necessary to perpetuate the effective population recovery and long term conservation of Hangul.

Resumen:

El ciervo rojo Kashmir, o Hangul (*Cervus elaphus hanglu*), una subespecie del ciervo rojo, endémico de Kashmir, tenía una amplia distribución en las montañas de Kashmir. Los ciervos Hangul en el presente son limitados al Parque Nacional Dachigam (141 km^2) y algunas poblaciones están restrictas en áreas adyacentes. Los resultados de nuestro estudio intensivo (2001-2013) sobre la ecología poblacional de este ciervo indican que los factores principales afectando la supervivencia a largo plazo del Hangul son los siguientes: tendencias a disminuir el tamaño de las poblaciones y el rango de distribución, muy baja proporción de sexos en adultos (23.18 machos: 100 hembras) y de cervatos a hembras (29.85 crías: 100 hembras), excesiva depredación por leopardo común (*Panthera pardus*), depredación de cervatos por oso negro (*Ursus thibetanus*), meso-carnívoros y perros de pastores, perdida continuada de hábitat de verano y degradación debida a pastoreo excesivo de ganado en el Dachigam superior, interferencia biótica en el hábitat de invierno y perdida de heterozigosis. Las presentes tendencias poblacionales indican que la subespecie podría llegar a la extinción si las intervenciones necesarias y serias no son implementadas inmediatamente. Proponemos medidas urgentes para contrarrestar la baja proporción de sexos y de cervatos a hembras. También proponemos fortalecer el programa de reproducción para repoblar los hábitats buenos del rango histórico del Hangul, imperativo para la recuperación de la población y su rango de distribución. El apoyo

internacional por grupos de conservación como la UICN y el DSG así como la necesidad de evaluación de esta subespecie en la categoría apropiada de amenaza por la Lista Roja de la UICN son necesarios para lograr la recuperación efectiva de la población y conservación del Hangul a largo plazo.

Key Words: Hangul, Dachigam, sex ratio, predation, conservation breeding, IUCN

Introduction

The Kashmir Red deer or Hangul, *Cervus elaphus hanglu*, is one of six Asian subspecies of Red deer and was once distributed widely in the Kashmir Himalayas along the Zanskar mountain range (Gee 1965; Schaller 1969; Prater, 1993; Nowak, 1999) of the Northwest Himalayan biogeographic region zone 2A (Rodgers & Panwar 1988) with the last viable population now existing in Dachigam National Park near Srinagar (Fig.1) (Ahmad *et al.* 2009; Qureshi *et al.* 2009). Among the eight red deer subspecies recognized (Nowak, 1999; Grzimek 1999), the six Asian subspecies include the Sikkim stag or Shou (*Cervus elaphus wallichi*) of East Tibet, the Maral or Caspian red deer (*C. e. maral*) of Asia Minor, Crimea, Caucasus Region and northwestern Iran, Bactrian deer, (*C. e. bactrianus*) of Afghanistan, Kazakhstan, Uzbekistan, Turkmenistan, and Tadjikistan, the Yarkand deer, (*C. e. yarkandensis*) (Xinjiang), MacNeill's deer (*C. elaphus macneilli*) from the upper elevations of the canyons of the Mekong and Yangtze rivers and western China (Grzimek 1999; Nowak, 1999; Ludt *et al.* 2004) and the Kashmir Red deer or Hangul.

The latter is the only surviving race of red deer in the Indian sub-continent (Holloway 1971; Ahmad *et al*. 2009; Qureshi *et al*. 2009). In the current IUCN's Red List of Threatened Species, Red deer (*Cervus elaphus*) is categorized as Least Concern and none of its subspecies has a separate assessment (IUCN, 2012). In India, recognizing the conservation status and declining population trends of this range restricted and endemic deer of Kashmir, it has been officially declared the state animal of Jammu & Kashmir State and listed as a Schedule 1 species in the Indian Wildlife Protection Act 1972 (amended 2002) and Jammu & Kashmir Wildlife Protection Act 1978 (amended 2002) (Ahmad *et al.* 2009). The population of Hangul deer declined drastically in the recent past due to human interferences owing to excessive livestock grazing in Hangul habitats, poaching, urbanization, habitat degradation and fragmentation and loss of corridors for free movement of the animals (Holloway 1971; Kurt 1978). At present a genetically viable population of around 150-170 animals is confined

to the 141 km^2 of Dachigam National Park although some isolated populations also occur in adjoining relic range areas (Ahmad 2006, Ahmad *et al*. 2009; Qureshi *et al.* 2009). The Hangul population estimated over the years showed a consistent decline from 5000 deer estimated in 1900, 2000 deer in 1947 (Gee 1965; Schaller 1969) to 218 deer in 2011 (State Wildlife Protection Department; Anonymous 2011). Though efforts have been made in the past to emphasize the conservation problems of Hangul (Gee 1965; Schaller 1969; Holloway and Schaller 1970;

Holloway and Wani 1970; Holloway 1971; Kurt 1978; Inayatullah 1987), there had been a lack of information on the ecology of Hangul, prerequisite for its effective management and long term conservation. Beginning in January 2001, we initiated long term intensive ecological studies in order to understand, monitor and investigate aspects of population dynamics, habitat use patterns, food and feeding habits and ranging and movement patterns of Hangul in Dachigam National Park and the Hangul's historical distribution areas.

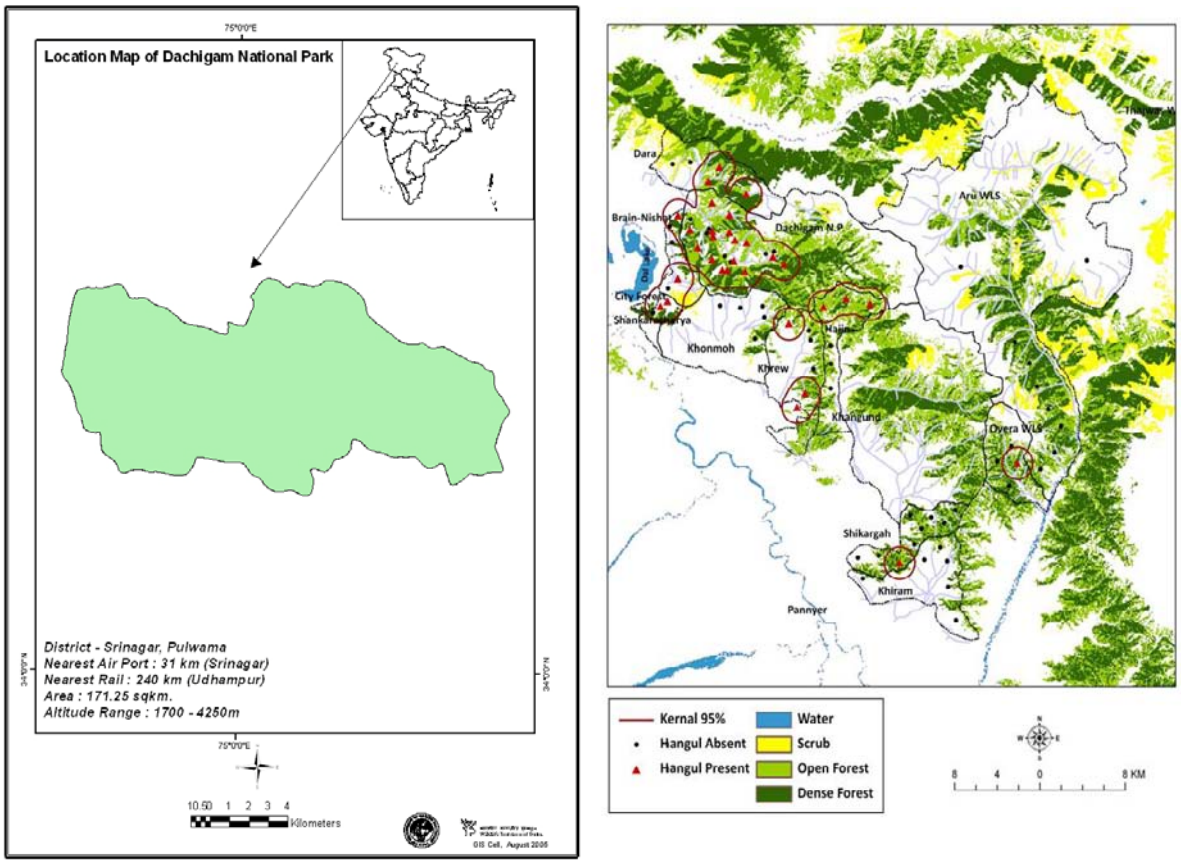

Figure. 1: Location Map of Dachigam National Park (Left) and the Map of the areas intensively Surveyed and the Hangul Distribution recorded in and Outside Dachigam National Park (2001-2013) (Right)

Methodology:

Because of the hilly terrain there was no possibility of using distance sampling (Buckland *et al.* 1993) or Line Transect (Burnham *et al.* 1980) methods to estimate this deer population. We designed a standard network of transects along trails, *Nullas* (streams) and contours using strip counts and bounded counts methods following Hayne (1949), Holloway (1971) and Rutledge (1982), which allowed the observers to move as swiftly as possible in

the area. We counted and monitored all deer observed in the fixed seven survey blocks in Dachigam National Park and 35 survey units in the adjoining relic Hangul range areas outside Dachigam N.P (Fig.1). Each such transect was monitored on a rotational basis regularly four times a month to collect data on daily activity patterns of the Hangul deer in relation to the resource availability and habitat use parameters. Furthermore, data on indirect evidences of Hangul (dung/pellets) were collected in (2× 20 m) belt transects randomly laid in the survey blocks. To capture Hangul for radio collaring, animals were monitored regularly, habituated, and lured into a darting site near Oak patch in Lower Dachigam using a variety of lures, including greens, vegetables, rock salt and a mineral mixture. On March 16, 2013, one young adult male Hangul was successfully darted at 1716 hrs, with a remotely administered drug combination of sedative (medetomidine) and dissociative (ketamine) using a Syringe projector (Dan Inject-Mod IM). The animal was successfully captured and collared using a Vectronics GPS Plus-4 IRIDIUM satellite collar (Fig. 2). During the process of capture, the sedation levels safe for handling were assessed (Fig. 3), and it was found that the physiological parameters were within normal limits and corresponded to that of Sambar (*Rusa unicolor*). The collared animal's movements have been tracked on a regular basis since March 16, 2013, through satellite as well as on ground through a VHF receiver and antenna.

Figure 2: GPS-Satellite Collar fitted Hangul Male showing recovery following sedation March 16, 2013 (Left); Collared animal in velvet captured in the camera trap exactly 02 months after it was fitted with the Satellite collar (Right).

Results and Discussion

Our decade long (2001-2013) intensive studies on Hangul deer in Dachigam National Park and range wide surveys and habitat assessments in 35 survey units in its former relic range areas outside Dachigam National Park, indicate that the last viable population of this endemic deer of Kashmir is presently confined to the 141 km^2 of Dachigam National Park. There are a few isolated populations occurring in the adjoining Conservation Reserve areas, restricted to an effective area of 351.15 km^2 outside Dachigam National Park, out of the approximately 884.41 km^2 of its historic distributional range. Based on the total of 326 Hangul sightings in Dachigam National, the recorded Hangul population parameters, as depicted in Table 1, indicate that the Hangul population dynamics vary significantly between seasons. The 153 Hangul sightings outside Dachigam N.P, however, indicate an overall mean Hangul encounter rate of 0.043 Hangul/kilometer walked with an overall Hangul Density of 0.49 Hangul/km^2 and an overall Hangul sex ratio of 11.81 males/100 females and fawn to female ratio of 5.93 fawn/100 females.

Table 1. Hangul Population parameters recorded in Different Seasons in Dachigam National Park.

Season	No. of monitoring	No. of Sightings	Male only groups	Mixed groups	Female, young Groups	Female only Groups	Male, female Groups	Encounter Rate Hangul/Hr. Effort	Encounter Rate Hangul/ Km Walk	Mean Group Size	Typical Group Size	Density Hangul/Km^2	Sex Ratio Male/100 female	Female/Fawn ratio Fawn/100 female
Spring	155	85	10	18	27	23	7	2.02	0.67	5.36 ± 0.66 (S.E)	17.50	8.93 ± 0.17 S.E.	14.05± 2.92 (S.E.)	2.70 ± 2.49 S.E.
Summer	176	55	11	8	21	13	2	0.41	0.14	1.10 ± 0.17 (S.E.)	5.28	0.71 ± 0.05 (S. E.)	14.29 ± 3.87 (S.E.)	34.25 ± 5.79 S.E.
Autumn	150	85	31	24	11	7	11	0.93	0.31	2.60± 0.27 (S.E.)	7.01	1.79 ± 0.06 (S.E)	52.30 ± 9.20 (S.E.)	32.19 ± 4.54 S.E.
Winter	212	101	3	36	37	17	7	1.17	0.55	4.86 ± 0.50 (S.E.)	15.76	9.02 ± 0.14 (S. E.)	18.19 ± 3.45 (S.E.)	32.96 ± 3.23 S.E.
Overall	**693**	**326**	**55**	**86**	**96**	**60**	**27**	3.54	1.66	3.54 ± 0.23 (S.E.)	14.11	5.6± 0.10 (S.E)	23.18 ± 2.58 (S.E.)	29.85 ± 1.89 S.E.

These study results and field observations are indicative of the fact that one of the major issues concerning long term conservation and survival of Hangul has been the declining population trend, the sex ratio and fawn to female ratio. Our studies showed an overall mean Hangul sex ratio of 23.18 males: 100 females and fawn to female ratio of 29.85: 100. The fawn- female ratio declined significantly ($t=3.4$, $p=0.01$) from 23:100 in 2004 to its lowest level of 9:100 in 2006, before showing some recovery. The low fawn to female ratio and fawn survival is presumed to be attributed to stress owing to the heavy biotic disturbance in Dachigam compounded with nutritional stress and fawn predation by common leopard, Asiatic black bear, jackal (*Canis aureus*), red fox (*Vulpus vulpes*) and stray dogs of shepherds and army installations. The predation by leopard and black bear, both of which prey principally on the young deer (Ahmad *et al.* 2009), seems to be the worst threat for Hangul deer. The predation on Hangul by leopard (60% biomass of leopard diet) (Ahmad *et al.* 2009) is very high in winter and summer when the Hangul has a limited distributional range in Dachigam National Park. This is due to the clumped distribution of resources in large areas which are snow bound in winter and possibly because of excessive livestock grazing in the upper alpine areas and even in some of the blocks in Lower Dachigam in summer. We recorded average livestock dung densities of 25.40± 17.67/km^2 for cattle and 132.77± 92.83/km^2 for sheep/goat during summer and autumn seasons in two

blocks of lower Dachigam. The predation, if it continues, will add to the demographic stochasticity and may produce a further future decline in the Hangul population in the future.

The satellite collared animal showed an initial movement pattern of using the lower areas until early summer and the middle Dachigam up to an altitude of 3000 meters (asl.) through summer and autumn using GPS-Satellite telemetry. This animal showed upward movements to Dagwan alpine meadows of upper Dachigam but restricted its movement further in to the alpine meadows, possibly due to heavy disturbances of excessive livestock grazing.

Investigations on habitat use indicate that the Hangul showed significant differences in the use of different habitat types ($F = 6.49$; $P = 0.00$) between seasons. Males showed significant differences in habitat utilization within a season ($F=3.63$; $p \leq .013$) and some differences between the seasons ($F=1.50$; $p \leq 0.087$). The females showed some differences in their habitat use within season ($F= 2.003$; $p \leq .093$) but not between seasons ($F= 14.771$; $p \leq .577$). Hangul showed greater use of lower (1700-1900 m) and middle (1900-2300 m) altitudes and generally south facing slopes. The Hangul feeding habits varied according to their availability in different seasons in Dachigam National Park (Table 2).

Table 2: Type of Food Plants consumed (%) by Hangul in different Seasons based on both direct observations and pellet Analysis in Dachigam National Park.

Season	Forbs/fern		Grass/Herb		Browse		Debarking
	Indirect	Direct	Indirect	Direct	Indirect	Direct	Direct
Spring	67.86	36.36	7.14	18.18	25.00	45.45	20.45
Summer	42.86	60.00	19.05	28.00	38.10	12.00	0.00
Autumn	50.00	41.18	0.00	0.00	50.00	58.82	5.88
Winter	32.43	19.23	16.22	0.00	51.35	80.77	50.00

Recommendations

Our decade long intensive studies on Hangul indicate that the species could go extinct if necessary serious interventions are not made immediately. We suggest that the Hangul population in Dachigam National Park and its adjoining areas needs an intensive population monitoring programme and further reproductive and behavioral ecology studies to better understand factors affecting population growth. In addition to traditional measures of Hangul deer protection, which include providing full protection to the animal and its habitats and strengthening of the conservation breeding programme and the anti-poaching measures, the following key measures are recommended for a rapid recovery of the Hangul population and its lost habitats:

- Steps to ensure the expansion of the range and habitat of Hangul to its alpine meadows in upper Dachigam including the rehabilitation of the livestock owners, providing them with alternate grazing lands and involving them in eco-development and conservation activities.
- Increasing the Hangul movement pattern studies using GPS/satellite telemetry which will help in establishing ecological deer corridors between protected areas.
- Initiation of reproductive ecology studies to better understand factors responsible for low male/female adult sex and fawn/female ratios, which among others could be increased male foetus abortion under stress.
- The former Hangul deer distribution range areas outside Dachigam National Park require immediate management and conservation efforts including the initiation of a scientific monitoring program for collecting baseline information on their habitat conditions and biotic interferences *vis-à-vis* present status and distribution of Hangul. These data would be then interpolated to assess the reestablishment of these relic areas as corridors and reintroduction areas for Hangul.

- There is an urgent need to regulate the common leopard and Asiatic black bear populations in Dachigam National Park to arrest the heavy predation on Hangul. Moreover, the stray dog population which has thrived in Dachigam due to the paramilitary forces in the Park should be eliminated.
- A supplementary diet provided to Hangul during winters should be distributed evenly along the main streams (*nullahas*) so as to ensure the availability of food and minerals to the Hangul in its distributional areas. The provisioning of supplementary food in winters is reported to be useful for both males and females, preventing greater winter male mortalities in red deer and elk (*Cervus canadensis*). ((Smith 2001; Clutton-Brock & Albon 1989)
- The establishment of 3 to 5 enclosures of the dimensions of 50×50 m both in Lower and Upper Dachigam, for *long term* study and monitoring of the impacts of grazing and habitat degradation.

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Extinction process of the sambar in Peninsular Malaysia

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Abstract
In Peninsular Malaysia, the sambar has lost more than 50% of its historical range in the past century and only a quarter of its current habitat is protected. Although multiple hunting moratoria have existed for five decades, the sambar has been relentlessly poached for local meat consumption. It now persists in only a few areas that receive active protection. Given the massive decline of its historical habitat, current rarity, and the lack of capacity and resources for large-scale restocking, effective protection as well as interest in forest restoration, we believe that the process of extinction will be exacerbated for this species in Peninsular Malaysia. Thus we recommend that the IUCN Red List authority review the Red List category of sambar, presently listed as Vulnerable (VU), but which would warrant listing as Endangered (EN) A2cd, and possibly A4cd, if these observations in Malaysia reflect global trends across the full species' range.

Resumen
En Malaysia Peninsular, el ciervo sambar ha perdido más de 50% de su distribución histórica en el siglo pasado, y solamente un cuarto de su hábitat actual es protegido de conversión. A pesar que moratorios múltiples de caza han existido sobre las últimas 5 décadas, el sambar ha sido cazado furtivamente para el consumo local de la carne. Ahora persiste solamente en algunas pocas áreas que reciben protección activa. Dado la disminución masiva de su hábitat histórico, bajos números y la falta de capacidad y recursos para su re-introducción en una escala grande, protección efectiva e interés en la restauración de bosques, creemos que el proceso de extinción probablemente va a aumentar para esta especie en Malasia Peninsular. Entonces, recomendamos que la autoridad de la Lista Roja de la UICN repase la categoría del sambar, listada actualmente como Vulnerable (VU), pero que podría merecer categorización como En Peligro (EN) A2cd y posiblemente A4cd, si estas observaciones en Malasia reflejan las tendencias globales del rango entero de la especies.

Keywords: conservation, extinction, IUCN Red List, poaching, protection, reintroduction, wild meat

Introduction

Ungulates (Artiodactyla), in particular, are disproportionately threatened with extinction compared with most other mammals, especially in Southeast Asia, largely due to massive overhunting (Corlett 2007). Large ungulate (species > 5 kg) populations have declined in recent decades due to commercial poaching to supply local and regional demand with meat, antlers and other body parts, causing many site-level extirpations in the region (Bennett &

Gumal 2001, Steinmetz *et al*. 2010, WWF 2013). This scenario is particularly relevant to the sambar in Peninsular Malaysia. A quick literature search in journals on wildlife ecology and conservation reveals a lack of focus on this species, which borders on negligence by Malaysia's conservation and academic community. Here, we present the sambar's status based on best available information in Peninsular Malaysia to garner greater national and global efforts for its conservation.

Biogeography and Taxonomy

Peninsular Malaysia represents the southern end of the continental distribution of Asia's largest deer species. According to the IUCN Red List (Timmins *et al*. 2008), it is treated as the same subspecies, *Rusa unicolor cambojensis* Kerr 1792, as found in Indochina. However, the Thai–Malay Peninsula populations have been completely isolated from northern populations due to forest loss in much of southern Thailand and thus, the sambar, as well as most other non-volant terrestrial species of the peninsula, cannot feasibly experience rescue effects regionally. Due to clear morphological differences among subspecies, Timmins *et al*. (2008) predicted a taxonomic revision, and Groves & Grubb (2011) propose two separate species of sambar: *Cervus unicolor*, in Sri Lanka and most of mainland South Asia and *C. equinus* in Southeast Asia and China. Because India contains the greatest number of sambar, this taxonomic change, if adopted, will necessitate an IUCN Red List category for *C. equinus*.

Threats

Poaching and Unsustainable Legal Hunting

Overhunting to the point of local extirpation, similar to that already observed in East Malaysia (Bennett & Gumal 2001), is increasingly threatening wildlife in Peninsular Malaysia. Poaching is a primary threat to the survival of this species, especially for the meat, which is favoured throughout the Sundaic region (Timmins *et al*. 2008). Unlike wild pigs *Sus* or tapirs *Tapirus indicus* that are not consumed by the majority of Malaysians due to religious or superstitious taboos (Kawanishi *et al*. 2003), the meat of sambar is highly prized by all ethnicities in Malaysia. The sambar is hunted for personal consumption, sales to restaurants and trophies (DWNP 1992a). There are no sambar farms in Peninsular Malaysia and thus wild sambar meat is 'laundered' as farmed Javan rusa, *R. timorensis*, to evade enforcement. However, sambar meat is considered superior and sold to trusted customers at a higher premium.

Their foraging behaviour, typically outside closed forest interiors, brings them closer to humans at the forest/cultivation ecotones or by roadsides where they are either shot or hit by cars. Sambars are also easily lured using artificial salt licks or baiting stations and are also prey to indiscriminate snares set for large mammals-- a practice widespread and chronic in Malaysia. Surveys of commercial trade in wild meat carried out by TRAFFIC in

2012 found as many as 20 restaurants selling sambar meat out of 242 restaurants investigated across Peninsular Malaysia (Caillabet *et al*. unpubl.) despite a moratorium in place since 2009 prohibiting sambar hunting.

Sambars are killed by local as well as Indochinese poachers (MYCAT 2012a), presumably since their own wildlife supplies are rapidly diminishing (WWF 2013). The number of poachers is on the increase as indicated by media reports, police reports at district police stations and also comments from indigenous people. These Indochinese poachers are also seen regularly in East Malaysia.

The steady decline in the number of hunting licenses issued over the past five decades despite the popularity of the deer meat is another indication of the decline in sambar and the unsustainability of the hunting. The number of licenses issued for sambar in the early 1960s was >600 annually (Medway 1965), 519 in 1982 (Habsah 1984), 373 in 1992 (DWNP 1992b) and 122 in 2006 (DWNP 2006). Meanwhile, perhaps to compensate the declining sambar, red muntjac hunting licenses showed slight increases (Kawanishi 2008).

The diminishing sambar population is corroborated by local people. According to an interview-based survey conducted by TRAFFIC between 2006 and 2007 on the perception of hunters and dealers in 18 villages across Peninsular Malaysia, more than 80% of the total of 61 respondents felt that between 2000 and 2005 the local sambar populations were either reduced or extirpated (Goldthorpe & Neo 2011). Over-hunting was given as the primary reason for depletion of the sambar, its being hunted at an unsustainable level throughout the year despite the 11-month closed season.

An assessment of the trend in hunting licenses and results of 23 camera-trapping studies submitted to the Malaysian Government in 2008 (Kawanishi 2008) alarmed policy makers who then instituted a 6-year hunting moratorium starting in 2009 (Kawanishi *et al*. 2013). Similar hunting moratoria where no licenses were issued for legal hunting were in place in 1963-1967 (Khan 1967), 1977-1982 (Habsah 1984), and 1994-1996 (Kawanishi 2008), but the sambar population has not recovered. It will take more than hunting moratoria to recover the population that has been subjected to five decades of over-exploitation both legally and illegally (Khan 1967, 1968; Habsah 1984; Zaaba *et al*. 1991) and neglect from the conservation community.

Habitat Loss

Although habitat loss and degradation is not currently the immediate threat to extinction in Southeast Asia, it was the main contributing factor in the 20th century. Logging roads now enable poachers to gain easier access into

forests once almost impenetrable. This coupled with the direct impacts of loss, fragmentation and degradation is having an acute impact.

Of the 131,800 km^2 total land area in Peninsular Malaysia, 57,000 km^2 (44%) is forested, comprising 48,900 km^2 Permanent Reserved Forests (PRF), 5,900 km^2 Protected Areas (PA), and 3,000 km^2 state or privately owned forests (Forestry Dept. 2012). When the sambar was globally listed as VU in the IUCN Red List 2008, Peninsular Malaysia had already lost more than 90% of lowland rainforest to agriculture, industry and settlements (Marshall 1973, Aiken *et al*. 1982, DWNP 2010).

Malaysia, Indonesia and Thailand are the world's top three producers of palm oil and rubber, the two main crops responsible for deforestation in Sundaic Southeast Asia. Agriculture and the construction industry contribute 4% and 16%, respectively, to Malaysia's GDP (EPU 2013). As almost all commercially viable alluvial lowland areas outside PAs and PRFs that could be drained had been cleared and converted to agriculture and settlements by 1992 (DWNP 2010), it had earlier appeared that further deforestation was less of a concern for large mammal conservation (DWNP 2008). This was incorrect as the recent 2011 government policies promote creation of industrial tree plantations via removal of native forests, even in PRFs (Lim 2012, MYCAT 2012b). These tree plantations are legally under the jurisdiction of each state with no requirement for consultation with the federal government or conservation NGOs. The habitat loss due to expansions of large-scale monoculture plantations and fragmentation due to road and railway construction is considered irreversible, or rather escalating, under current Malaysian economic growth models (MYCAT 2012b).

Population Decline and Process of Extinction

The National Red List assessment estimated the Area of Occupancy (AOO) for the sambar to be 52,490 km^2 based on the extent of sambar habitat still available in 2000, where occupancy was supported by data at a district level (DWNP 2010). Only 16% of the AOO was in PAs, managed either by federal or state park authorities (Table 1). This does not mean that they are protected on the ground, but at least their habitats are safe from conversion to monoculture plantations.

Table 1. Historical Extent of Occurrence (EOO) and current Area of Occupancy (AOO) for the sambar by different types of land category, extracted from the National Red List assessment conducted by the Department of Wildlife and National Parks Peninsular Malaysia (DWNP 2010).

	Extent of Occurrence	**Area of Occupancy**			
Land category	All	Private or state owned land	Permanent Reserved Forests	Protected Areas	Total
Area (km^2)	103,064	8,691	35,415	8,383	52,490

EOO: The total historical extent of occurrence of the sambar prior to the 1970s based on the areas of the districts where the sambar has been recorded
AOO: The extent of available habitat within EOO that existed at the end of 2000. It is assumed that habitat quality is uniform and species density consistent over the whole habitat.

The sambar AOO gradually declined from 71,001 km^2 in 1980, 59,442 km^2 in 1990 and finally to the current 52,490 km^2, a 49% decline in its original habitat (areas including non-forested land) prior to the 1970s (DWNP 2010). We however feel this AOO is a gross over-estimation because: 1) the assumptions (Table 1) are not met; 2) a district is too large a spatial scale to assess sambar occupancy; and 3) unsustainable legal hunting and unabated poaching have resulted in many suitable sambar habitats being "empty" of them. Suitable habitats, actually occupied by sambar, declined by a much greater extent than 50%. Using the IUCN criterion, we argue that the sambar in Peninsular Malaysia was already in EN status at the beginning of the 21st century.

There has never been a nationwide population estimate of the sambar and it is thus impossible to document the numerical decline of the whole sambar population. We thus infer its status based on the best available information.

In 2008, biologists from WWF-Malaysia, Wildlife Conservation Society-Malaysia Program and the Malaysian Conservation Alliance for Tigers (MYCAT) looked at 23 camera-trapping studies conducted throughout Peninsular Malaysia between 1997 and 2008 to understand the conservation status of tiger prey species (Kawanishi *et al*. 2013). Most studies targeted tigers while a few were part of general biodiversity surveys. All cameras were set aiming at ground level to photograph medium-large terrestrial mammals. The data (10,145 wildlife photographs from 40,303 trap nights) showed that the sambar was rarely detected outside PAs and was rare even among the six large ungulates assessed.

The sambar was confirmed present in all PAs sampled (Taman Negara, Krau and Endau-Rompin) as well as Ulu Muda and Temengor PRFs. Of 414 photos of sambar, 346 (84%) were taken in PAs. It was not photographed in 15

other sites, which all fell within PRFs (Table 2), despite very intensive efforts (e.g. 9-month sampling, 7,631 trap-nights, etc). If sambar were still present, they were undetectable during the sampling period.

Table 2. Comparison of the total number of photographs of the sambar collected in 23 camera-trapping studies conducted between 1998 and 2008 by two of the main forest categories in Peninsular Malaysia, Protected Areas and Permanent Reserved Forests (PRFs). Data on muntjac and tapir are included to show the relative rarity of sambar, especially in PRFs.

	Total trap nights	**No. sites surveyed**	**No. sites where sambar detected**	**No. sambar photos**	**No. muntjac photos**	**No. tapir photos**
Protected Areas	19,883	5	5	346	697	580
Permanent Reserved Forests	20,420	18	3	68	1044	590

Adopted from Kawanishi et al. 2013

More recent and even more intensive camera-trapping (Appendix 1) and sign surveys in some of the nation's largest PRFs show no record of the species in areas where the sambar was legally hunted up until 1983 (Habsah 1984).

Even in PAs, the declining trends in the sambar's area of occupancy and abundance are expected to continue into the future, following the pattern of the now-possibly-extirpated Sumatran rhinoceros *Dicerorhinus sumatrensis* in Peninsular Malaysia. In 1951, the Chief Game Warden of Malaya noted that "We have every reason to believe that Sambur [*sic*] are in a very strong position," in King George V National Park (Fetherstonhaugh 1951), now known as Taman Negara, the country's largest national park at 4,343 km^2. In the early 1970s, the sambar was still common in the park (Khan 1971). It now occurs at very low densities (Kawanishi & Sunquist 2004) and in western Taman Negara, the abundance index based on camera-trapping rates and estimated occupancy based on camera-trap and sign-survey data have all declined over the past 12 years (Table 3), despite a slight increase in patrol efforts and maintenance of an open grass field with provision of salt cubes by the government. In the same period, the tiger population in the area has plummeted from an estimated seven individuals to one.

Table 3. Sambar data from camera-trapping studies in western Taman Negara, Peninsular Malaysia, collected over the 12-year period in the same 200-km^2 sampling area, using the same sampling methodology (Kawanishi & Sunquist 2004) except that sambar occupancy was analyzed using PRESENCE (Hines 2006) instead of CAPTURE software (Otis *et al.*, 1978, White *et al*., 1982, Rexstad & Burnham, 1991).

Date	Total camera-trap night	Total no. Photo	Total no. Detection*	Abundance Index	No. individual stag	Crude density estimate	Occupancy estimate** (Standard Error)
4/1999 – 5/2000	4336	20	12	0.28	3	0.20	0.54 (0.19)
12/2010-11/2011	7582	19	11	0.15	2	0.01	0.19 (0.10)

*A detection is a trap night with any number of photographs of sambar taken at each camera-trap site.
**Based on the camera-trap and sign-survey data.

This pattern of vanishing sambar in western Taman Negara is corroborated by track-encounter rates by wildlife survey teams over the past few decades throughout the park and also coincides with the disappearance of the bearded pig *Sus barbatus* in its entirety (Kawanishi *et al*. 2006), and now, quite possibly, of the Sumatran rhinoceros (DWNP 2009, DWNP 2011, DWNP 2012, Tan 2012).

Exceptions to this pattern are the Endau-Rompin landscape that has been intensively patrolled by a multi-agency enforcement team since 2010 (Gumal *et al*. 2010), and the Royal Belum State Park that has been regularly patrolled by army personnel since the 1960s due to the earlier presence of communists. Darmaraj (2012) attributes a high tiger density in Belum to the abundant sambar, unmatched elsewhere (Appendix 1, Table 2).

A comparison of camera-trapping data between areas under low to medium protection (Appendix 1, Locations 5 and 6) and under high to very high protection (Appendix 1, Locations 7 and 8) within the contiguous Endau-Rompin landscape reveals that the former have no images of sambar. The latter areas, encompassing both PA and PRF, have received greater political support for wildlife: a royal mandate banning hunting of all wildlife and continuous reporting by administrators and NGOs. There, sambar and other wildlife persist but relentless poachers continue to nibble at the population.

Conclusion

Restocking of sambar has been planned with a breeding programme initiated by the government since the 1970s. Historically however, large mammal reintroduction programmes in Peninsular Malaysia (e.g. Sumatran rhinoceros and gaur *Bos gaurus*) have met little success (Rabinowitz 1995, Tan 2012). The capacity and resources are lacking for large-scale restoration and protection of the original sambar habitat and for successful reintroduction of captive sambar. Under current economic and government priorities, this situation is unlikely to change.

Given the past massive decline of its habitat, current rarity and the unfavourable future scenario, we recommend that the IUCN Red List authority review the Red List category of sambar, which is presently listed as Vulnerable (VU), but would warrant listing as Endangered (EN) A2cd, and possibly A4cd, if these observations in Malaysia reflect global trends across the full species' range.

At the national level, we urge increased conservation effort by: 1) upgrading the status from 'Protected' to 'Totally Protected Species' under the wildlife legislation, 2) intensifying on-the-ground protection in priority conservation areas; and 3) collaborating with NGOs and universities for field research to monitor populations, so that effectiveness of conservation interventions can be measured.

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Appendix 1. The total number of the sambar photographs obtained in recent 10 camera-trapping studies in the three priority conservation areas in Peninsular Malaysia identified in the National Tiger Conservation Action Plan and qualitative indication of the level of protection, threat of forest conversion and hunting pressure. Data on muntjac are added for comparison. The priority areas from north to south are: Belum-Temengor (1 and 2), Greater Taman Negara (3 and 4), and Endau-Rompin landscape (5-10).

Location	State	Forest category *	Sampling period	Study area	Total trap nights	Sambar photos	Muntjac photos	Level of protection effort	Threat of forest conversion	Hunting pressure
1. Royal Belum State Park	Perak	PA	08/2010-04/2011	400	17758	1519	6912	Low	None	Medium
2. Temengor	Perak	PRF	08/2009-05/2010	400	15969	11	1642	None	Medium	Very high
3.Taman Negara Merapoh	Pahang	PA	12/2010-11/2011	200	7582	19	513	Low	None	Medium
4. Sg Yu-Ulu Jelai	Pahang	PRF	9/2009-12/2010	200	5715	0[#]	439	None	Medium	High
5. Endau-Rompin State Park Pahang	Pahang	PRF**	07/2013-01/2014	170	1255	0	285	Medium	None	Medium
6. Lesung-Endau	Pahang	PRF	07/2013-01/2014	90	1198	0	204	Low	Medium	High
7. Endau-Rompin Johor National Park	Johor	PA	07/2013-12/2013	400	2516	0[##]	204	Very high	None	Low
8. Labis-Mersing-Lenggot-Kluang-Ulu Sedili-Panti	Johor	PRF	07/2013-12/2013	2100	7591	15	802	High	Medium	Medium
9. Ulu Sedili Acacia Forest Plantation	Johor	State land	07/2013-12/2013	15	324	0	24	Low	Already converted	High
10. Endau-Rompin corridor	Johor	State land	07/2013-12/2013	40	443	0	15	Low	Very high	Medium-high

* Forest categories are: 1) Protected Areas (PAs)- Gazetted under the National Parks Act or protected area enactment and managed by the Department of Wildlife and National Parks Peninsular Malaysia or state park agencies for conservation and recreation; 2) Permanent Reserved Forests (PRFs) managed by state Forestry Departments for timber production and protection of water catchment areas; and 3) state land forest that has no protected status.

** Unlogged recreation forest.

[#] No sambar tracks were detected during intensive sign surveys on 300m transects.

[##] In this long-term study, cameras are set only on paths confirmed to be used by tigers, indicated by previous images, scent-marking or tracks. Sambar tracks were detected during intensive sign surveys on 300m transects.

Ranging pattern and habitat use of Sambar (*Rusa unicolor*) in Sariska Tiger Reserve, Rajasthan, Western India.

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Abstract

Sambar home range and habitat use were studied in Sariska Tiger Reserve, from March 2013 to April 2013. The estimated individual home ranges of sambar in 100% Minimum Convex Polygon (MCP), 95% and 50% Fixed Kernel Density (FKD) estimators were 11.8 km^2 and 29.1 km^2, 25.1 km^2 and 42.8 km^2, 5.4 km^2 and 9.6 km^2 respectively for males; and for female home ranges were 2.4 km^2 and 14.4 km^2, 13.9 km^2 and 24.7 km^2, 3.4 km^2 and 5.2 km^2 respectively. Radio collared locations were plotted on a classified habitat map of Sariska Tiger Reserve to evaluate habitat use and availability during the study period. Habitat preference was computed using Bonferroni Confidence Interval method, which was compared with Friedman's test. In the overall study area, sambar largely preferred *Anogeissus* dominant forest ($P<0.0001$), while agricultural land and scrubland were avoided and barren land was used according to availability.

Resumen

Fueron estudiadas las Áreas de acción e uso de hábitat del ciervo sambar en la Reserva Sariska de Tigres, desde marzo 2013 hasta abril 2013. Las áreas de acción estimadas por 100% Polígonos Convexos Mínimos (MCP), y por Densidad Fija de Kernel (FKD) de 95% y 50% fueron 11.8 km^2 y 29.1 km^2, 25.1 km^2 y 42.8 km^2, 5.4 km^2 y 9.6 km^2 respectivamente, y por hembras individuales fueron 2.4 km^2 y 14.4 km^2, 13.9 km^2 y 24.7 km^2, 3.4 km^2 y 5.2 km^2, respectivamente. Las locaciones obtenidas por radiotelemetría fueron colocadas en un mapa de hábitat de la Reserva para evaluar el uso y disponibilidad de hábitat durante el período de estudio. La preferencia de hábitat fue computada por el método del Intervalo de Confidencia Bonferroni, lo que fue comparado con el test de Friedman. En el área de estudio, los sambar prefieren generalmente el bosque dominante de *Anogeissus* ($P<0.0001$), mientras que terrenos cultivados y monte seco fueron generalmente evitados. Tierras sin vegetación fueron usadas según su disponibilidad.

Key words: Sambar, home range, habitat use, minimum convex polygon, fixed kernel density estimator.

Introduction:

The sambar (*Rusa unicolor*) is the largest Southeast Asian deer with sizeable antlers. Its height is about 1.5 m. Adult sambar stags weigh between 225-320 kg. Sambar hinds are smaller and weigh between 135 and 225 kg (Lydekker 1916, Crandall 1964, Downes 1983). Sambar are closely related to red deer (*Cervus elaphus elaphus*) of Asia and Europe, Rusa deer (*C. timorensis*) of Asia, and Rocky Mountain Elk (*C. e. nelsoni*) of North America.

The sub-species *R. u. niger* is confined to India. Within India sambar occur in thorn forests of Gujarat and Rajasthan, moist deciduous forests throughout peninsular India, pine and oak forests at the Himalayan foothills, and evergreen and semi-evergreen forests of north-eastern India and the Western Ghats (Sankar & Acharya 2004)**.**

Objectives

The present study covers the ranging and movement pattern of this cervid, along with availability and utilization of habitat. Since sambar is an important prey base for tigers and leopards in the country, the study was aimed to provide information on the ecological functions of the study species in Sariska Tiger Reserve, for further management of this herbivore.

Study Area

The study area is the Sariska Tiger Reserve, Western India. The park (Latitude N27^{o}05' to N27^{o}45', Longitude: E76^{o}15' to E76^{o}35', altitude 540–777 m asl) is situated in the Aravalli Hill Range of a semi arid part of Rajasthan (Rodgers & Panwar 1988). It became a wildlife sanctuary in 1955 and a Tiger Reserve in 1982. The total area of the Tiger Reserve (881 km2); it contains a 400.14 km^2 area that is an official National Park. Sariska terrain is undulating to hilly with numerous narrow valleys. The climate is subtropical, with a distinct summer, monsoon, post monsoon and winter. The vegetation is Northern Tropical Dry Deciduous Forest and Northern Tropical Thorn Forest (Champion & Seth 1968). Apart from leopard and tiger, other carnivores present are striped hyena (*Hyaena hyaena*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), desert cat (*Felis silvestris*), common mongoose (*Herpestes edwardsi*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*) palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*) and ratel (*Mellivora capensis*). Prey species include chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), common langur (*Semnopithecus entellus*), wild pig (*Sus scrofa*), rhesus macaque (*Macaca mulatta*), porcupine (*Hystrix indica*), rufous tailed hare (*Lepus nigricollis ruficaudatus*) and Indian peafowl (*Pavo cristatus*). The predominant domestic livestock found inside the reserve are buffaloes (*Bubalis bubalis*), Brahmin cattle (*Bos indicus*) and goats (*Capra hircus*). There are eight villages located inside the National Park area which have been due for relocation since 1984. The human population is over 1700 in the villages of the National Park with a population of 10,000 livestock (Sankar *et al.* 2009). There are 19 villages located outside the National Park but within the Tiger Reserve, with a human population of around 6000 and a livestock population of more than 20,000 (Sankar *et al*. 2009).

Methodology

Home range evaluation:

Ranging pattern:

Home range (HR) and daily movement of sambar were determined by using radio-telemetry. Four sambar (2 males and 2 females) abbreviated as SS (Sariska Sambar) followed by a number specifying their unique identities and order of chemical immobilization, were the study animals (SS2 (female), SS3 (male), SS5 (male), SS6 (female)) The sambar were chemically immobilized and radio-collared by a team of the Wildlife Institute of India (Fig 1), using **MEDITOMIDINE** and **ATIPAMIEZOLE** and VHF collars (Telonics, USA). The radio-collared sambar (Fig 2) were monitored daily, for two months (1st March to 30th April, 2013), through ground tracking using 'homing in' and triangulation techniques (Deat *et al.* 1980; White and Garrot 1990; Seaman *et al.* 1999; Kernohan *et al.* 2001). Coordinates for the reference points i.e. animal locations, were determined with GPS. Locations were recorded each day for each animal. Home range estimations was done using the program, ArcGIS (Environmental System Research Institute, Redlands, CA, USA) and two methods of analysis; Minimum Convex Polygon (MCP) method (Mohr 1947) and Fixed Kernel (FK) method (Katajisto & Moilanen 2006).

Figure 1: Radio collaring of a sambar male in Sariska Tiger Reserve by an expert team of Wildlife Institute of India (WII)

Habitat use:

All the radio telemetry locations from 4 radio-collared sambar were analyzed to evaluate habitat use patterns. Locations collected during the study period were plotted on the classified Landsat ETM and imagery of Sariska Tiger Reserve.

The habitat use data was collected from each location of radio-collared individuals during the study period. Sambar locations were sampled randomly spreading over their entire HRs. The availability of major vegetation types in the study area was assessed from the vegetation and land cover map already available. Habitat preference of sambar was evaluated based on the availability/utilization data.

Figure 2: Radio collared sambar male in Sariska Tiger Reserve

Habitat use was evaluated based on selection of HRs (100% MCP) within a geographic area, and selection of habitats within established HRs. The extent of intensive use within the study area was determined by plotting MCPs (HRs), of all collared animals. Land cover categories were assigned to the 6 types described above by distributing utilization distribution grids on the GIS layer using ArcGIS 9.2

Bonferroni Simultaneous Confidence Intervals (Neu *et al*. 1974) were used to determine the habitat use within the given geographical area and within established HRs and this was compared with Freidman's Test (Freidman 1937). An individual's use of habitat was defined by the proportion of utilization distribution volume in each habitat type

within individual's HR (Millspaugh *et al.* 2006). The program RSW (Resource Selection Analysis Software for Windows) was used for statistical analysis. Each sambar was considered as a sample for statistical analysis.

Results

Home range:

In total, 283 locations of radio collared sambar were obtained (homing + triangulation), of which 125 locations were males and 158 locations were females (1st March 2013 to 30th April 2013). The number of radio collared locations obtained, HRs of individual sambar for MCP and FK for all contours are shown in Fig 3.

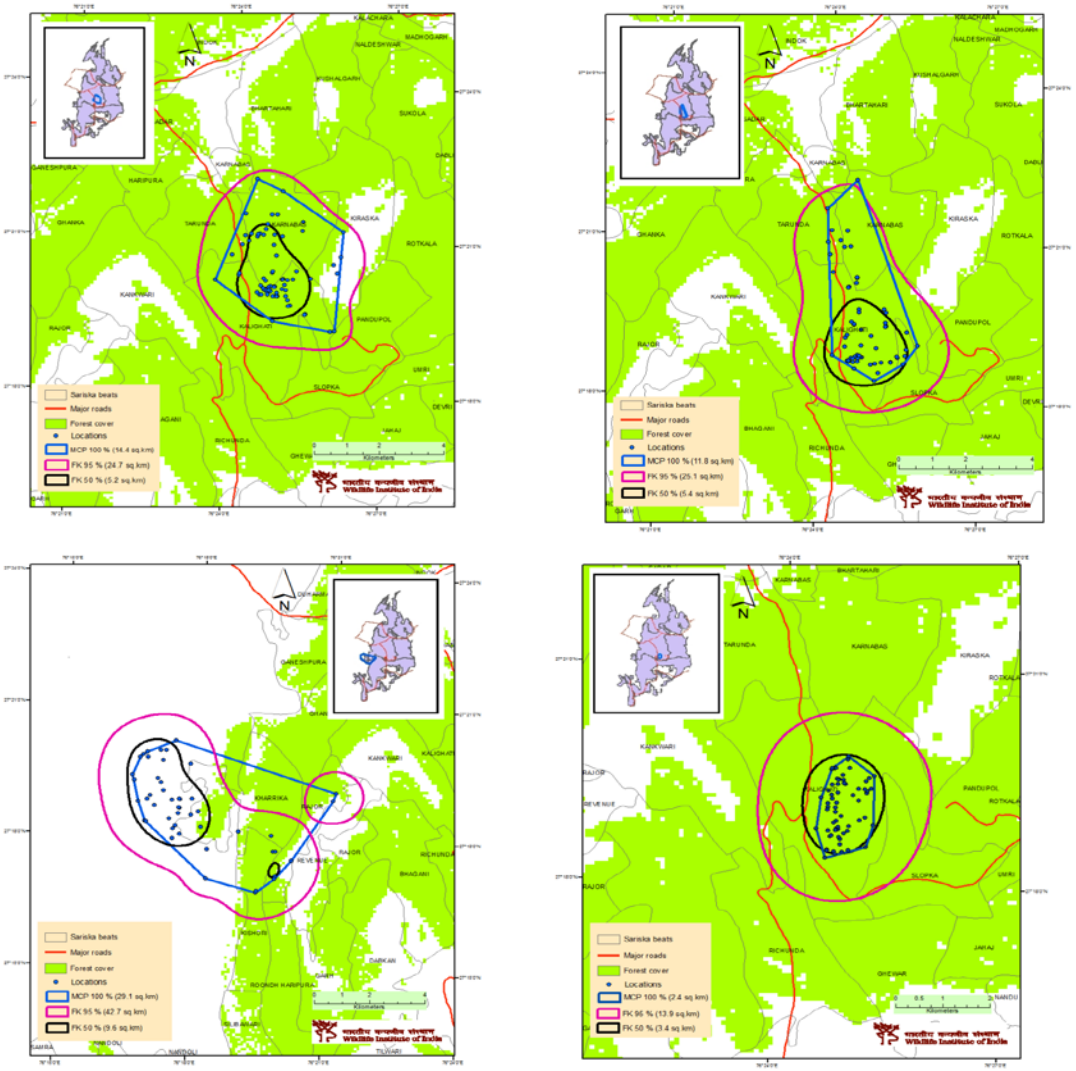

Figure 3. Estimated home ranges of individual radio-collared sambar viz. SS2(female), SS3 (male), SS5 (male), SS6 (female) in Sariska Tiger Reserve using 100 MCP, 95% FKD, and 50% FKD From left up to right(a)- (d):

Habitat use of sambar:

During the study period, the proportion of use of *Anogeissus* dominant forest (P<0.0001), Mixed forest and *Boswellia* dominant forest (P<0.0001) by radio-collared sambar was greater as compared to their availability; the proportion of use of Scrub land (P<0.0001) and Agricultural land (P<0.001) were less than the proportion of availability; Barren Land was used in proportion to its availability (X^2=6.9604, df= 5, P<0.0001, λ= 0.0045; Bonferroni simultaneous confidence intervals and Chi-square test). The habitat preference of sambar during the study period was in the following order: *Anogeissus* dominant forest> Mixed forest> *Boswellia* dominant forest> Barren land> Scrub land> Agricultural land. This was compared with Freidman's test for ranking of preference of different habitats by sambar in the overall study area, and similar results were obtained (Tables 1 and 2).

Table 1: Habitat preference of radio-collared sambar in overall study area (100% Minimum Convex Polygon) of Sariska Tiger Reserve, Rajasthan (March-April 2013)

Sno	**Habitat type**	**Proportion Available**	**Proportion of Use**		**Preference**	**Significance**
			Lower Limit	Upper Limit		
1	Barren land	0.0558	0.0000	0.0300	used in proportion to availability	P<0.05
2	Mixed forest	0.1428	0.2272	0.3481	Proportion of use more than proportion of availability	P<0.0001
3	Agriculture\Fallow land	0.239	0.0062	0.0505	Proportion of use less than proportion of availability	P<0.0001
4	Scrubland	0.2486	0.0607	0.1411	Proportion of use less than proportion of availability	P<0.0001
5	*Anogeissus* dominant forest	0.2151	0.3118	0.4413	Proportion of use more than proportion of availability	P<0.0001
6	*Boswellia* dominant Forest	0.0987	0.1356	0.2458	Proportion of use more than proportion of availability	P<0.0001

Table 2: Friedman's Test for ranking of habitats of radio-collared sambar in overall study area (100% Minimum Convex Polygon) of Sariska Tiger Reserve

Sno	**Vegetation type**	**Difference Rankings (of %use-%available)**					**Rank**
		SS2	**SS3**	**SS5**	**SS6**		
						total	
1	*Anogeissus* dominated forest	5	5	6	6	22	1
2	Mixed forest	6	6	3	4	19	2
3	*Boswellia* dominated forest	4	4	5	5	18	3
4	Barren Land	3	3	2	3	11	4
5	Scrubland	2	2	4	1	9	5
6	Agricultre/ Fallow Land	1	1	1	2	5	6

N.B: SS2, SS3, SS5, and SS6 are individual sambar.

Discussion

Little information is available on the ranging patterns and habitat use of sambar in its entire distributional range in Asia and South-East Asia. This study contributes information in an Indian area.

Ranging Pattern:

Previous studies using radio-telemetric techniques on sambar include the following: Sariska: mean HRs of sambar stags, 4 km^2 , hinds, 1.7 km^2; estimated annual HR of sambar stags, 15 km^2, hinds, 3 km^2 (Sankar 1994); Panna: annual male HR, 13.3 km^2, females, 6.46 km^2 (Chundawat *et. al*. 2007); Florida: stags, 11 km^2 ; hinds, 6 km^2 (Shea *et al* 1990); Texas: stags, 10 km^2, hinds, 5 km^2 (Richardson 1972). In this study we found that home ranges of sambar males were larger than the females. All the previous studies found the same; it seems to be generally true for the species.

The observed large HR of sambar males during this study was attributed to exploration of large areas by sambar males during rut in search of females. Similar findings were reported by Sankar (1994) in the same study area. By covering a large area a male of a polygynous species increases its chances of finding receptive females (Lewis

1990). Male SS5 was found ranging around the south-western boundary of the park and beyond. These areas, Rajor, Kishori (lying in the buffer zone of STR), Gudha, Jaisighpura (villages outside the park) are human dominated landscape units, scrubland, agricultural land and barren land, which have no permanent water sources. The observed large HR of SS5 was attributed to these factors. The small HRs of females SS2 and SS6 was attributed to availability of water, cover and food plants within their HRs.

Resource utilization

The habitat flexibility of sambar is permitted by its broad diet: It has been documented to eat 130–180 species of plants in India alone (Schaller 1967; Johnsingh and Sankar 1991; Kumar 2000), with food requirements less specialised than those of other deer (Schaller 1967). Sambar graze or browse depending upon the forage available (Schaller 1967; Richardson 1972; Martin 1977; Bentley 1978; Dinerstein 1979; Kelton and Skipworth 1987; Ngampongsai 1987; Sankar 1994; Semiadi *et al*. 1995). Sambar live at much higher densities in moist than in dry deciduous forests of Nagarahole National Park (Karanth and Sunquist 1992). Although the highest densities of sambar so far recorded were in the semi-arid forests of Ranthambore (Kumar 2000), across most of its Indian range sambar seem to thrive best in well-watered, moist deciduous hilly terrain (Kumar 2000). Sambar are largely restricted to hilly terrain in the Terai Arc Landscape (Johnsingh *et al*. 2004), although how much this reflects real habitat selection and how much is an artificial pattern produced by human effects (habitat conversion and hunting) is unclear. More widely in India, there seems to be a marked preference for undulating terrain (Kumar 2000). Kushwaha *et al*. (2004) found that in Kumaon Himalaya (India), sambar usage was greater at higher than at lower altitudes. In southern and central India, where much of the forest is deciduous, sambar are true forest ungulates, conspicuously avoid disturbed and open forests, and are highly sensitive to any sort of forest resource extractive activities (Kumar 2000). Kushwaha *et al*. (2004) found that in Kumaon Himalaya (India), sambar occurred primarily in areas of high tree and herb density with low shrub density.

In the overall study area, in Sariska, sambar utilized Anogeissus dominant forest most. Sambars also rely on two of its major browse species, *Grewia flavescense* and *Capparis sepiaria*. Mixed forest habitat was also preferred by the sambar, since high temperatures, shade and water (the major waterholes are located in these areas) attracted them, especially during day light. Scrubland was avoided because it lacks adequate food plants and cover. Agricultural land was avoided by sambar because of anthropogenic disturbance.

Water is an important component of the sambar's summer HR and use of habitat, especially with high temperatures. Being an animal of hilly terrain, sambar cannot travel long distances to water. Usually large aggregations of sambar (>10 individuals) were in the vicinity of sprouting grass (monsoon) and around water holes (summer), in Bandipur (Johnsingh 1983). Water holes were sites where most sambar in a given area aggregate temporarily at dusk, before

dispersing to forage (Eisenberg and Lockhart 1972). Similar observations in Sariska showed large aggregations, ranging from 25 to 55 individuals, near water holes and under the shade of shrubs like *Capparis sepiaria* during the study period.

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New free tool to assess the use of forage resources in deer: *DELTADIET*

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Abstract:

A new free tool for micro-histological analysis of faecal samples has been developed. The software program DELTADIET is an illustrated key that identifies and characterizes the epidermal cells of plant species found in the faecal samples of all plant eating animals. It enables researchers to evaluate and monitor forage resource use of herbivores through the collection of faecal samples.

Resumen:

Una nueva herramienta de uso libre para el análisis micro-histológico de muestras fecales ha sido desarrollada. El software DELTADIET es un clave ilustrado que identifica y caracteriza las células epidérmicas de especies de plantas encontradas en las muestras fecales de todos los animales que comen plantas. Permite que investigadores puedan evaluar y monitorear el uso de recursos de forrajeo de herbívoros a través de la recolección de muestras fecales.

Key words: micro-histology; faecal samples; diet; herbivory

Introduction

Micro-histological analysis of faecal samples consists of identifying under the microscope plant fragments found in faecal samples of plant eating animals. It is one of the most common techniques used when animals cannot be manipulated. Botanical composition of diets can be accurately estimated by faecal analyses (Free *et al*. 1970, Alipayo *et al.* 1992). However micro-histological analysis is also difficult, time-consuming and requires rigorous training (Holechek & Vavra 1981, Holechek & Gross 1982, Mcinnis *et al*. 1983). The use of this technique can be greatly facilitated by storing diagnostic characteristics of the epidermal cells of plants in an interactive illustrated database, based on the DELTA (DEscription Language for TAxonomy) system, instead of relying on memory and training. Such a tool has been developed for important forage plants of the Pantanal; it is named DELTADIET (Desbiez *et al*. 2010) and can be downloaded from the Embrapa Pantanal Website http://www.cpap.embrapa.br/.

Anatomical plant descriptors and manuals are also available for download (Santos *et al.* 2010, Magalhães *et al*. 2010ab).

The DELTA format is a flexible and powerful method for recording taxonomic descriptions for computer processing (Dallwitz & Paine 1986). The DELTA System is an integrated set of programmes based on the DELTA format that includes software packages such as Intkey. Intkey enables interactive identification and information retrieval (Dallwitz *et al.* 1995), and offers better and more comprehensive features than any similar programme (Dallwitz 2000). It gives the user much flexibility such as the ability to enter or delete attributes in any order during identification, allows for diagnostic errors whether made by the user or in the data, calculates the 'best' characters for use in identification, and can display illustrations to characterise descriptions (see Dallwitz, 1995, for a complete list of features). Intkey interactive keys are in use worldwide for a diversity of organisms, including viruses, corals, crustaceans, insects, fish, fungi, plants, and wood (Dallwitz 2006).

The DELTADIET interactive key (Desbiez *et al*. 2010) was created by observations made from the reference collection and a detailed list of characters and descriptors (Santos *et al*. 2010, Magalhães *et al*. 2010a,b). Between January 2004 and August 2005, almost 200 plants were characterised, categorised and photographed using the DElta System for use in the interactive intkey. Separate keys were built for grasses (Gramineae), sedges (Cyperaceae), palms (Arecaceae) and eucodicotyledons. Up to 70 characters were used for each key and were described by up to 30 descriptors, using terminology from Metcalfe and Chalk (1950) and Metcalfe (1960).

Creating the DELTADIET based interactive key is labour intensive, but greatly facilitates and improves the reliability and speed of micro-histological analysis. The defining feature of interactive keys is that characters can be used in any order (Dallwitz *et al*. 2000). Characters that are not available in a particular epidermal fragment on a slide, or whose interpretation is not clear to the user, can be avoided. If it is known or suspected that an error has been made, the programme can be instructed to eliminate taxa only if they differ in more than one attribute from the specimen (Dallwitz *et al.* 1995). Keeping digital photographs of all the characteristics of plant cells greatly facilitates making a rapid comparative analysis. The user does not need to rely as much on memory. Microscope slides can break, get lost and, over time, their quality can decrease. Having a digital reference data base in the key is another advantage of the system. The key can be continuously improved and is maintained simply by making corrections and additions to the data matrix. An inevitable consequence of the flexibility of an interactive key is that much of the strategy involved in carrying out identification is left to the user. Good strategies must be learnt for the

interactive key to be used to its best advantage. This is achieved through practice. The use of the reference collection to compare identification results from the key is recommended.

Micro-histology using the DELTADIET based interactive key is an efficient technique and it should be used and promoted for research on the ecology of deer and other species that consume plant material. Using the reference materials and manuals a key can be made for plants from any region of the world and we hope this tool will be used in deer research or with other plant eating animals.

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Analysis of suitable habitat for sambar (*Rusa unicolor*) using remote sensing and GIS

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A study was conducted on sambar (*Rusa unicolor*) to evaluate its suitable habitats in Chandoli tiger reserve, India (17^0 04' 00" N to 17^0 19' 54" N and 73^0 40' 43" E to 73^0 53' 09" E). Chandoli tiger reserve is situated on the Syahdari range of Western ghats (India). While the main results of the study are under preparation, a brief account is discussed herewith.

Habitat degradation and loss had been widely recognized as the main cause for the decline of wildlife populations. Evaluating the quality of wildlife habitat can provide essential information for wildlife refuge design and management. Habitats were evaluated using multiple logistic regression integrated with remote sensing and geographic information system. Satellite imageries of LISS-III of IRS-P6 of study area were digitally processed. To generate collateral data topographic maps were analysed in a GIS framework. Layers of different variables such as Landuse land cover, forest density, proximity to disturbances and water resources and a digital terrain model were created from satellite and topographic sheets. These layers along with GPS locations of sambar presence/absence and multiple logistic regression (MLR) techniques were integrated in a GIS environment to model a habitat suitability index of sambar. The results indicate that approximately 69.92 km^2 (24%) of the forest of tiger reserve was least suitable for sambar, whereas, 82.60 km^2 (28%) was moderately suitable, 88.25 km^2 (30%) suitable and 54.01 km^2 (18%) was highly suitable. The accuracy level of this model was 97.6%. The model can be considered as potent enough to advocate that forests of this area are most appropriate for declaring it as a reserve for sambar conservation, ultimately to provide a prey base for tiger.

Summary of a study on modeling of habitat suitability index for muntjac (*Muntiacus muntjak)* using remote sensing

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As the availability and suitability of habitat is the most crucial factor for survival of a wildlife species, a study was conducted in Chandoli Tiger Reserve (17^0 04‘ 00” N to 17^0 19‘ 54” N and 73^0 40‘ 43” E to 73^0 53‘ 09” E) in 2005 to evaluate suitable habitats for muntjac. The details of the results of this study have been published (Imam *et al*. 2012). A summary of the findings is given here in view of wider dissemination of the findings for the conservation and management of this interesting species of deer. Habitats were evaluated using multiple logistic regressions integrated with remote sensing and a geographic information system. Satellite imageries of LISS-III of IRS-P6 of the study area were digitally processed. To generate collateral data topographic maps were analyzed in a GIS framework. Layers of different variables such as Land use land cover, forest density, proximity to disturbances and water resources and a digital terrain model were created from satellite and topographic sheets. These layers along with GPS location of muntjac presence/absence and multiple logistic regression (MLR) techniques were integrated in a GIS environment to model habitat suitability index for muntjac deer.

The results revealed that out of about 300 sq km, 20.70 km2 (7.02%) of forest area was most suitable, 22.12km2 (7.5%) moderately suitable, 29.54 km2 (10.02%) less suitable, whereas 222.4 km2 (75.44%) was least suitable for the muntjac. The modeling revealed that suitable habitats for muntjac are confined along with dense forests; however these habitats are highly fragmented. It is a well known fact that the presence or absence of a species in a particular habitat can result from the size and structure of the fragments and also from the characteristics of the surrounding landscape. Therefore, the population of muntjac in this reserve is noticeably low. The major portion of suitable habitats is located in the northern part of the Reserve, whereas in the southern part only 3-4 small and fragmented patches of suitable habitat are present. It was observed during field visits that the northern part of the reserve was well protected and having corridor connectivity with other neighboring forest areas, and probably this may be one of the causes that these areas are suitable for the muntjac. The Southern part of the reserve is exposed to more anthropogenic activities and has more cattle grazing pressure than the northern portion of the Reserve.

Before declaration of this forest as protected area, major portions of forests lying along the river were owned by villagers as their private forests and, while evacuating, villagers felled almost all privately owned forests and destroyed the natural habitats of wild animals. Probably this may be another reason that the southern part of reserve does not provide suitable habitat for the muntjac. Human population density and other anthropogenic pressures remarkably influence local extinction of animal species. At the time of the establishment of the Tiger Reserves, there were 32 villages inside the protected area with a human population of 7900, whereas, approximately 78 villages with a human population of 10,150 were present at the periphery (within a 10 km radius of PA) There is evidence that protected natural reserve areas are critical for reducing the local extinction probabilities of most Indian large mammals and India‘s current fragmented network of relatively small protected areas (average size less than 300 km2) do not have high carrying capacities for large mammals. Probably these are the reasons that in spite of all pressures, local average extinction estimated for muntjac across a 100-year time-frame is 0.39. Presently only about 4% of the land is under a protected area system in India. However, the real effective protected area is less than 1%.

The study suggests that the quality of this forest improved after declaring it as a reserve, and privately owned forests, which were destroyed almost completely, are rejuvenated and coming up as forests, and evacuated village areas are turning into grass lands. Although very few wild animals were seen during the field visits, indirect evidence of their presence indicated that wild animals are thriving here after getting conservational attention. If adjoining areas are added to the protected area it would safeguard the future of biodiversity in this Reserve. However, more extensive field work, sound data collection and analysis would help further in predicting the potentiality of suitable habitats for wild animals. The present study highlights the role of Remote Sensing, GIS, GPS and geospatial technique in evaluation of wild animals' habitats with acceptable accuracy.

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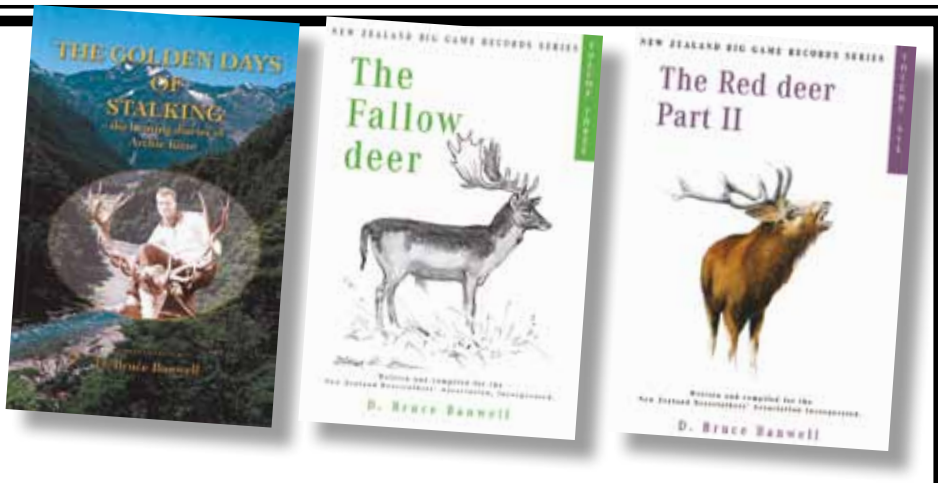
By Graham Gurr, Halcyon Publishing

Bruce Banwell Legacy



D Bruce Banwell passed away on the 4th of September surrounded by his family. Until he was no longer able he had spent his remaining weeks organizing others to complete the remaining work on the manuscript of the last book in the New Zealand Big Game Record series.

The D stood for David although in the thirty plus years I was Bruce's publisher I had never heard anyone use that name, he was Bruce to everyone that knew him. In some ways he was a throwback to the Victorian gentleman naturalist, a bank manager by profession Bruce had a passion for the Red deer and Wapiti found in New Zealand. He grew up hunting them and his enquiring mind wanted to know more about them. In his own time and at his own expense he painstaking researched the origins of the animals introduced into New Zealand and wrote three books: Wapiti in New Zealand (1966), The Highland Stags of Otago (1968) and The Red Stags of the Rakaia (1970). All published by AH & AW Reed.

The Halcyon Press republished the three books in a limited edition The Banwell Books in 1985, the original editions by then long out of print but still hugely in demand.

Bruce was fiercely proud of his Scottish roots, insisting that the correct Gaelic spelling be used in his books rather than the sassenach version. He amassed an amazing collection of photographs and archival materials while researching his books, and continued to do so all of his life. So much so that we went on to publish three volumes of Great New Zealand Deer Heads over the period 1986 to 1989. In each describing the taking of the then best heads for Red Deer, Wapiti and in Volume III Fallow, Rusa, Sambar, Sika and Whitetail.

The Royal Stags of Windsor (1994) examined the Windsor Park Red deer, their origins from Europe and beyond and their introduction to Australia and New Zealand. He also found time to write The Golden Days of Stalking (2008) based on the hunting diaries of Archie Kitto.

On behalf of the NZDA he commenced the Big Game Record Series, published by The Halcyon Press, with The Sika, (1999), The Wapiti and Moose (2001), The Fallow Deer (2003), The Rusa, Sambar and Whitetail (2006), The European Red deer Part I (2009) and Part II (2011), The Alpine Chamois was published earlier this year. A monumental undertaking that took over fourteen years to complete.

Bruce traveled extensively, with his wife Barbara and often with his good friend (the late) Jack McKenzie, visiting more countries than I can list here to further his research and understanding of the origins of the various species of Red deer, Sika and Wapiti. His contribution to the literature has been incredible. He wrote not only for New Zealand publications such as Hunting and Wildlife, Rod and Rifle and Deer Farmer but also many international publications such as the British Deer Association's journal Deer.

Internationally his contribution in scientific circles is highly regarded, he was a member of the Deer Specialist Group of the I.U.C.N. and I doubt there has been a research paper published in the past decade on the subject of Red deer or all its subspecies that does not use something that Bruce wrote as a reference. At one point they were even considering naming a subspecies Banwelli after Bruce had identified it as a new subspecies.

Bruce could be bull headed, blunt, difficult, generous and charming, sometimes all in the same conversation, he was like all of us - far from perfect. His boyish humour and impish grin was never far away in all the years I knew him. It was the grin that usually told you he was giving you a bit of a wind-up. He was always happy to talk about deer and had an infectious way of sharing his latest discovery.

I will leave the last word to Dr. Susana Gonzáles, Co-Chair of the Deer Specialist Group IUCN. One of the many tributes that have come in from around the world since news of his death.

"Bruce was a devoted researcher very concerned and committed with the deer management and conservation. He was part of the Deer Specialist Group/SSC/IUCN, having an important role in all the relative issues with the Red deer. He dedicated his life to study, research and writing his books.

We always are going to remember Bruce and his books will be a legacy for the future generations."

8TH INTERNATIONAL DEER BIOLOGY CONGRESS

The 8th International Deer Biology Congress is scheduled for July 27-31, 2014 in Harbin located in the northeastern corner of the People's Republic of China in the Heilongjiang Province. The hosting institution is the Northeast Forestry University under the directional organization of Professor Minghai Zhang (College of Wildlife Resources).

The organizers invite deer researchers to contribute presentations on any topic related to deer biology. Contributed presentations can be either oral or poster.

Scheduled Plenary speakers include:

Edward A. Hoover, DVM, PhD (Chronic Wasting Disease)
University Distinguished Professor
Department of Microbiology, Immunology, and Pathology
College of Veterinary Medicine and Biomedical Sciences
Colorado State University, Fort Collins, Colorado, USA

Jiang Zhigang, Ph.D. (Asian Deer Conservation)
Professor, Institute of Zoology, Chinese Academy of Sciences, Beijing, China

Yushu Huo, Ph.D. (Traditional Chinese Medicine)
Emeritus professor of Jilin Academy of Traditional Chinese Medicine and Medicinal Herbs;
Executive Officer of Jilin Dongfeng Deer Velvet Station of Chinese Academician

Chunyi Li, Ph.D. (Recent progress in antler stem cell research)
Executive Director, State Key Lab for Molecular Biology of Special Economic Animals,
Changchun City, Jilin, China

Dale McCullough, Ph.D. (Population Regulation/Abundance)
Emeritus Professor, Dept of Environmental Science, Policy, & Management
University of California, Berkeley, USA

Sessions already lined up on topics of interest to deer biologists and managers include:
Health and Disease
Traditional Chinese Medicine
Antler Products and efficacy
Deer Conservation in Asia
Population regulation/overabundance
Antler Biology: Development
- Stem cells/biomedical applications
Endangered species management
-Ex-situ as reinforcement to in-situ management
Ethics in deer velvet farming
Predation

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