TAPIR SPECIALIST GROUP

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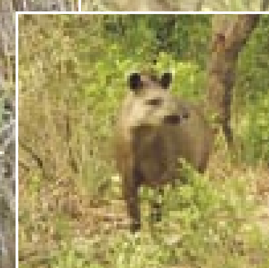
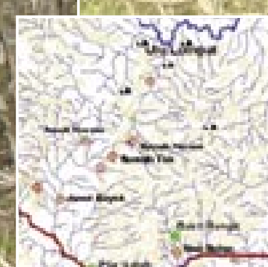
Tapir Conservation

The Newsletter of the IUCN/SSC Tapir Specialist Group

www.tapirs.org

■ **The Tapir Research Spotlight**





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HOUSTON ZOO NATURALLY WILD

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TAPIR CONSERVATION

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FROM THE CHAIR

Letter from the Chair

Patrícia Medici

It is always nice to be able to start my Letter from the Chair by saying that the IUCN/SSC Tapir Specialist Group (TSG) continues to make progress in many different fronts!

We continue to work tirelessly on the development of **National Action Plans for Tapir Conservation** in several different tapir range countries in South and Central America, as well as Southeast Asia. Our TSG Country Coordinators are making considerable advancements on the design of their National Plans. Our Ecuadorian Regional Action Planning Committee has just held an action planning workshop last May to finalize their National Action Plan for Tapir Conservation in Ecuador. Argentina is taking the final steps on the development of their National Plan. French Guiana, Guatemala, Honduras and Indonesia are planning for a series of activities related to tapir action planning. Very soon we will have a series of new plans ready to be implemented for the benefit of tapir conservation!

The new **Red List Assessments** for the four species of tapirs, compiled by our Red List Authority Alan Shoemaker and members of the TSG Red List Committee were released during the IUCN Conference held in Barcelona in October 2008 is available online at www.iucnredlist.org. Our TSG Red List Committee will continue to work with the Red List Unit of the IUCN Species Programme to keep our tapir assessments up to date. In order to be more efficient in doing that, we will try to find way to support members of the TSG to participate in regular Red List training courses organized by the IUCN Red List Unit around the world.

The team of editors of ***Tapir Conservation***, including Carl Traeholt, Anders Gonçalves da Silva, Kelly Russo and Stefan Seitz, has been working hard to improve our newsletter. We have put together a new Editorial Board and developed brand new, updated guidelines for contributions, which are included in this issue and will soon be available online on the TSG website. Additionally, our editors are working to develop and implement an online system to submit contributions to the newsletter, which will certainly make our lives much easier and provide a much more professional way to carry out our submission & review process. Authors will be able to check the status of their contributions and communicate with our editors more effectively. The Houston Zoo Inc. in the United States continues to sponsor the printing and distribution of two issues of *Tapir Conservation* per year and we are extremely grateful for their support. Furthermore, I would like to thank the Copenhagen Zoo in Denmark for their continued financial support for the TSG operation costs.

Patrícia Medici,
Chair of the IUCN/SSC Tapir Specialist Group

A second webmaster – Kara Masharani from the Houston Zoo Inc. – has come on board to help us improve our **TSG website (www.tapirs.org)** and keep it up to date. Gilia Angell, Kelly Russo and Kara have been working on completely re-designing and updating the website. In a few weeks we will have an entirely new navigation format, new sections for the general public, and pages focusing on tapir field projects. Therefore, we will soon start chasing tapir conservationists around the world for information about their tapir conservation efforts so that we can create pages about in-situ and ex-situ tapir conservation projects. We will need help!

The TSG Education and Marketing Committee is also working on building profiles for the TSG on several **vehicles of social media and networking** such as Facebook, Twitter, Flickr, YouTube, among others.

Our **Virtual Library** manager Mathias Tobler continues to improve and maintain our library. We currently have 550 bibliographical references available online in PDF format for all TSG members. The references include scientific papers, BS, MSc and PhD dissertations, magazine articles among others. Our TSG members have been helping us keep our library as up to date as possible.

We have recently established a **Steering Committee for the TSG**, which is formed by a group of 14 members representing several different professional backgrounds, institutional affiliations, and range countries. The current structure of the TSG which includes a variety of committees, taskforces and working groups, works very efficiently and in a very integrated way. However, the group felt the need to have a Steering Committee dedicated to discussing the group's major issues and, most importantly, helping us implement our Strategic Plans and Action Plans.

On a final note, I would like to let you all know that I have been invited by the new chair of the IUCN Species Survival Commission (SSC) - Dr. Simon Stuart - to be part of the Steering Committee of the SSC. I accepted the invitation and participated in the first meeting of this new established **SSC Steering Committee** held at the IUCN Headquarters in Gland, Switzerland, last June. It is incredibly challenging to be a member of this group of conservationists and I feel I have so much to learn, but being able to learn about and contribute to conservation on a global level is extremely rewarding.

Thank you so much for your continued support to the Tapir Specialist Group and to tapir conservation in general! Hope to see all of you in Malaysia in 2011! Yes, it is final! The Fifth International Tapir Symposium will be held in Kuala Lumpur in April 2011. We will start the organization of the meeting in early 2010. Therefore we recommend you all start saving up for the long trip to Southeast Asia!

All the best from Brazil,

Patrícia Medici
M.Sc. in Wildlife Ecology, Conservation and Management
Ph.D. Candidate, Durrell Institute of Conservation and Ecology (DICE), University of Kent, United Kingdom
Lowland Tapir Conservation Initiative, IPÊ - Instituto de Pesquisas Ecológicas, Brazil
Chair, IUCN/SSC Tapir Specialist Group (TSG)
Facilitator, IUCN/SSC Conservation Breeding Specialist Group (CBSG) - Brasil Network
Rua Taiobá, 672, Bairro Cidade Jardim, CEP: 79040-640, Campo Grande, Mato Grosso do Sul, BRAZIL
Phone & FAX: +55-67-3341-8732 /
Cell Phone: +55-67-9965-6960
E-mail: epmedici@uol.com.br; medici@ipe.org.br; 5@kent.ac.uk

SPOTLIGHT

The Tapir Research Spotlight

Anders Gonçalves da Silva and Mathias Tobler

Welcome to our first research spotlight. Mathias Tobler and I have examined some of the amazing new literature involving tapirs and tapir-relevant subjects to bring you a short summary of what is out there. For this edition, we picked three articles. The first is about tapirs and their evolutionary history. The other two deal with one of conservations most fundamental problems, how do we estimate the abundance of individuals in an area? We hope you enjoy it!

What do Tapirs, Rhinos, Horses and Humans have in Common?

Trifonov et al. 2008. Multidirectional cross-species painting illuminates the history of karyotypic evolution in Perissodactyla. *Chromosome Research* 16: 89-107

In the *Origin of the Species*, Darwin proposed the controversial notion that all organisms descend from a common ancestor. The major loophole in his theory was that he had no explanation as to how information would be transmitted from one organism to the other. In the early 20th century, the works of Gregor Mendel were re-discovered shedding new light into how information may be transmitted between organisms. Thomas Hunt Morgan, in the famous Fly Room at Columbia University, proposed that all the information was exchanged via chromosomes based on his observations of polytenic chromosomes (which multiply without separating, allowing for easy observation under a microscope) in fruit fly salivary glands. Almost a century later, the use of variation at the chromosome level to understand evolutionary patterns has largely given way to the study of DNA sequences. However, as Trifonov and colleagues show us, there is still plenty to learn about evolution from examining patterns of fusion (when two or more chromosomes form one chromosome) and fission (when one chromosome is broken into two or more different chromosomes) of chromosomes across related species. In this study, they paint chromosomes of reference species (horses, Grevy's zebra, white rhinoceros, Malay tapir, and humans) in different colors, and bind them to the chromosomes of the three other tapir species, one other rhinoceros species and another three equine species. Where the chromosomes bind, indicate areas of homology (i.e., similar) between species – lending empirical proof to Darwin's idea about descent. Through the patterns of homology, they were able to estimate the fusion/fission events across Perissodactyla, showing that Ceratomorphs (tapirs and rhinos) have slower rates of change than Hippomorphs (horses) at the chromosome level. Furthermore, the evolutionary tree deduced from changes at the chromosomes level is largely concordant with trees derived from DNA sequence data. However, unlike some previous studies that suggest a close relationship between Baird's and Malay tapir, this study finds that the American tapir species form a single branch of tapir history, independent of the Malay tapir. While this study takes us a step further in understanding tapir history, it still leaves open questions about some of the finer relationships among extant tapir species.

Anders Gonçalves da Silva

Abundance that matters ...

Royle et al. 2009. A hierarchical model for estimating density in camera-trap studies. *Journal of Applied Ecology* 46: 118-127

One of the fundamental problems in conservation biology, and one that is faced by many tapir biologists, is estimating the abundance, density, or number of animals in a specific area. From an ecological and conservation perspective, figuring out this number (with a reasonable degree of accuracy) is paramount. Without this number, defining conservation strategies would be akin to defining a financial strategy without knowing how much money you have in the bank. Unlike our finances though, biologists can't go to the ATM or logon to their online wildlife-banking page. Ultimately, the problem comes down to a sampling issue – and that means statistics! Biologists have figured out a number of ways of sampling tapir, tiger, and other elusive species to estimate the number of individuals. Camera-traps are quite popular, and more recently, bait stations and scratching posts have been used to collect genetic material (saliva and hair) to provide a count of how many individuals are in a certain area. These methods belong to a class of techniques called mark-recapture. Ideally, in a mark-recapture scenario, you capture a number of individuals (say 80) in a short period of time, mark and release them all. Some time later, you capture another 80 individuals over the same time, of which maybe 20 where marked. If you assume that you are sampling a closed population (i.e., no individuals leave or arrive in the population) and that the chance of capturing an individual is the same for all individuals, then the proportion of individuals recaptured relative to the individuals captured in the second round will be equal to the proportion of individuals originally marked relative to the whole population – the variable of interest. So, in this case the total population size would be 320. However, these assumptions rarely hold in nature. Rather, populations are often open, individuals will leave or arrive into the sample area; and, the chance of sampling an individual may vary with a number of parameters (for instance, the position of its territory relative to the trapping location). To address this, Royle and colleagues build a model that uses the spatial information contained in the dataset (the camera-traps or baiting stations are spatially distributed in some manner) and the number of observations of each individual over several "capture rounds" with camera-traps to estimate the density of "activity centers" – each "activity center" being the hypothetical home range of an individual. This models takes into account the fact that we are usually dealing with an open population, and is able to estimate the area that is effectively covered by the trapping stations, and furthermore, takes into account individual variability in trapping history. The authors show the improvements to estimates of tiger population density in a park in India that can be obtained by using their method. In addition, their method could be used in preparing mark-recapture methods by estimating how different spatial distributions of trapping stations might change the effective area being sampled. The question still remains whether camera-trapping and other methods are good mark-recapture techniques for tapirs. As seen below, it seems they can be!

Anders Gonçalves da Silva

A Picture is worth a Thousand Words – Camera Traps reveal Tapir Density in the Brazilian Pantanal

Trolle, M et al. 2008. Brazilian tapir density in the Pantanal: A comparison of systematic camera-trapping and line-transect surveys. *Biotropica* 40: 211-217

Getting accurate estimates of tapir density can be a challenging task. For tapirs, line transects have long been the methods of choice, however, collecting sufficient data to get an accurate density estimate is often very time consuming and for many sites requires nocturnal transect. In recent years, camera traps have been widely used to estimate the density of spotted cats and other species with distinctive individual markings. The method is based on a capture-recapture analysis where the capture history of identified individuals is used to estimate the total number of individuals in the study area. Trolle and his colleagues successfully applied this method to a tapir population in the Pantanal using markings such as scars, ear notches, spots, tail length and size to distinguish individuals. Their cameras, set out 1 km apart over an area of 54 km^2, photographed a total of 27 different tapirs, resulting in a density of 0.58 ± 0.11 tapirs/km^2. This number was almost identical to the density of 0.55 tapirs/km^2 estimated by line transects at the same site. As pointed out by the authors different survey designs still need to be evaluated, but the results from this study showed that camera traps are promising new methods for estimating tapir density. Data collected by the large number of camera trap surveys currently being carried out to study jaguar and ocelot populations could be analyzed to estimate tapir density for many different sites, helping to better understand variation in tapir density across different habitats.

Mathias Tobler

SCIENCE

Abstracts of Dissertations and Theses

The number of students conducting research on tapirs is growing continuously. Here, we give an opportunity to publish abstracts of dissertations and theses, which inform the community about finished projects.

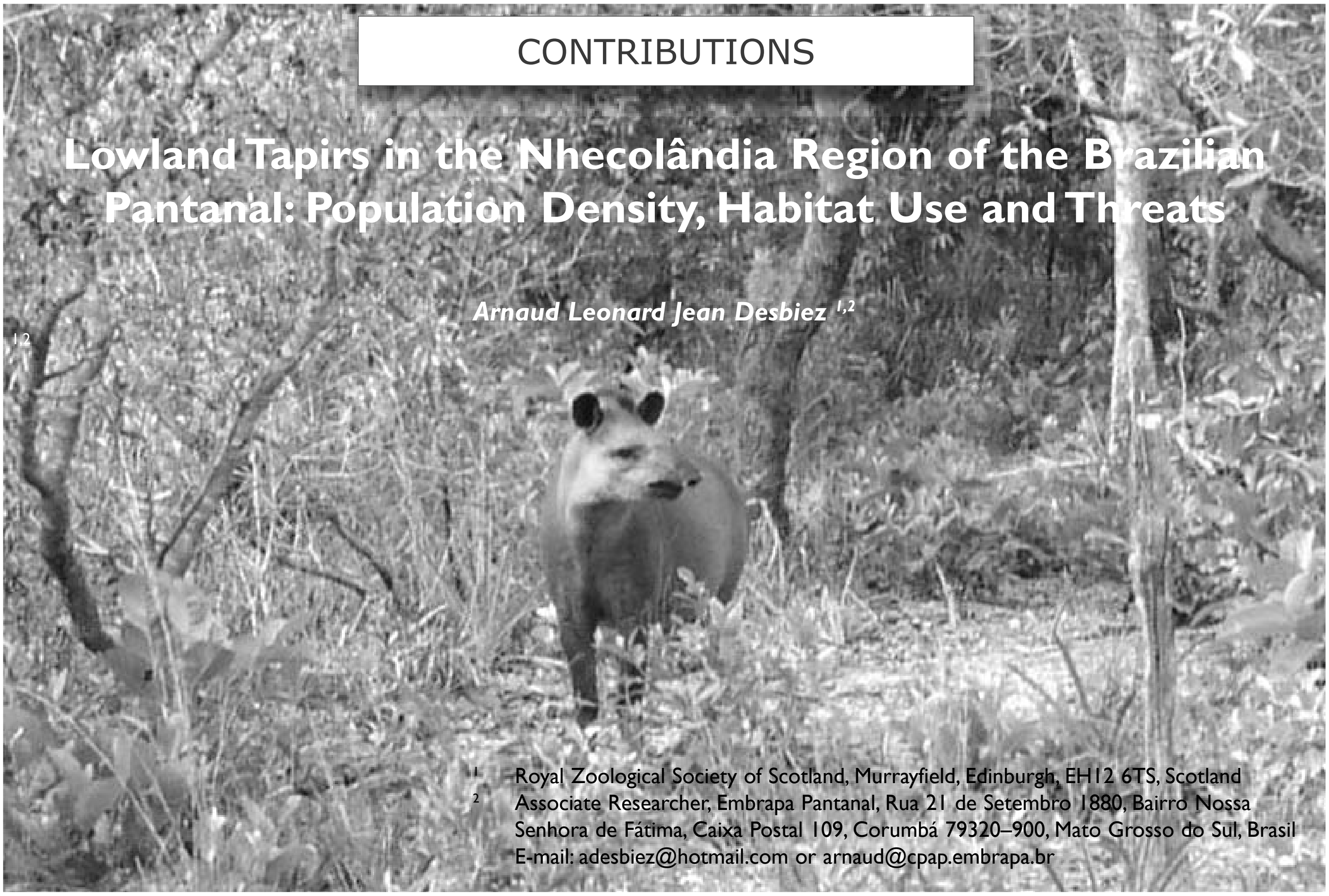
Communication of Malayan and Lowland Tapirs (*Tapirus indicus* and *Tapirus terrestris*) kept in Zoological Gardens – Experimental Investigations and a Survey of the Keeping Staff

Until now, unlike their relatives, rhinos and horses tapirs have received considerably less attention in studies on communication. Therefore, it was the aim of this study to test which stimuli contain communicational information for tapirs. For this purpose, the reactions of tapirs on olfactory (faeces of male tapirs), acoustical (playback of different animal voices) and optical stimuli (posters with edited tapir silhouettes) were examined and the animal keepers were questioned on tapir perception and communication. Research visits took place at the zoos of Berlin, Dortmund, Heidelberg, Munich, Nuremberg, Osnabrueck (Germany) and Mulhouse (France) during the years 2004, 2005 and 2006. A total of 30 individuals, thereof 13 (8.5) Malayan tapirs (*Tapirus indicus*) and 17 (7.10) Lowland tapirs (*Tapirus terrestris*) attended the experiments.

Differences in the tapirs' interest in the separate dung samples suggest the perception of olfactory information according to the "scent-matching" and the "mate-choice" hypothesis. Yet the reactions of the tapirs could neither be related to the age of the sample-providing animal nor with the animals' parasitic status. The playback experiments showed that tapirs distinguish between the voices of different animal species. The results point to the conclusion that the reactions of the tapirs relate to phylogeny. The most intense interest was taken in their own species followed by the closely related ones. The results of the optical test with variously intense edited tapir silhouettes speak for the importance of the white ear rims as a family specific key stimulus. But that effect could not be amplified by adding a greater extent of white to the silhouette. Tapirs of both species reacted most strongly to the normal tapir silhouette followed by a silhouette without proboscis. In their questionnaires keepers placed the meaning of olfaction and acoustics ahead of that of optics both by evaluating the perception of tapirs and by estimating their communicational forms.

This dissertation can only provide a starting point for future studies on tapirs living in zoos. Therefore, at the end of the paper, suggestions for further studies on tapir communication and mate choice are made as well as for experiments concerning olfactory, acoustical and optical environmental enrichment for tapirs.

Susanne Zenzinger
Ernst-Moritz-Arndt-University Greifswald, Germany
Rainwiesenweg 6b, 90571 Schwaig, Germany,
E-mail: susanne.zenzinger@yahoo.de



CONTRIBUTIONS

Lowland Tapirs in the Nhecolândia Region of the Brazilian Pantanal: Population Density, Habitat Use and Threats

Arnaud Leonard Jean Desbiez [1,2]

[1] Royal Zoological Society of Scotland, Murrayfield, Edinburgh, EH12 6TS, Scotland
[2] Associate Researcher, Embrapa Pantanal, Rua 21 de Setembro 1880, Bairro Nossa Senhora de Fátima, Caixa Postal 109, Corumbá 79320–900, Mato Grosso do Sul, Brasil
E-mail: adesbiez@hotmail.com or arnaud@cpap.embrapa.br

Abstract

The Pantanal is one of the world's largest freshwater wetlands. Most of the land is under private cattle ranching. Using line transect methods, lowland tapir (*Tapirus terrestris*) densities were estimated at 0.21 ind/km² in a 200 km² area which comprised different landscapes. Tapir density was highest in the forested landscape (0.40 ind/km²), and no tapirs were sighted in the floodplain landscape. Hunting was not found to be a major threat in the region. Currently, deforestation and intensification of ranching practices are thought to be the biggest threats to tapir populations in the region. Suggestions for further research on population estimates, impacts of cattle ranching, landscape connectivity and livestock disease transmission are made.

Keywords: density, habitat use, hunting, Pantanal, *Tapirus terrestris*

Introduction

The Pantanal is an immense floodplain located in the centre of the South American continent, spreading across three countries: 140 000 km² belong to Brazil, 15 000 km² to Bolivia and 5 000 km² to Paraguay. The wetlands consist of mosaics of seasonally inundated grasslands, river corridors, lakes, gallery forests, scrub and semi-deciduous forests which supports an abundance of wildlife including the lowland tapir (*Tapirus terrestris*). The Pantanal is subject to annual floods, but there is considerable variability in flooding intensity and climatic events which will strongly affect the development and dynamics of the fauna and flora (Hamilton *et al.* 1996; Junk & Da Silva, 1999; Nunes da Cunha & Junk, 2004).

Less than 5% of the Brazilian Pantanal is formally protected in national and state parks, or in private protected areas (Harris *et al.* 2005). Almost all the land is occupied by private cattle ranches. Until recently, the low human population density and traditional extensive cattle ranching practices were considered to have little impact on the ecosystem. However, during the past few decades, economic and political changes have lead to an increase in habitat conversion to open pastures planted with exotic grasses. New technologies and alterations in exploitation practices are being introduced and are often accompanied by environmental degradation, deforestation, damage to watercourses and natural vegetation (Alho *et al.* 1988; Gottgens *et al.* 2001; Seidl *et al.* 2001; Santos & Costa, 2002; Padovani *et al.* 2004).

The Pantanal can be divided in sub-regions based on soil, vegetation and flooding characteristics (Hamilton *et al.* 1996). It is generally considered that lowland tapirs are present in all the sub-regions; however there is still very little information about the species in this biome. I present results on density, habitat use and potential threats to lowland tapirs from the Nhecolândia region Pantanal as well as a discussion of possible research opportunities.

Methods

Study Area

Field work took place in a 200 km² area, which included six traditionally managed cattle ranches in the Nhecolândia Region of the Brazilian Pantanal. Traditional management means that most of the ranch is comprised of native vegetation, cattle are managed extensively and human impact is generally considered low. The study area included three different landscapes characteristic of the region: 1.) Floodplains, dominated by seasonally flooded grasslands; 2.) Forests, characterised by strips and patches of semi-deciduous forest; and 3.) Cerrado, covered by scrub forest and open scrub grasslands.

Population Density and Habitat Use

Tapir population densities were estimated through 21 line transects ranging between 3.5 and 5 km that were randomly placed throughout the study area. Seven transects were opened in the forest landscape, six transects in the cerrado landscape, and eight in the floodplain landscape. Line transects were almost always walked alone by the same observer and census began at sunrise. No nocturnal surveys were conducted. Details of census methods are provided in Desbiez (2007). A total of 2,174 km of transects were walked between October 2002 and November 2004 during which I sighted tapirs 19 times. Distance sampling methods (Buckland *et al.* 2001) could not be applied due to the low number of sightings. Instead, strip transect methods were used. Strip transect counts presume a complete census of all animals within a fixed distance from the transect (Cochran 1977). A 35-meter width from the transect was used, as it was estimated that all tapirs 35 meters from the line transect were seen in all habitat types crossed by the line transects.

Hunting Assessment

Between April 2004 and November 2005, hunting practices within the Nhecolândia Region of the Pantanal were investigated. A total of 97 semi-structured interviews were conducted in 71 cattle ranches distributed throughout the region. Hunting practices were further investigated through the use of hunting registers and by accompanying hunters in the field.

Results

Population Density and Habitat Use

Lowland tapirs were sighted 19 times from the trails. Two of these sightings included a pair (mother and calf and two adults). Sixteen of these sightings were made within a 35 m distance from the trail and were used to estimate densities. Almost half the sightings of tapirs were made in the semi-deciduous forest (46%), 25% were made in the scrub grasslands, 20% in the scrub forest, and 9% in the open grasslands. The overall density of tapirs was 0.21 ind/km². The density of tapirs was highest in the forested landscape 0.40 ind/km², with no tapirs sighted in the floodplain landscape.

Hunting Assessment

The semi-structured interviews, hunting register and the hunting expeditions I participated in all showed that feral pigs are currently the main hunting target of people living in the Nhecolândia Region of the Pantanal (see Desbiez 2007 for details). Lowland tapirs, which are commonly hunted throughout their distribution, are

Table 1. Density and sightings of lowland tapirs in the different landscapes of the study area.

	Overall	Forest landscape	Cerrado landscape	Floodplain landscape
Number of sightings (N)	16	12	4	0
Density of lowland tapirs (ind/km²)	0.21	0.40	0.13	0.00

rarely targeted in the Nhecolândia Region. In addition, no human-wildlife conflict between local people and tapirs was reported. While many ranchers complained that collared peccary and deer raid the small crops near settlements, tapirs were never mentioned as a source of contention. Tapirs' well known use of artificial water holes or consumption of supplemental feed or salt and minerals left for cattle was never mentioned as a problem. During the interviews, when directing the conversation towards the use of wild animal hides and leather it was mentioned on several occasions that tapir hides provided one of the strongest leathers known. On two occasions, it was mentioned that tapirs had been kept as pets. In one occasion, an orphan tapir was "found". This tapir lived for many years in close vicinity of the ranch, one day it disappeared and was reported to have established itself near another ranch some 30km away. In another ranch, a baby tapir was captured to be deliberately kept as pet, but it disappeared after a few months.

Discussion

In this study, walking diurnal line transects was not found to be an appropriate method to estimate tapir density. These results are most likely an under-estimated. When conducting field activities at night, tapirs were observed on a regular basis, whilst during the day they were sighted only 19 times after walking 2,174 km of transects. In the mornings fresh tapir tracks were frequently observed. Faecal deposits either single or in heaps were also regularly found, usually in forested areas (heaps) or at the edge of fresh water and alkaline ponds (single deposits). Other methods such as nocturnal census or camera trapping should be tested in the area to provide more reliable density estimates.

The density of tapirs estimated from this study was lower than estimates reported from two other field sites in the Pantanal. In the Acurizal ranch in the south-western part of the Pantanal, Schaller (1983) estimated a density of 0.64 tapirs/km^2. However, the estimate is based on a best guess of number of tapir and then only the forested area of the acurizal ranch is considered. Therefore density estimates from Schaller (1983) should only be compared to the forest landscape density estimates from this study (0.40 tapirs/km^2). In the north-eastern part of the Pantanal in the private reserve Estância Ecológica SESC Pantanal, Trolle *et al*. (2008) estimated a density of 0.55 tapirs/km^2 using diurnal line transects. Trolle *et al*. (2008) obtained 23 tapir sightings after walking only 692 km of transects. I sighted less tapirs after walking more than three times that distance. The higher densities in the SESC Pantanal may be due to the presence of a river and the associate gallery forest habitat. It is also possible that the higher coverage of dense scrub, and thick forest undergrowth due to the removal of cattle from the area in 1998 favoured the tapir population.

It could be speculated that by decreasing the amount of vegetation coverage cattle may be degrading the habitat for tapirs. Vegetation cover is important for tapirs and in this study, no tapirs and few tapir tracks were observed within the open grasslands of the floodplain landscape. Overall, cover in this landscape is very low and cattle tend to trample the undergrowth on the small forest islands within this landscape. Cattle regularly enter forested areas to forage or take refuge from wind (Santos 2001), they trample the undergrowth preventing forest regeneration (Johnson *et al.* 1997). This may have an adverse effect on tapir habitat. On the other hand, tapirs were sighted in the cerrado landscape at the height of the dry season where no water besides artificial water points was available. It could therefore also be speculated that traditional cattle ranching may favour tapirs by providing them with a constant supply of water.

During the study, hunting was not found to be a threat in the Nhecolândia region. Overall traditional ranching practices are considered to have contributed to the maintenance of biodiversity and tapir populations in the Pantanal (Seidl *et al.* 2001). However, current changes in ranching practices may impact lowland tapir populations in the near future. Since the early 1970s, ranchers have been clearing land and planting pastures of exotic grasses to increase the carrying capacity for livestock. Ranchers tend to plant pastures on the highest grounds available on their ranch since these are not subject to regular flooding. However, these areas are usually forested (Comastri Filho and Pott, 1996; Seidl *et al.* 2001) and these were the habitats found to have the highest densities of tapirs in this study. In the year 2000, deforested areas in the Pantanal were quantified and mapped, and the largest deforested area detected was for the sub-region of Nhecolândia of which 10% or 2,676 km^2 of the area had been altered for cattle ranching (Padovani *et al.*,2004). Currently, deforestation and intensification of ranching practices is thought to be the biggest threat to tapir populations in the region.

Tapir habitat connectivity may also be affected by the increase in fences and fencing practices. Traditional fencing in the Pantanal was done with four strands of stretched wire. Larger native mammals such as tapirs crossed them easily. Unfortunately, as properties are being sold, new owners unfamiliar with the region are placing fences with five to six strands that may prevent or at least impede tapirs from crossing these barriers (Comastri Filho and Santos, 2004). Habitat use and connectivity may be affected by these changes, and the impact of these new fences on tapirs needs to be evaluated.

Understanding tapir habitat connectivity throughout the Pantanal needs to be fully appreciated before anthropogenic impacts alter landscapes and tapir habitats. Rivers, marsh areas or large tracks of open seasonally flooded grasslands may act as natural barriers to tapir dispersal. Understanding the permeability of the landscape and identifying what constitutes natural barriers to tapirs within the landscape are important to understand for tapir conservation purposes.

Finally during the lowland tapir PHVA the importance of epidemiological studies on tapirs was highlighted (Medici *et al*. 2007). In the Pantanal, tapirs are in constant contact with livestock. In other regions, disease transmission between native wildlife and livestock has been widely documented (Hudson *et al*., 2002; Brook and McLachlan, 2006; Morgan *et al*., 2006; Gortazar *et al*., 2007). Tapir tracks near salt and mineral licks, cattle food supplements or artificial water points during the dry season have been regularly observed. The opportunity for disease exchange is very high. In addition, the anthropogenic changes in the landscape may affect tapir health. There is evidence that habitat alteration and destruction can disrupt natural epidemiological cycles, leading to an increase or triggering the emergence of infectious diseases and other etiological agents in wild mammals (Daszk *et al*., 2001). For example, loss of marsh area and habitat shrinkage were blamed for higher tick infestation levels in marsh deer (Szabo *et al*., 2003). Ticks are well known vectors for disease. The current changes in the landscape as well as tapirs' constant contact with livestock may increase the incidence and prevalence of diseases in the tapir population.

The Pantanal is an exciting place for tapir research. Understanding the ecology of this species in the naturally fragmented, seasonal and diverse landscape of the Pantanal will certainly provide new insights about the species. As for conservation purposes in the region, understanding the ecology of a species that has such a significant impact on shaping and maintaining the diversity of the plant community is very important, particularly as habitat alteration and anthropogenic impacts modify the landscape.

Acknowledgements

This work was a collaboration between the Durrell Institute of Conservation and Ecology (DICE) and Embrapa Pantanal. This study was part of a Ph.D. thesis which received funding from the European Union INCO PECARI project. The last year of field work was funded by the Royal Zoological Society of Scotland (RZSS). I am very grateful to the ranch owners for allowing research on their properties and the people living on the Embrapa Pantanal Nhumirim ranch for their help and support with the work. I would also like to thank Paulo Lima Borges for his assistance walking trails in the floodplain. Thanks to Sian Waters and Patricia Medici for comments on this manuscript.

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Population Estimates of Malay Tapir, *Tapirus indicus*, by Camera Trapping in Krau Wildlife Reserve, Malaysia

Carl Traeholt[1] and Mohd. Sanusi bin Mohamed[2]

[1] Copenhagen Zoo, Denmark / Department of Wildlife and National Parks, Malaysia, Malay Tapir Conservation Project, 841 Ukay Bayu, Jalan Tebrau 1, Ukay Heights, 68000 Ampang, Malaysia. E-mail: ctraeholt@pd.jaring.my

[2] Malay Tapir Conservation Project, Institute of Biodiversity, Bukit Rengit, Krau Wildlife Reserve, Lancang, Pahang, Malaysia.

Abstract

The Malay tapir (*Tapirus indicus*) is the only Old World tapir species. Its distribution ranges from Southern Thailand and Myanmar, Peninsular Malaysia and Sumatra. Due to habitat destruction it is believed that the population density has decreased during the past two decades. There have been no specific population density studies of Malay tapir in the past. This study proposes a new method for identifying tapir individuals and estimating the population density of Malay tapir from photographs. The study took place in Krau Wildlife Reserve, Malaysia, consisting of 63.000 ha undisturbed tropical forest. Two units of camera traps were deployed at 13 different salt-licks where tapirs had been recorded. All animal species photographed were recorded and all photographs containing tapirs were analysed and individuals were identified. The results reveal that using necklines is a reliable method for identifying and distinguishing between individual tapirs. The results also suggest that tapirs frequent salt licks relatively often when compared to other species, and that any individual frequently visit salt licks more than 15km apart. The study estimated approximately 45-50 tapirs in Krau Wildlife Reserve.

Keywords: *Tapirus indicus*, Malay tapir, population estimate, camera trapping, Krau Wildlife Reserve, Malaysia

Introduction

Without the benefit of firsthand observations, researchers have traditionally had to rely on indirect evidence such as tracks or scats to confirm the presence of certain species. Recently, automatic camera trapping has been increasingly utilised in surveying a range of elusive wildlife species that are difficult to detect through direct, and even indirect, observation (El Alqamy *et al.*, 2003; Cearley, 2002; Holden *et al.*, 2003; Kawanishi *et al.*, 2002; Lynam, 1999; Sanderson and Trolle, 2005). Although camera traps provide extremely useful "presence-absence" data it does not immediately present population estimates of specific target species and, hence, offer little support in terms of population management of elusive species. However, camera traps *can* provide a method for surveying animal abundance. The combination of automatic camera trapping and capture–recapture statistical modelling has been used to estimate population sizes of many wildlife species (Carbone *et al.*, 2001; Karanth 1995; Karanth and Nichols 1998; Maffei *et al.*, 2005; Noss *et al.*, 2004; O'brien *et al.*, 2003; Silver *et al.*, 2004). Although the methodology has been used successfully in many cases, it remains fraught with possible statistical complications and assumptions about a species' behavioural ecology that are often too simplified (Jennelle *et al.*, 2002). Some of the issues that can bias estimates relate to, for example, the functional relationship between an index and density that is invariant over the desired scope of inference, estimating "effective trapping area" of large mammals, the value of random deployment of cameras when a target species is not homogenously distributed and the need for distinguishing between individuals. The latter may be of less concern in large homogenous populations when trapping frequency and probability of individuals are relatively equal. In other cases, where populations are small and where monopolisation of habitat by certain individuals occur, estimating population size from camera trapping is difficult without, at least, being able to identify individuals.

Several camera trapping studies of tapirs have taken place during the past decade (Holden, 1998; Holden *et al.*, 2003; Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999; Lynam, 1999; Navarino *et al.*, 2004) but only a few are concerned with estimating population densities of tapirs (Jafferally, 2001; Noss *et al.*, 2003; O'brien *et al.*, 2003). This is partly due to the problem of identifying individual tapirs, which is normally limited to identifying externally induced features such as scars, black and white spots and torn or missing ears. Apart from the latter, many of such features are often temporary in nature and, therefore, less useful over an extended period of time.

The Malay tapir, *Tapirus indicus*, is the only Asian representative of the World's four tapir species. The remaining three species are found in Central and South America. With a recorded weight of up to 540 kg (Lekagul and McNeely, 1977) the Malay tapir is the largest of the tapir species and the only one with a conspicuous black and white colouration. It is known to roam lowland dipterocarp forest, often relatively wet areas along small streams and river (Lekagul and McNeely, 1977; Khan, 1997) although it has also been recorded in sub-montane forest above 1500 m (PERHILTAN/DANCED, 2001). Historically the range extended through Burma and Thailand to Cambodia and Vietnam (Khan, 1997) although there have not been any observation and knowledge of tapirs by local communities and researchers in Cambodia and Vietnam in modern time (personal communication and observation). The former range is now reduced to southern Thailand and Burma (Lekagul and McNeely, 1977; Lynam, 1999), Peninsular Malaysia and Sumatra. The Malay tapir is categorized as "Endangered" on the IUCN red list (IUCN, 2006).

While many camera trap surveys have been undertaken during the past 10 years in Malay tapir range countries (Holden, 1998; Holden *et al.*, 2003; Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999; Lynam, 1999; Navarino *et al.*, 2004; PERHILITAN/DANCED, 2001) none of them have gone into details of estimating population sizes based on individual identification. Some of them, however, reveal very high capture rates of Malay tapirs in comparison with other large mammal species in West Malaysia such as wild boar (*Sus scrofa*), tiger (*Panthera tigris*), gaur (*Bos gaurus*), sambar deer (*Cervus unicolor*), Asian elephant (*Elephas maximus*) and barking deer (*Muntiacus muntjak*) (Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999; O'brien *et al.*, 2003). In some cases tapirs are even the most frequently captured species (PERHILITAN/DANCED, 2001; Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999), which has led to the belief that tapirs are one of the most abundant large mammals in Malaysia with a possible population exceeding 10.000 individuals in Peninsular Malaysia alone.

This study aims at identifying an accurate methodology to identify Malay tapir individuals from camera trap pictures and, subsequently, use these for population estimates and for potential selectivity of salt licks.

Material and Method

Study area
The study took place in Krau Wildlife Reserve, Malaysia, from August 2002 to December, 2006. Krau WR consists of approximately 63.000 ha of undisturbed lowland dipterocarp forest with the slopes of Gunung Benom (2107 m) forming the northern-western border, and Bukit Tapah (870 m) located at the southern end of the reserve adjacent to Bukit Renggit (Fig.1). Approximately 70% of Krau WR consists of lowland dipterocarp forest (Fig. 1). On two occasions tracks of tapirs were found on the slopes of Gunung Benom at an altitude of 1400 m (PERHILITAN/DANCED, 2001).

Methodology
Preliminary studies suggested that tapirs are not homogenously distributed in Krau WR (PERHILITAN/DANCED, 2001) but limited to, primarily, wet areas near small streams, swampy areas and bush. It also suggested that tapirs frequent the area around Jenut

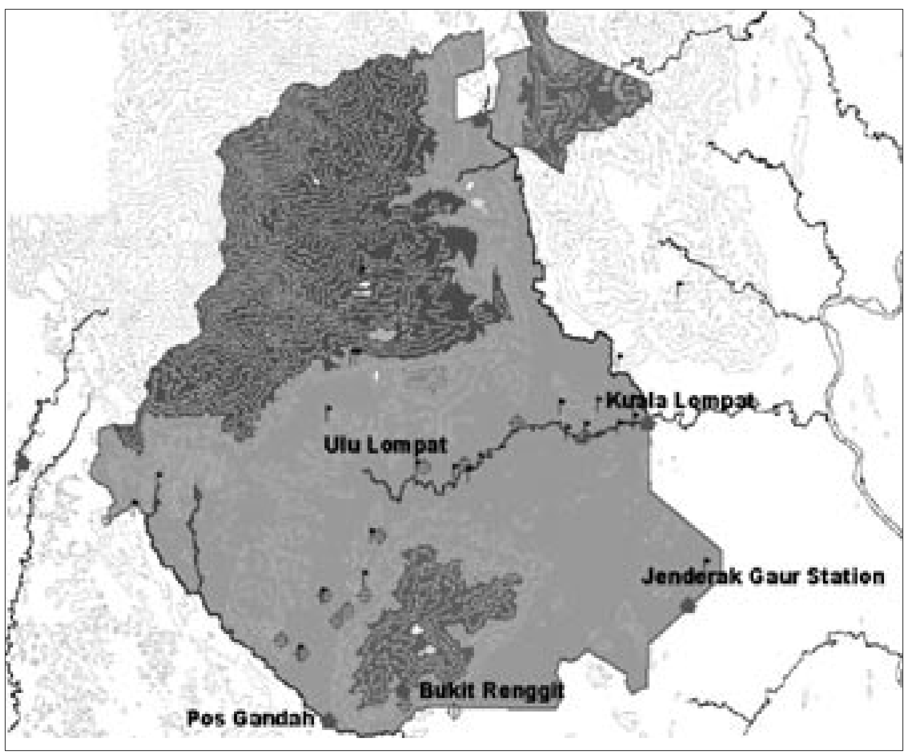

Figure 1. Krau Wildlife Reserve with key DWNP centres, salt licks (flag) and camera trapping sites (⌖). Light green colour illustrates lowland *dipterocarp* forest.

Figure 2. Flank shots of three different tapir individuals photographed at a) Wan Bulan (April, 2004), b) Neram (July, 2004) and c) Wan Bulan (April, 2004). Pictures have been desaturated and outlines have been enhanced using Adobe Photoshop CS2 revealing the necklines unique to each individual. The necklines are permanent features, which makes it useful for identification over a long time period. Necklines on left and right flank are not necessarily symmetric and therefore it is important to utilise two camera traps at each site to ensure "full" identification of an individual.

Bayek (Bayek saltlick) as well as the area around west of Jenderak Gaur Station. From various trips into Ulu Lompat following the Lompat River, which is the main water way of Krau WR, our team recorded occasional presence of tapirs (tracks) although in very scarce numbers.

We deployed camera traps at 13 different sites, all of which were known as salt licks (Fig. 1). This covers the heart of Krau WR and all traps are located in lowland *dipterocarp* forest (Fig. 1). At each site, we deployed two cameras in order to capture both flanks of any animal photographed, which enabled individual identification. We deployed the cameras for 14 days before changing film, and when needed, batteries. Each camera trap consist of a 35 mm automatic camera with autofocus and flash. The camera is triggered by a passive sensor sensitive to movements up to a distance of 10 m. Each camera trap was fitted with 1-2 units of silica gel to keep them as dry as possible. A unit of silica gel was made of empty film cartridges with holes made by a pinup needle. In periods with exceptional amount of precipitation and humidity we recovered the camera traps because films ceased up within two-three days after deployment in spite of fitting the trap with units of silica gel. We utilised Fujichrome Provia 100 at the onset of the study, but due to the high cost of these films, we switched to Kodak Colour 400. Where possible all species were identified and, for tapirs, individual identification was carried out.

In order to estimate the effective sampled area where the population size (N) was estimated, we measured the mean maximum distance covered by all individuals photographed at two or more locations during the survey period as a proxy for home-range diameter (Karanth and Nichols, 2002). We used half the mean maximum distance (w) to buffer each camera trap location (following Silver *et al.*, 2004).

We refrained from using the CAPTURE programme (Rexstad and Burnham, 1991) because camera traps were not deployed randomly. In addition, we did not consider "trapability" normally distributed in relation to trapping site and, therefore, it is a less useful measurement in a scenario where individuals and/or individuals have strong affinity to certain sites.

Individual identification

Tapirs were identified from permanent body marks such as damaged ears and scars as well as on the neck lines (Fig. 2a-c). We did not utilise colour patterns on the hind part of the animal (Navarino *et al.*, 2004) because we found it too unreliable as the patterns change appearance according to the actual position of the hind legs. Prior to using necklines for identifying individuals we compared the patterns with five "known" individuals that were previously caught and fitted with radio-collars. Since these patterns did not change over a 2-year period, we considered them permanent "fingerprints" of a respective individual. Therefore, we assumed that the identification of necklines on Malay tapirs could be employed as a very useful fingerprint as they appear as unique to each individual as the palm lines are in human beings and whisker patterns are in lions (Kissui and Packer, 2004; Pennycuick and Rudnai, 1970). However, these lines can only be significantly observed on a flank-photograph of an individual and within a certain angle. Therefore, it is important that other features (scars, broken ears) are considered at the same time.

Each individual was identified from both left and right flank whenever it was possible. In some cases, flank shots were absent, but still allowed identification of the respective individual because, for example, it was a picture frame from a serious of pictures showing the same individual. In other aspects, a single frame revealing only a glimpse of an ear was enough for identification if this matched a clear picture of a known individual.

Results

A total of 1108 trap nights yielded 665 pictures of various animal species, humans and "ghosts". Out of this, we recorded a total of 14 species of mammals and one bird species (Tab. 1). Malay tapirs were recorded significantly more often (291) than any other animal species ($p<0.05$, t-test matched pairs), followed by barking deer (95) and wild boar (62) (Fig. 3). Although herbivores such as tapir and barking deer were very common at Bayek saltlick sambar deer, *Cervus unicolour*, was only recorded once (December, 2002).

In spite of being the most frequent photographed species, tapirs were only recorded at five different salt licks (Fig. 4) in contrast to barking deer (Fig. 5) and wild pigs that was recorded at nine and six different sites respectively.

All of the five different salt licks where tapirs were recorded were located in the south-western part of Krau WR. Apart from Wan Bulan the remaining four trap sites, where tapirs were recorded, are situated relatively close together (Fig. 5). Barking deer showed much wider distribution in Krau WR and was recorded south of Bukit Renggit to the interior of Krau WR in Ulu Lompat (Fig. 6).

Of the 291 pictures of tapirs 82% could be identified as belonging to only 18 different individuals, whereas 18% did not allow for individual identification. This was primarily due to rear shots and/or unclear pictures. Although many of them could be ascribed to some of the identified individuals with relatively certainty, we chose to treat them as "unidentified", because the time intervals between two, or more, picture frames on which they occurred were too large (>10 minutes). Some individuals (e.g. number 1, 3 and 9) were recorded repeatedly throughout the entire period from 2002 until 2006, whereas others were often recorded more than a year apart.

The largest total number of pictures showing any species was recorded at Bayek saltlick (Fig. 7). We recorded 224 picture frames with either tapir, barking deer or wild boars at Bayek, followed by Wan Bulan (83) and Rumah Tok (39). At the remaining part of saltlicks we recorded less than five pictures of any animal species.

Bayak saltlick also exhibited the highest total number of species recorded at the nine study sites (Fig. 8). Rare species such as tiger, *Panthera tigris*, and leopard, *Panthera pardus*, were recorded only once at Bayek saltlick, whereas Malayan sunbear, *Helarctos*

Table 1. The list of species photographed by camera traps during the survey.

Species		
	English name	**Latin name**
1	Malay tapir	*Tapirus indicus*
2	Tiger	*Panthera tigris jacksonii*
3	Leopard	*Panthera pardus*
4	Sun bear	*Helarctos malayanus*
5	Common Palm civet	*Paradoxurus hermaphrodites*
6	Malay civet	*Viverra tangalunga*
7	Banded palm civet	*Hemigalus derbyanus*
8	Wild boar	*Sus scrofa*
9	Mouse deer	*Tragulus sp.*
10	Barking deer	*Muntjiacus muntjak*
11	Sambar deer	*Cervus unicolour*
12	Water buffalo	*Bubalus babalis*
13	Common porcupine	*Hystrix brachyura*
14	Pig-tailed macaque	*Maccaca nemestrina*
15	Great argus	*Argusianus argus*

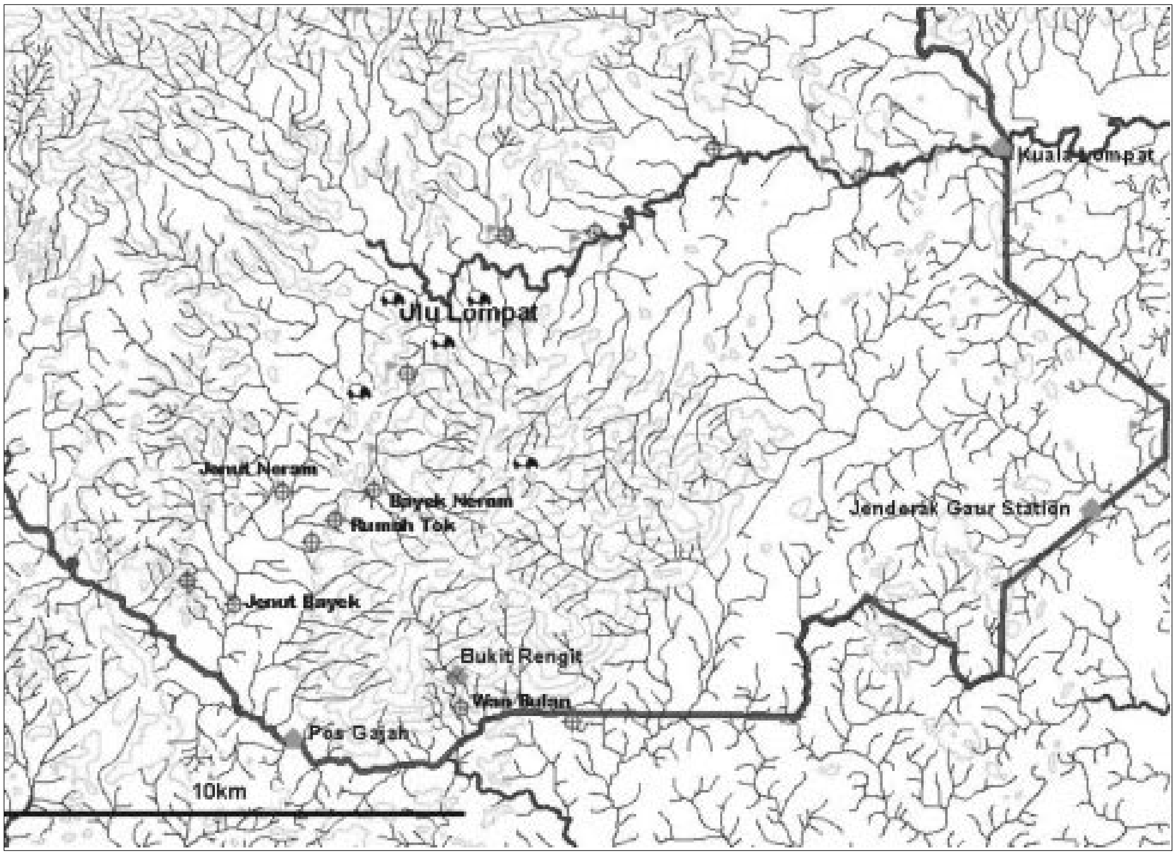

Figure 5. Krau Wildlife Reserve with key DWNP centres, salt licks (green flags) and camera trapping sites (red ⌖). Malay tapirs were recorded at the five salt licks Neram, Bayek, Tok, Bayek-Neram and Wan Bulan.

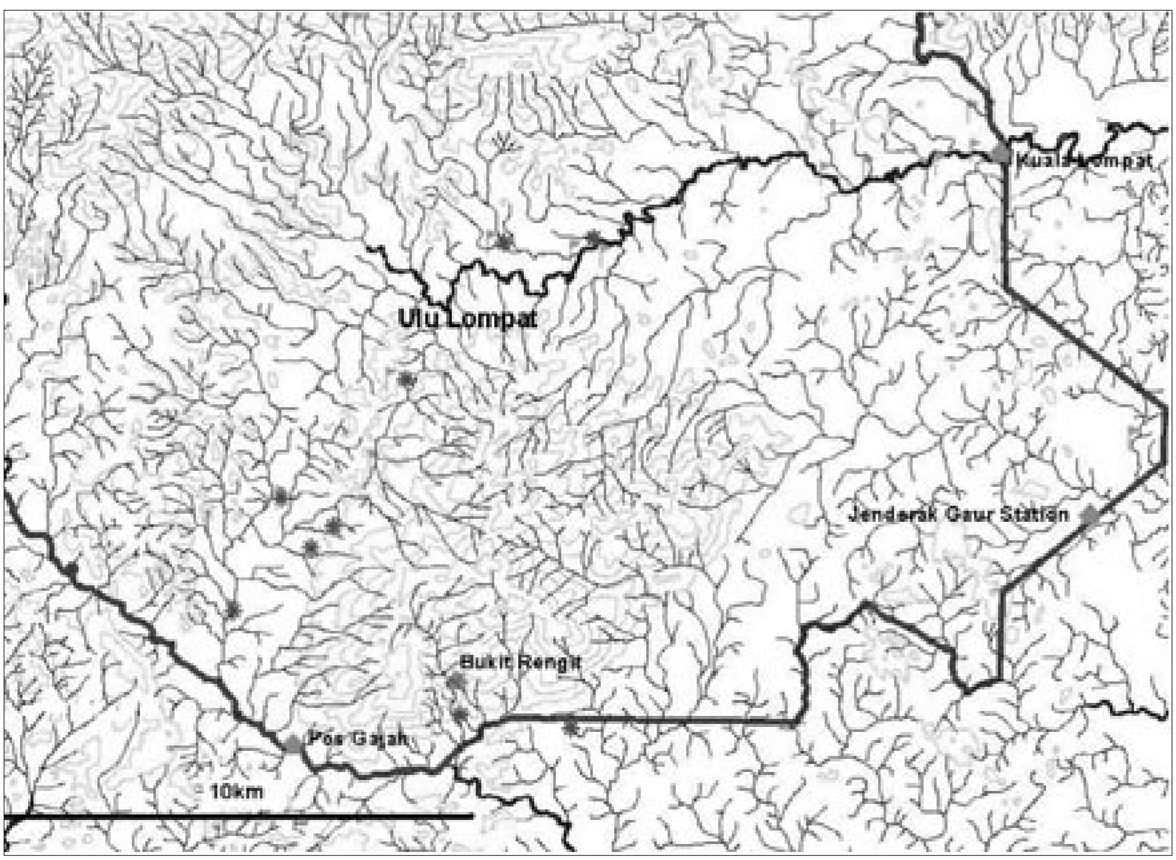

Figure 6. Krau WR with key DWNP sites, salt licks (green flags) and camera trapping sites (✱) where barking deer was recorded.

malayanus, was recorded twice (Neram and Padang Seladang). Six species were recorded at Neram whereas five species were recorded at Wan Bulan and Rumah Tok (Fig. 8).

Of 18 known tapir individuals, 13 visited Bayek saltlick at some point in time. This was the highest number followed by Neram (8) and Wan Bulan (6) (Fig. 9) suggesting that Bayek saltlick is a key area for tapirs in Krau WR.

The accumulated number of newly recorded individuals appeared to reach a saturation point in the beginning of 2006, indicating that no new – or very few - individuals frequent the salt licks (Fig. 10). Similarly, the number of newly recorded individuals at Bayek reached a saturation point at more or less the same time (Fig. 10).

Discussion

Few studies have attempted to make population estimates of Malay tapirs from camera trapping. It is partly due to the fact that nobody has previously developed a reliable method allowing for individual identification of Malay tapir individuals and, consequently, population estimates have often relied on “indirect” data (e.g. trapability estimates, frequency capture). This has often resulted in an overly optimistic estimate of populations (Kawanishi et al., 2002) and the belief that tapir may be more abundant than is the case.

Using necklines as means of identification has proven exceptionally useful in this study. Although flank shots of individuals are important for clear identification, a big advantage is that these lines are permanent features of an individual. This study has recorded individuals in 2002 throughout 2006 and in some instances with 1-2 years interval at different sites. Using necklines alone can account for approximately 50% of all individual identifications, whereas additional features such as permanent body scars and ear damages are critical in supporting and reassuring correct identification of individuals on non-flank pictures. As is important for the identification of tigers (Karanth, 1995; Karanth and Nichols, 1998) two cameras are needed for “full” identification of tapirs, because there is no symmetry between the left and right flank necklines.

Previous camera trap studies often captured tapirs in large numbers, often as the second or third most frequent species photographed (Kawanishi et al. 2002; Kawanishi et al., 1999; Holden et al., 2003). These studies have often followed a randomized deployment of cameras and as such it was expected that tapirs would trigger camera traps as frequently when deploying cameras at saltlicks. However, tapirs appeared three times more frequently on photographs than any other species in this study (Fig. 3). This only account for the number of picture frames recorded with tapirs and does not take into consideration the number of individuals in the picture. However, three rolls of 36-frame films reveal a couple of tapirs feeding right in front of the cameras, which accounts for almost 100 “excessi-

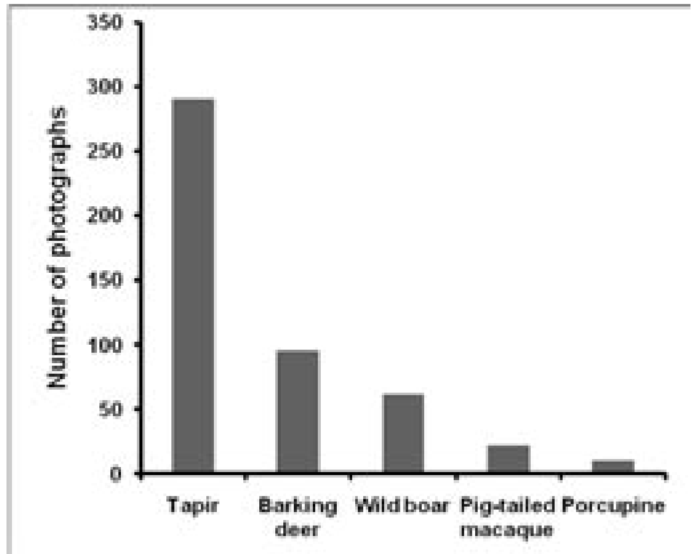

Figure 3. The five most frequently photographed animal species recorded during the study. Tapir was photographed significantly more often than barking deer ($p<0.05$, Student’s t-test, 2-tailed matched pairs). All other species listed were recorded only once (tiger, leopard, banded palm civet, common palm civet, great argus) or twice (sun bear, Malay civet, mouse deer).

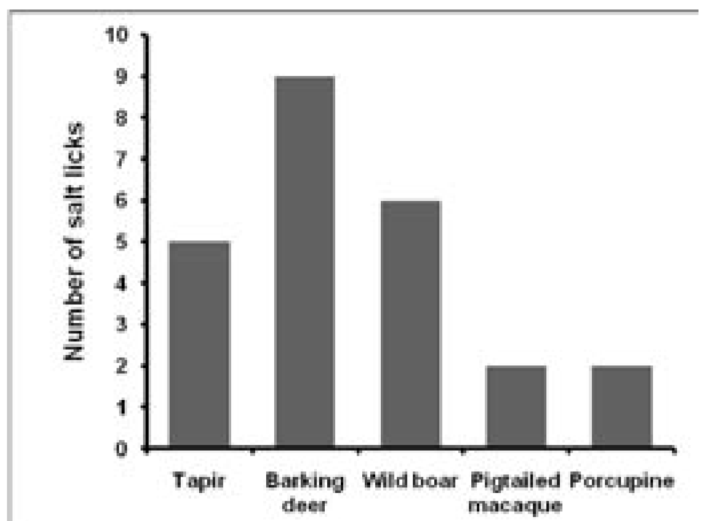

Figure 4. The presence of the five most frequently photographed animal species at various salt licks in Krau WR. Barking deer was recorded at the highest number of salt licks (9) followed by wild boar (6) and tapir (5).

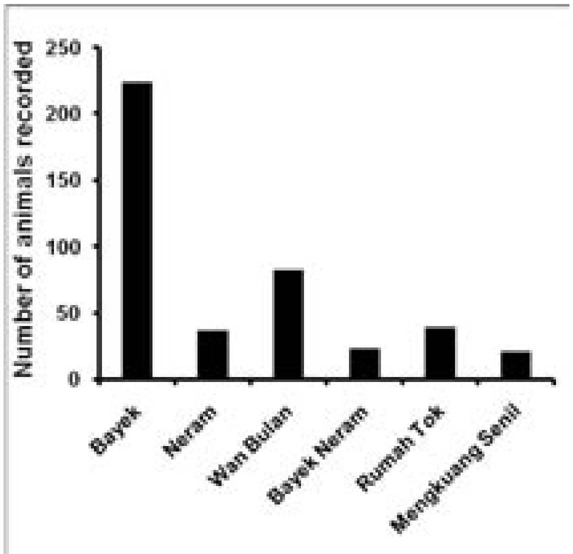

Figure 7. The combined number of tapirs, barking deer and wild boars recorded at the six different salt licks.

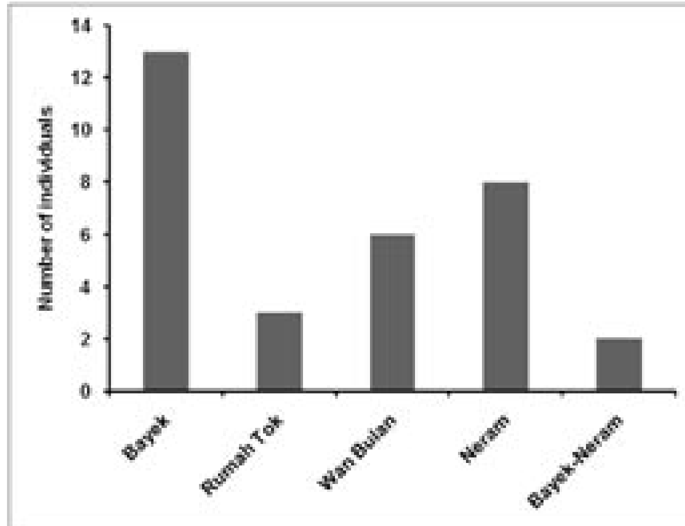

Figure 9. The number of different tapir individuals recorded at five different salt licks in Krau WR.

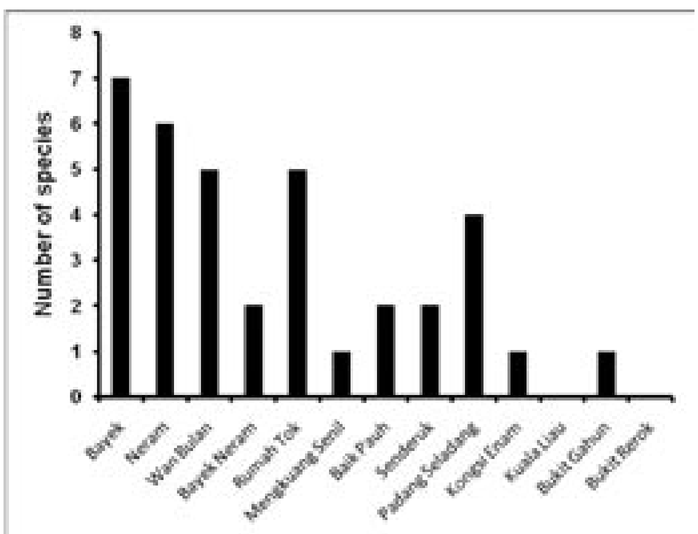

Figure 8. The number of different species recorded at every camera trap site in Krau WR between 2002 and 2006.

ve" pictures. If these individuals are omitted, tapirs are still twice as frequent visitors at the various saltlicks than the second most frequent animal species (barking deer).

This, combined with the results that the same individuals are recorded at different saltlicks, suggests that saltlicks in certain areas are critical for tapirs, and that, once the circumstances are right, they return to the same site repeatedly over an extended period of time. The accumulated number of newly recorded individuals appears to reach a saturation point in 2006 overall as well as in Bayek alone, which indicates that tapirs exhibit relatively permanent home-ranges. Considering that most identified individuals visited a saltlick approximately every 3-4 months it is reasonable to believe that all tapirs in an area will be captured on photograph within a year. Therefore, a population estimate using camera traps can approximate "direct" counting and provide a very accurate population estimate. The main variable that can influence the estimate significantly is the "effective" trapping area covered by the 13 trap sites. Following the procedure described by Silver *et al.* (2004) the 13 trap sites covered an effective area of 484.30 km^2, which constitutes 77% of the entire reserve, or corresponds to an area of equal size as the entire lowland *dipterocarp* forest area. As such, if we assume that the effective trapping area is representative in terms of size, and assuming tapirs are homogenously distributed across the entire reserve extrapolation of this study's data will result in a population estimate of 25-30 individuals. The assumption, however, is unlikely to accept in reality, because tapirs have not (yet) been found above 1600 m and are not homogenously distributed (PERHILITAN/DANCED, 2001). Even if they are found at higher altitudes, they are likely to be occasional visitors rather than "resident" individuals with a permanent home-range at that altitude. The estimate of effective trapping area following Silver *et al.*, (2004) did not seem to provide useful results in this study.

The question of how large an area our camera trapping effectively covered remains? This study revealed a heavy preference by tapirs towards the south-western

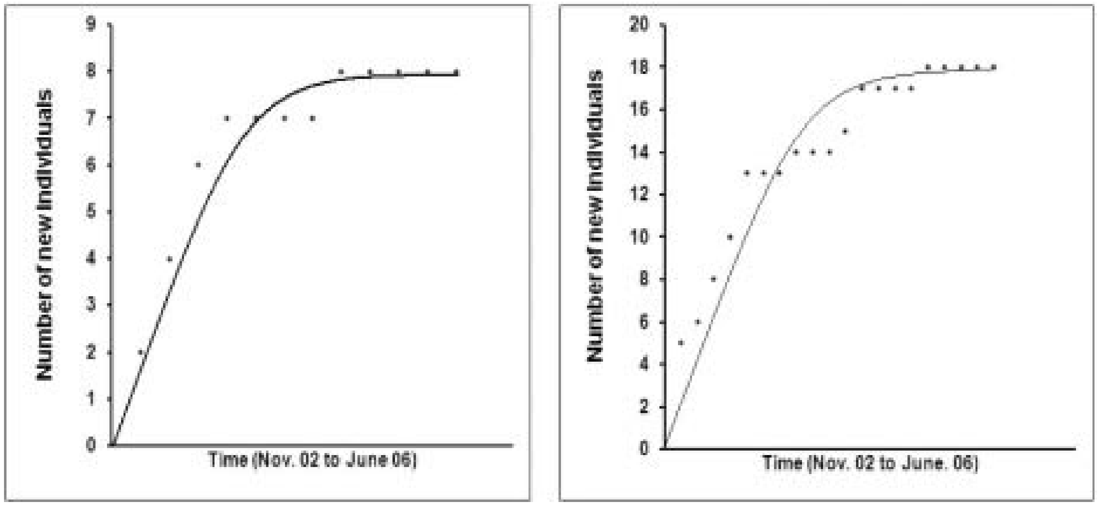

Figure 10. The accumulated number of new tapir individuals recorded at Bayek salt lick (left) and in total (right).

corner, with most frequent visits to Bayak and other nearby saltlicks (Neram, Bayak-Neram, Rumah Tok) and this is consistent with the results of the survey undertaken in 2001 (PERHILITAN/DANCED). The 2001 survey covered the entire Krau WR at all elevations and revealed two primary tapir areas, Bayek, and the area around Jenderak Gaur station. Considering that the two primary sites are of similar topographic composition and size, it could be assumed that the Jenderak area contains a similar number of tapirs (18±2) as we recorded in the Bayek basin. This suggests there are approximately 35-40 individuals within the two primary tapir areas alone. In addition, our study recorded tapir tracks – albeit very few – in Ulu Lompat, as well as in areas north of Lompat, which suggests, with reasonable certainty, that Krau WR contains individuals other than the "resident" individuals at Bayek and Jenderak areas. This, however, does not exclude the possibility that the few individuals recorded in Ulu Lompat can be some of the individuals recorded in Bayek as well, and further studies are needed to cast light on this issue. Considering they are not from the Bayek or Jenderak area, it is realistic to assume that the tapir population in Krau WR reaches 45-50 animals.

Bayek saltlick appeared to be the most attractive of all the salt licks. However, since the number of trap nights (<75) at Bayek were higher than, for example, that of Padang Seladang (>25) in Ulu Lompat, it could indicate that the bias towards Bayek, in relation to the number of pictures captured, is caused by the higher number of trap nights. Whilst this provides part of the explanation for the significant difference in number of species, total number of animal visits and total number of individual visits between Bayek and trap sites in Ulu Lompat (Fig. 7-8), it cannot explain the higher number of visits to Bayek in comparison with, for example, Neram, Wan Bulan and Rumah Tok because the number of trap nights at these sites were equal to Bayek.

This study reveals that tapirs appear to roam within relatively confined home-ranges up to, at least, four years. It also shows that tapirs are very frequent visitors to certain saltlicks and, consequently, population estimates of tapirs by camera trapping must make use of a combination of randomised grid deployment and more target specific trapping at salt licks. There are, however, many individuals that are recorded over a wider area, for example, individual No. 9 (male) was recorded at four different salt licks 11 km apart. Our data did not provide enough information to suggest that males distribute significantly more than females. There are certain trends that point into that direction, which will be the focus in the continuation of the study.

The results of this study suggest that tapirs exhibit habitat preference in Krau WR and that the area around Bayek contains advantageous resources. It also indicates that tapirs can co-exist in relatively small areas provided there are sufficient resources available. It is uncertain, however, what exactly makes the area attractive to tapirs. To answer some of these questions additional studies are being carried out on the microhabitat in Bayek area, which will be compared to that of Jenderak area and other areas in Krau WR.

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Ticks of New World Tapirs

***Marcelo B. Labruna*[1] *and Alberto A. Guglielmone*[2]**

[1] Department of Preventive Veterinary Medicine and Animal Health, Faculty of Veterinary Medicine, University of São Paulo, São Paulo, SP, Brazil. Av. Prof. Orlando Marques de Paiva 87, Cidade Universitária, São Paulo, SP, CEP: 05508-270, Brazil, Phone: +55-11-3091-1394, **Fax:** +55-11-3091 7928, E-mail: labruna@usp.br

[2] INTA, Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Rafaela, CC 22, CP 2300 Rafaela, Argentina, E-mail: aguglielmone@rafaela.inta.gov.ar

Abstract

In this paper, we present an updated list of ticks that have been found infesting New World tapirs. For this purpose, literature records were obtained from the INTA tick database. Data are presented according to tick species, tapir species, and country. A total of 27 tick species have been reported infesting New World tapirs. Most of the reports were on *T. terrestris* (20 tick species in 10 countries). Thirteen tick species were reported on *T. bairdii* in 3 countries, and only 2 tick species on *T. pinchaque* in 2 countries. Ticks reported on tapirs comprised 18 species of the genus *Amblyomma*, and 7 other species representing the genera *Ixodes*, *Haemaphysalis*, *Dermacentor*, and *Rhipicephalus* from the Ixodidae family, and at least 2 *Ornithodoros* species from the Argasidae family. Indeed, tapirs are very significant hosts for the Neotropical tick fauna. Since tapirs are usually found in less fragmented biomes with high biodiversity, and the richness of tick species is higher in tapirs than any other Neotropical vertebrate species, further studies are needed to evaluate the role of tapir-associated ticks on biodiversity. The role of these ticks on tick-borne diseases for tapir and other vertebrates also needs further investigations.

Keywords: ecology, Ixodida, Neotropical tapirs, parasites, ticks

Introduction

Ticks are obligate hematophagous ectoparasites, belonging to the class Arachnida, order Acari, and are divided into three families: (i) Ixodidae (hard ticks), the largest family, composed of 13 genera and 692 species; (ii) Argasidae (soft ticks), composed of 5 genera and 186 species; (iii) and Nuttalliellidae, a monotypic family composed of the species *Nuttalliella namaqua* (Nava *et al.*, 2009), although this arrangement is not universally accepted. In the Neotropics, there are 194 valid tick species (115 Ixodidae and 79 Argasidae) (Guglielmone *et al.*, 2003, Estrada-Peña *et al.*, 2004a, Labruna *et al.*, 2005a, 2008, Venzal *et al.*, 2008).

Ticks are responsible for vectoring a variety of pathogens (including virus, bacteria, protozoon and helminthes) to humans and animals (Guglielmone *et al.*, 2003). In fact, it has been reported that ticks are vectors of more kinds of microorganisms than any other single arthropod taxon, including mosquitoes (Oliver, 1989). Most of the ticks of medical and veterinary importance are within the Ixodidae family. Thus, studies on these ticks have been much more frequent than on Argasidae ticks. Of the 115 Ixodidae tick species established in the Neotropical region, 58 (50.4%) belong to the genus *Amblyomma*. In South America alone there are 53 established *Amblyomma* species, which represent almost half of the 129 *Amblyomma* species occurring in the world (Guglielmone *et al.*, 2003, Nava *et al.*, 2009). Indeed, South America bears the largest diversity of *Amblyomma* species in the world.

During the life cycle, Ixodidae ticks undergo four stages: eggs, larvae, nymphs, and adults. They have only one nymphal instar, in contrast to the several nymphal instars of Argasidae. Usually, all stages (except eggs) need a blood meal for further development. Ixodidae also differ from Argasidae in that each stage requires several days or longer to engorge with blood, and they also require larger blood meals (Oliver, 1989). For completion of the life cycle, ticks undergo a parasitic phase – when they feed on a vertebrate host that can be amphibians, reptiles, birds or mammals, depending on the tick species – and a free-living phase – when they are in the environment for molting, egg deposition and incubation, or just waiting for a host. For development to the next stage, most ticks feed as one stage (eg. larva) and then undergo ecdyse (molting) in the environment. Ixodidae females feed only once, produce one large egg mass of thousands of eggs, and die. Argasidae females lay several small egg masses of dozens to hundreds of eggs, with a blood meal preceding each eggs mass. A few tick species ecdyse on the host, going to the environment for egg laying. Generally, when ticks are feeding on the host, their survivorship is mostly affected by host innate and acquired (immunologic) defenses. On the other hand, when ticks are at free-living stages, they do not feed and their survivorship is mostly affected by variations in environmental temperature and relative humidity. Most of the Neotropical ticks require cool temperatures (between 18 to 28ºC) and high relative humidity (>80%) for successfully development in the environment. Usually, ticks from dense rainforests require higher relative humidity (>95%) for free-living development than ticks from less humid biomes, such as Cerrado and Chaco.

Given the numerous pathogens ticks transmit and their blood-feeding habits, most people would instinctively think that ticks are of no benefit for nature (Durden & Keirans, 1996). However, ticks (and other parasites) are an integral component of healthy ecosystems and have important roles in nature, some of which may be still incompletely understood. Ectoparasites, like ticks, exert selective pressure on host populations and are at least responsible for maintaining high levels of genetic diversity in their hosts when compared with nonparasitized animals, and help to eliminate weaker or susceptible host individuals in nature, thereby maintaining a healthier host population (Durden & Keirans, 1996). Some tick species also represent important food source for a few bird species; thus, dramatic extinction of ticks from a given area could affect these bird species, as has been shown in some parts of Africa (Bezuidenhout & Stutterheim, 1980). For a direct anthropic point of view, ticks are proving to be a storehouse of useful biochemicals (Durden & Keirans, 1996). For example, various pharmaceutically active compounds have been isolated from tick saliva, with antiplatelet, antihemostatic, anti-inflammatory, immunosuppressive, or antimicrobial properties (Durden & Keirans, 1996, Ribeiro *et al.*, 2006).

Among the four species of Tapirs in the world, three occur exclusively in the New World. These are *Tapirus terrestris* (low land tapir), *Tapirus bairdii* (Baird's tapir), and *Tapirus pinchaque* (mountain tapir). *T. terrestris* occurs through a wide geographic range from North-Central Colombia and east of the Andes throughout most of tropical South America. It occurs mostly in tropical lowland rainforest but can also be found in seasonally dry habitats such as the Brazilian Cerrado and Chaco of Bolivia and Paraguay. *T. bairdii* is distributed from Oaxaca Province in Mexico through Central America to the western side of the Andean mountain range in Colombia (the Darien). It occurs in rainforests, lower montane forests, deciduous forests, flooded grasslands and marsh areas. *T. pinchaque* is restricted to Montane forests and Paramos in Colombia, Ecuador and northern Peru, between 2000 to 4000 meters elevation (data from http://www.tapirs.org/tapirs/index.html, where geographic distribution maps of tapirs are available). In this paper, we present an updated list of ticks that have been found infesting New World tapirs, and discuss how important these animals are for New World ticks.

Material and Methods

Literature records of ticks on New World tapirs were obtained from the INTA tick database. This database was created in the year 2000 and has been maintained since then by one of the authors (A.A.G.) with information compiled from literature for records of ticks from the Neotropical region. Data are presented according to tick species, tapir species, and country. Some literature records for ticks on tapirs did not specify the *Tapirus* species. In this case, we deduced the species by consultation the geographical distribution of New Word tapirs published by Emmons & Feer (1997) and that available at http://www.tapirs.org/tapirs/index.html. For most tick species, there are more than one literature report on a given tapir species in an individual country. In this case, we considered only one literature report since our intention is to provide a distribution according to country, with no indication of number of reports per country.

Results and Discussion

As shown in Table 1, a total of 27 tick species have been reported infesting New World tapirs. Most of the reports were on *T. terrestris* (20 tick species). Thirteen tick species were reported on *T. bairdii*, and only two tick species on *T. pinchaque*. A high number of tick species was expected for *T. terrestris* since this tapir is largely distributed in almost the entire South America. The low number of tick species recorded for *T. pinchaque* was also expected since this species has a narrow distribution area restricted to high lands between 2000 to 4000 meters elevation, besides being less studied than the remaining tapir species. Among the 27 ticks species reported on tapirs, the majority [18 species (66.7%)] belonged to the genus *Amblyomma*, which is also expected as this genus comprises most of the New World tick species. Dunn (1934) found *A. humerale* on tapirs in Panama, but Fairchild et al. (1966) consider this tick to be *A. sabanarae*. This contradictory finding was not included in our list of ticks from tapir.

In addition to the 18 species of the genus *Amblyomma* reported on tapirs, there are 7 other species representing the genera *Ixodes*, *Haemaphysalis*, *Dermacentor*, and *Rhipicephalus* from the Ixodidae family, and at least 2 species from the Argasidae family (*Ornithodoros rudis* and *Ornithodoros tuttlei*). However, while the number of tick species reported infesting tapirs in each country vary widely, it is quite possible that this variation is due to incomplete records. Most of the tick species are found across *Tapirus* spp range and have simply not yet been recorded on tapirs. For example, almost all tick records on *T. bairdii* are from Panama, however *T. bairdii* occurs in other countries as well. This result is certainly biased to the high number of studies that have been done with ticks of Panama (Fairchild *et al.*, 1966).

Tick-tapir ecology

In nature, ticks are found parasitizing practically all land vertebrate species. In South America, individuals of most vertebrates are found infested by a single tick species at any point in time, although a few species are commonly found infested by two species. Rarely, three different tick species are found on a single host at the same time (Neiva & Penna, 1916, Aragão, 1918, 1936, Barros & Baggio, 1992). Tapirs are a great exception to this rule, since most animals are commonly found to be infested by 3 to 5 tick species, sometimes reaching 7 species (Aragão, 1936, Dun, 1934, Boero & Prossen, 1960, Labruna *et al.*, 2005b). No other vertebrate animal in the Neotropical region is found harboring so many tick species under natural conditions. This fact shows how important tapirs are for the biodiversity of ticks. The following 3 reasons could be related to the richness of tick species on tapirs: (i) natural tapir populations are usually established in high biodiversity-biomes with low anthropogenic activity (Bodmer & Brooks, 1997), favoring richness of tick species, as for example in the Amazon and Atlantic rainforest biomes; (ii) tapirs have large home ranges (Foerster & Vaughan, 2002), favoring direct contact with different tick species in a given area; (iii) *T. bairdii* and *T. terrestris* are the largest land vertebrates of the native Neotropical fauna (Emmons & Feer, 1997); it has been shown for other mammals that tick parasitic load is positively correlated to body size (Mohr, 1961), thus, as more ticks infest a tapir, greater should be the chances of finding different species.

Most of the tick species associated with tapirs (Table 1) are known as ambush ticks. Ambush ticks wait on the tips of leaves, waiting for the passage of a suitable host, i.e., tapirs (Sonenshine, 1991). Notably, ticks are known to be capable of surviving for months or years in the environment without having a blood meal (Oliver, 1989). Thus, the successful establishment of ambush ticks in a given area will basically depend on two factors: (i) primary host density – the higher the host density, the higher the probability of a chance contact between primary host and the ticks; (ii) environmental suitability – suitable environment is where free-living stages of ticks encounter favorable microclimatic conditions for survivorship and development. Both primary host density and environmental suitability are inter-related and can be extremely variable in different habitats. This interaction will determine tick presence/absence and abundance. For example, highly suitable environments with low host density could support tick populations similar to poorly suitable environments with high host density. On the other hand, highly suitable environments with high host density would result in the largest tick populations; conversely, ticks might be absent from areas with poorly suitable environments with low host density.

Typically, tapirs are solitary individuals but several individuals can use the same area; they have very well established home ranges, but do not seem to be territorial due to high percentages of home range overlap between neighboring individuals (Medici *et al.*, 2006). Since tapirs travel widely through their habitat (large home range), even low tapir densities favor ambush ticks. Tapir paths are frequent where tapirs occur. These paths are usually used by other mammals, such as peccaries and deer (Emmons & Feer, 1997), and thus participate in the life-history of most tapir-associated ticks; and vice-versa.

Since *T. terrestris* is distributed in most of the major biomes of South America (eg. Amazon, Atlantic Rainforest, Pantanal, Cerrado, and Chaco) (Emmons & Feer, 1997), the diversity of ticks parasitizing tapirs in these different biomes depends on the adaptation of ticks to each of these biomes. For example, *Amblyomma cajennense* is a typical Savannah tick, commonly found parasitizing tapirs in the Cerrado and the Pantanal, but very rarely found in the Amazon or primary Atlantic Rainforest (Estrada-Peña *et al.*, 2004b, Labruna *et al.*, 2005b). However, its distribution has expanded into areas where the original Atlantic Rainforest biome has been degraded or replaced by livestock pastures resembling savannah (Estrada-Peña *et al.*, 2004b, Labruna *et al.*, 2005b). Conversely, *A. incisum*, *A. scalpturatum* and *A. latepunctatum* are typical of large patches of primary Amazon or Atlantic Rainforests (Labruna *et al.*, 2005a), and practically absent from other biomes. These differences in biogeographic distribution are intimately related to the microclimatic conditions required by each tick species within its distribution. A unique example is *Ixodes tapirus*, for which its free-living stages are well adapted to low temperatures prevailing in high land mountain forests of Panama and Colombia (Fairchild *et al.*, 1966). At least in Colombia, this tick occurs within the distribution area of *T. pinchaque*, a primary host for *I. tapirus*.

Table 1. Ticks reported on New World tapirs. For each country record, a reference is provided in parentheses.

No.	Tick species	Countries with records on *Tapirus terrestris*	Countries with records on *Tapirus bairdii*	Countries with records on *Tapirus pinchaque*	Additional countries where the tick species was reported but not on tapirs [+]
1	*Amblyomma brasiliense*	Brazil (Aragão 1936)			Argentina, Paraguay
2	*Amblyomma cajennense**	Argentina (Guglielmone & Nava 2006), Brazil (Aragão 1913), British Guyana (Tonelli-Rondelli 1937), French Guyana (Floch & Fauran 1959), Paraguay (Tonelli-Rondelli 1937), Surinam Keirans 1985), Venezuela (Jones et al. 1972)	México (Dugès 1891), Panama (Dunn 1934)		Southern United States, Mexico, remaining Central American countries, Caribbean, and the remaining South American countries (except for Chile and Uruguay)
3	*Amblyomma calcaratum*	Brazil (Keirans 1982)			Argentina, Belize, Bolivia, Colombia, Costa Rica, Ecuador, French Guyana, Panama, Paraguay, Peru, Surinam, Trinidad & Tobago, Venezuela,
4	*Amblyomma coelebs**	Argentina (Guglielmone & Nava 2006), Bolivia (Robinson 1926), Brazil (Aragão 1936), British Guyana (Tonelli-Rondelli 1939), French Guyana (Floch & Fauran 1959), Peru (Mendonza-Uribe & Chavez-Chorocco 2004), Surinam (Keirans 1985), Venezuela (Jones et al. 1972)	Costa Rica (Hernadez-Divers et al. 2005), Mexico (Cruz-Aldán et al. 2006), Panama (Dunn 1934)		Belize, Colombia, Guatemala, Honduras, Nicaragua, Paraguay
5	*Amblyomma dubitatum*	Argentina (Zerpa et al. 2003a), Brazil (Robinson 1926)			Bolivia, Paraguay, Uruguay
6	*Amblyomma incisum**	Bolivia, Brazil, Peru [#]			Argentina, Paraguay [#]
7	*Amblyomma latepunctatum**	Brazil, British Guyana, Ecuador, Peru, Venezuela [#]			French Guyana [#]
8	*Amblyomma multipunctum**	Bolivia (Boero & Prosen 1959), Venezuela (Robinson 1926)		Colombia (Kohls 1956b), Ecuador (Voltzit 2007)	none
9	*Amblyomma naponense*	Brazil (Barros & Baggio 1992), French Guyana (Floch & Fauran 1959)			Bolivia, British Guyana , Colombia, Costa Rica, Ecuador, Panama, Peru, Surinam, Venezuela
10	*Amblyomma neumanni*	Argentina (Guglielmone & Nava 2006)			Colombia
11	*Amblyomma oblongoguttatum**	Brazil (Aragão 1936), British Guyana (Keirans 1985), French Guyana (Floch & Fauran 1959), Venezuela (Jones et al. 1972)	Costa Rica (Hernandez-Divers et al. 2005), Mexico (Chavarría 1941), Panama (Dunn 1934)		Belize, Bolivia, Guatemala, Nicaragua, Peru, Surinam
12	*Amblyomma ovale**	Argentina (Guglielmone & Nava 2006), Bolivia (Boero & Prosen 1955), Brazil (Aragão 1936), Ecuador (Zerpa et al. 2003b), French Guyana (Floch & Fauran 1959), Paraguay (Pallarés & Usher 1982),	Mexico (Cruz-Aldán et al. 2006), Panama (Dunn 1934)		Belize, British Guyana, Colombia, Costa Rica, Guatemala, Nicaragua, Surinam, Trinidad & Tobago

		Peru (Mendonza-Uribe & Chavez-Chorocco 2004), Venezuela (Jones et al. 1972)			
13	*Ambyomma pacae*		Mexico (Guzmán-Cornejo et al. 2006)		Belize, Brazil, British Guyana, Colombia, Panama, Paraguay, Surinam, Venezuela
14	*Amblyomma parvum*	Brazil (Aragão 1913)			Argentina, Bolivia, Colombia, Guatemala, Mexico, Nicaragua, Panama, Venezuela
15	*Amblyomma pseudoconcolor*	French Guyana (Floch & Fauran 1959)			
16	*Amblyomma scalpturatum**	Bolivia, Brazil, British Guyana, Colombia, Ecuador, Peru, Venezuela #			French Guyana, Surinam #
17	*Amblyomma tapirellum**		Panama (Dunn 1934)		Belize, Colombia, Nicaragua
18	*Amblyomma triste*	Brazil (Kohls 1956a), Paraguay (Nava et al. 2007)			Argentina, Colombia, Ecuador, Mexico, Peru, Uruguay, Venezuela
19	*Ixodes boliviensis*		Panama (Fairchild et al. 1966)		Bolivia, Colombia, Costa Rica, Guatemala, Honduras, Mexico, Peru
20	*Ixodes tapirus**		Panama (Fairchild et al. 1966)	Colombia (Kohls 1956b)	None
21	*Haemaphysalis juxtakochi*	Argentina (Guglielmone & Nava 2005), Brazil (Barros & Baggio 1992), Colombia (Kohls 1956a), French Guyana (Kohls 1956a), Venezuela (Jones et al. 1972)	Panama (Dunn 1934)		British Guyana, Costa Rica, Ecuador, Mexico, Panama, Paraguay, Surinam, Trinidad & Tobago, Uruguay
22	*Dermacentor halli*		Mexico (Cruz-Aldán et al. 2006)		Costa Rica, Guatemala, United States
23	*Dermacentor latus**		Costa Rica (Fairchild et al. 1966), Mexico (Cruz-Aldán et al. 2006), Panama (Fairchild et al. 1966)		none
24	*Dermacentor nitens*		Mexico (Cruz-Aldán et al. 2006),		In all American countries except for Canada, Chile, and Uruguay
25	*Rhipicephalus microplus*	Argentina (Ivancovich & Luciani 1992), Brazil (Labruna et al. 2005b), French Guiana (Floch & Fauran 1959), Paraguay (Nava et al. 2007)	Costa Rica (Cooley 1946)		In all American countries except for Canada and Chile, and various countries in Africa, Asia and Oceania
26	*Ornithodoros rudis*	Venezuela (Guerrero 1996)			Brazil, Colombia, Ecuador, Panama, Paraguay, Peru
27	*Ornithodoros tuttlei*	Venezuela (Jones et al. 1972)			none

* ticks for which tapirs are considered to be primary hosts.

[+] based on country records provided by Guglielmone et al. (2003) and additional records by López and Parra (1985), Cáceres et al. (2002), and Blair et al. (2004).

[#] Records on tapirs and geographic distribution of *A. incisum*, *A. latepunctaum*, and *A. scalpturatum* followed Labruna et al. (2005a).

Threatened tick species associated with tapirs

Tapirs are threatened in a large portion of their range, with several cases of local extinction caused primarily by habitat destruction (deforestation) and hunting (Costa, 1998, Moraes *et al.*, 2003). Since ticks depend on the availability of the vertebrate host, and a suitable environment for development and survival of free-living stages, extensive deforestation followed by tapir extinction are crucial factors leading to extinction of tapir-dependent tick species.

At least 18 (34%) of the 53 South American *Amblyomma* species have been associated with tapirs. In Table 1 we appoint that 9 of these *Amblyomma* species, plus 1 *Ixodes* and 1 *Dermacentor* species use tapirs as primary host – a primary host is the one considered to be amongst the most important hosts for a tick species to successfully feed on in a given area. Consequently, the occurrence of these tick species is intimately associated with the presence of tapirs in a given area. This dependence suggests that the extinction of tapirs from a given area would result in a drastic population reduction of these tick species, or in some cases, in tick extinction (coextinction). In fact, it has been shown that a number of tick species in the world are threatened with extinction (a few might have become extinct) due to drastic reduction of their primary host population and its corresponding habitat (Durden & Keirans, 1996).

Among the ticks that use tapirs as a primary host, some have additional mammalian primary hosts, but a few – including *Amblyomma coelebs*, *A. incisum*, *A. latepunctatum*, and *A. multipunctum* – seem to have only tapirs as its primary host under natural conditions, at least for the adult tick stage (Aragão, 1936, Labruna *et al.*, 2005a,b). Due to habitat requirements of the free-living stages, the above tick species have been restricted to well preserved forest areas, with the exception of *A. coelebs*, which is also found in secondary forest patches (Labruna *et al.*, 2005b). Thus, extensive deforestation, regardless of tapir presence, will culminate in the elimination or at least drastic reduction of these tick species. However, in some areas, in spite of habitat degradation, suitable conditions may still exist for the free-living stages. Nevertheless, the remaining habitat may not be able to support tapir populations, which could become locally extinct. Under these conditions, tick species would also be eliminated because their main source of food (tapirs) would not be available.

Ticks, tapirs and tick-borne diseases

While attached to their hosts, ticks secrete saliva that contains various substances responsible for neutralizing host homeostatic responses, allowing the tick to have a successful blood meal (Ribeiro *et al.*, 2006). Additionally, the saliva is also the main route of transmission of pathogens.

Most of the tapir-associated tick species shown in Table 1 are known to be human-biting ticks, with some of them being very aggressive to humans (Guglielmone *et al.*, 2006). Infestation normally occurs while walking on tapir paths (as mentioned above for other animals). In the Amazon region, humans are infested chiefly by *A. ovale*, *A. oblongoguttatum*, and *A. scalpturatum* (Labruna *et al.*, 2005b); in parts of the Atlantic rainforest, by *A. incisum* (Szabo *et al.*, 2006); in secondary forests, by *A. coelebs* and *A. cajennense*; in Savannah and Pantanal, chiefly by *A. cajennense* (Szabo *et al.*, 2007). All these ticks are tapir-associated, although not all of them use tapirs solely as primary hosts.

A. cajennense is the most aggressive human-biting tick in the central-eastern portion and in parts of the northern portion of South America. In some of these areas (Brazil and Colombia), *A. cajennense* has been incriminated as the main vector of the bacterium *Rickettsia rickettsii*, the etiological agent of the deadliest rickettsiosis of the world, named Rocky Mountain Spotted Fever (RMSF) (Labruna, 2009). Currently, all endemic areas for RMSF are degraded and devoid of tapirs, indicating that these animals do not play any significant role in the occurrence of RMSF. In the RMSF-endemic areas, horses, cattle, and/or capybaras act as primary hosts for *A. cajennense* (Labruna, 2009).

Several other *Rickettsia* species have been reported infecting most of the tapir-associated ticks in the Amazon and Atlantic rainforest areas, but with no zoonotic role reported so far (Labruna *et al.*, 2004). Regarding animals, studies on vector capacity of pathogens by these ticks to animals (including tapirs) are lacking, therefore, the role of tick-borne diseases on tapir conservation deserves further investigations.

Concluding remarks

Indeed, tapirs are very significant hosts for the Neotropical tick fauna. In this regard, tapir conservation will result in tick conservation. Most of the tapir-associated ticks have been poorly studied, thus their conservation is even more important. So far, there has been no indication of harmful effects of ticks on tapirs, nor has there been any record of tick-borne pathogens on tapirs. This scenario is probably linked to the absence of studies in this field. Since tapirs are usually found in less fragmented biomes with high biodiversity, and the richness of tick species is higher in tapirs than any other Neotropical vertebrate species, further studies are needed to evaluate the role of tapir-associated ticks on biodiversity. The role of these ticks on tick-borne diseases for tapir and other vertebrates also needs further investigations.

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Elevational Distribution and Abundance of Baird's Tapir (*Tapirus bairdii*) at different Protection Areas in Talamanca Region of Costa Rica

*José F. González-Maya[1, 2 *], Jan Schipper[1, 2, 3], Karla Rojas-Jiménez[1]*

1 Proyecto de Conservación de Aguas y Tierras, ProCAT Internacional. Las Alturas, Coto Brus, Puntarenas, Costa Rica.
2 ProCAT Colombia. Calle 127 # 45 – 76, Bogotá, Colombia.
3 IUCN/SSC - CI/CABS Biodiversity Assessment Unit, Center for Applied Biodiversity Science, Conservation International, Arlington, VA 22202, USA
* Corresponding Author, e-mail: jfgonzalez@procat-conservation.org

Abstract

Baird's tapir, *Tapirus bairdii*, is distributed from lowlands to 3600 m from México to Colombia. In Costa Rica the species was distributed across the entire country, but currently its precluded to isolated areas and national parks. Here we present the first elevational abundance estimation for the species in the Talamanca region, one of the most important and key habitats for the species throughout the region. A total of 36 paired camera-trap stations reaching a total of 2,160 trap-nights were deployed in an elevation range from 800 to 3600 m. A disrupted distribution pattern was observed with a high density for the La Amistad National Park at 2600 m. Also, low visitation (low human presence) and highly isolated sites showed a strong preference. Also, night activities were the most frequent with peaks around 1900-2000 hours and 2300-0000 hours. It seems that tapirs have disappeared from both pacific and Caribbean lowland of the Talamanca, precluding the species to mid and high elevation habitats with high degrees of isolation. This study represents an important tool for conservation planning and a key aspect to be considered for regional and species level plans. Other aspects of the species ecology, including diet and feeding habits are necessary to be compared with lowland habitats in order to retain the species on the long term.

Keywords: Central America, Central American Tapir, Ecology, National Parks, Protected Areas.

Introduction

Baird's Tapir (*Tapirus bairdii*) is the largest Neotropical mammal species and is currently listed as Endangered (EN A2abcd+3bce) on the 2008 IUCN Red List of Threatened Species (Castellanos *et al.* 2009). Although the species is distributed from southern Mexico to Colombia and Ecuador (Reid 1997), we know very little about its use of habitat – especially in mountainous areas. Increasingly it is these montane and/or isolated habitats, which retain the majority of the last large blocks of forest and where conservation efforts must focus for the persistence of this and other area-sensitive species.

In Costa Rica, Baird's tapir once occurred throughout the country but today viable populations remain only in a few national parks (Mora, 2000). Extensive surveys in remaining lowland Caribbean forest mosaics of Costa Rica failed to turn up even a single individual over a 3 year study (J. Schipper, pers. comm.). The species requires large areas of intact forests (March & Naranjo, 2005) and is susceptible to hunting (Emmons, 1999) throughout its range, for sport hunting and for food (Gonzalez-Maya *et al.*, 2008). These observations suggest that Baird´s tapir is a conservation dependant species, that is to say – that it will likely not persist without active conservation actions and management. There are already concerns about its genetic viability because population sizes are very low and fragmented.

Baird's tapir is herbivorous and is considered an important disperser and/or predator of seeds, influencing the structure and dynamic of the ecosystems where they remain (March & Naranjo, 2005). Although little is known of the species ecology at higher elevations, it has been observed to be associated with shrubs and especially mountain bamboo (*Chusquea spp.*), which is distributed from 0 to 4,300 m in the tropics (Londoño, 1996). Much of the available literature describes the distribution of this species as being from sea level to 3,600 m (Reid, 1997); however, there is very little information on habitat use and relative abundance above 1,000 m. Naranjo y Vaughan (2000) reports the presence, by track detection, of the species at up to 3600 m in Chirripó National Park, which is the highest elevation where the species is known to occur.

The data presented in this study have been obtained from a regional conservation assessment project (ProCAT) in the Cordillera Talamanca, among the largest remaining forest blocks in Central America. Results described herein were part of an ongoing project to evaluate the interaction of jaguars with their principal prey, and the effects of ecological and anthropomorphic variables on the distribution of threatened species.

This report looks to establish a more complete description of the elevation distribution and conservation needs for the species in Mesoamerica and Costa Rica

Materials and Methods

Study Area

The Cordillera Talamanca is located in southern Costa Rica and extends into western Panama. The range protrudes abruptly from the surrounding lowlands and is characterized by steep slopes and variety montane habitats, including cloud forests, elfin forests and páramo. The study site (Figure 1) consists of an elevation transect spanning the Pacific slopes of the Cordillera Talamanca, from 3600 m in Chirripó National Park to 1200 m in Las Alturas de Cotón Farm in the Las Tablas Protected Zone. Very little remaining habitat remains below 1,000 m on the Pacific slopes and thus was not sampled. In 1982 and 1983, this area was designated as a Biosphere Reserve (6,126 km^2) and as a Human Natural Heritage Area by UNESCO (Kapelle, 1996). In addition, the region includes an Endemic Bird Area (Stattersfield *et al.* 1998, Harcourt *et al.,* 1996), is a Center for Plant Diversity (Davis *et al.,* 1997), a Global

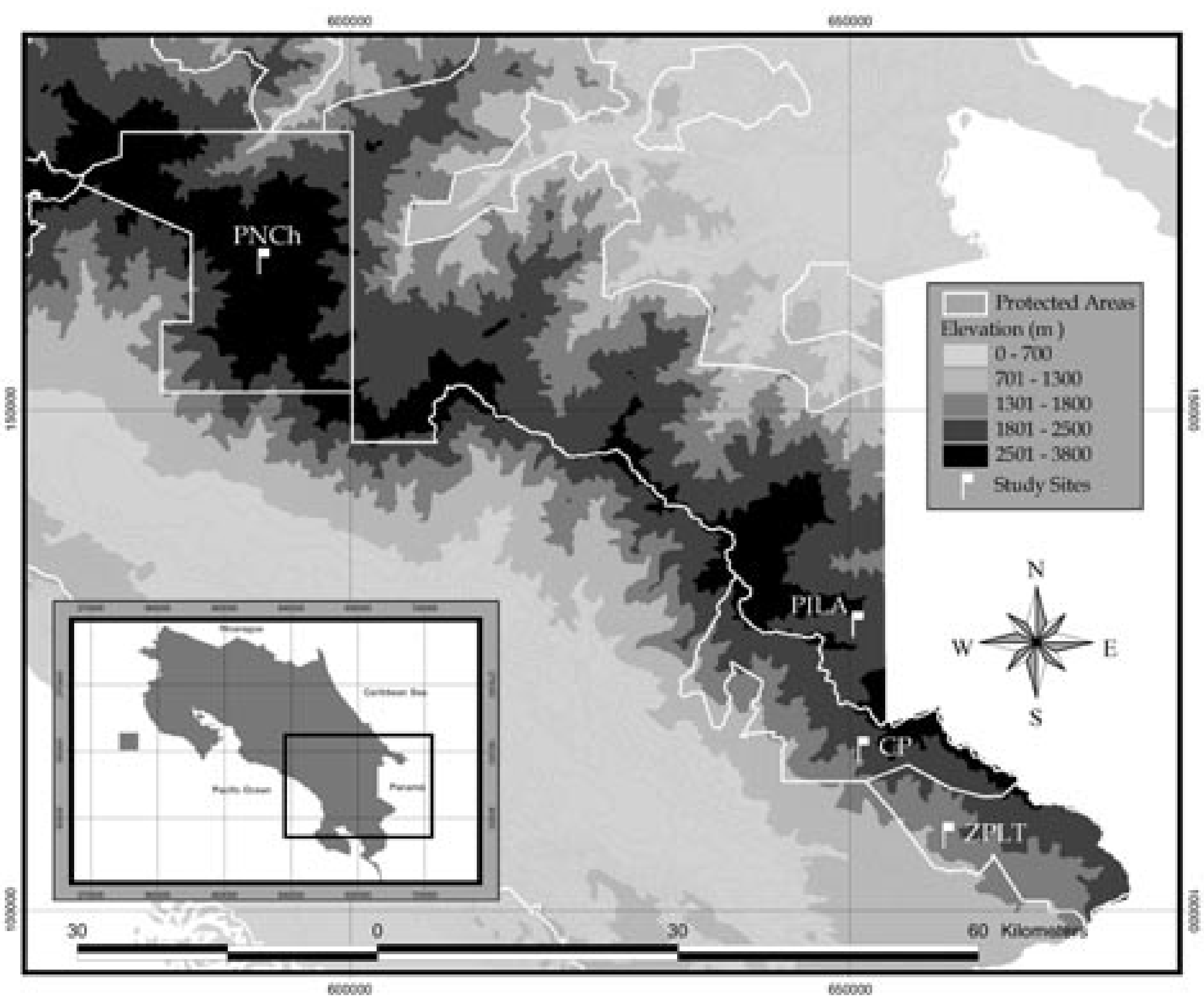

Figure 1. Map of the study area including sampling sites, protected areas and elevation range.

200 Ecoregions (Olson & Dinerstein, 2002) and is considered an important component of the Mesoamerican Hot Spot (Myers *et al.*, 2000, Mittermeier *et al.*, 2005). The region is considered one of the most important protected corridors of forest remaining in Mesoamerica, has more endemic species than any other part of Costa Rica (Gonzalez-Maya *et al.*, 2008) and is considered among the four regions with the highest endemic species concentrations in Central America (Jenkins & Giri, 2008). The region consists of a mosaic of protected areas, indigenous and private reserves and farms, and includes the largest Protected Area in Costa Rica, La Amistad International Park (PILA), which is shared between Costa Rica and Panama (Gonzalez-Maya & Mata-Lorenzen, 2008).

The mean annual precipitation is approximately 5,000 mm, generally with a pronounced rainy season from the end of April to the end of October, and dry season from November to April (Mora-Carpio, 2000) with temperatures ranging from 10º C to 27º C and relative humidity ranging between 80 to 90 % (INBio, 2007). PILA covers 199,147 ha in Costa Rica, and represents about 28.9% of the Costa Rican national park system (Gonzalez-Maya *et al.*, 2008). The region still retains almost 75% of its original forest (DGF, 1989) and approximately 40% is under some kind of formal protection (Powell *et al.*, 2006).

PILA extends approximately from 500 m on Caribbean slope, and 1,500 m on pacific slope to 3,820 masl in Chirripó National Park. It is characterized by steep slopes, small inter-montane valleys and is extremely inaccessible – which is why it has thus far escaped exploitation. However, the pressure for land use change is strong, especially convertion from oak “cloud” forests to pastures and croplands (Kappelle, 1996).Such modifications alter the natural distribution of the species because of habitat loss and fragmentation, thus marginalizing the species to higher, inaccessible parts of the mountain range. These changes also resulted in the loss of middle elevation habitats and in many cases cause species migrations towards higher altitudes, but also caused local extinctions and isolation between lowland forests habitat (as Corcovado National Park) and high elevation forests, affecting altitudinal and seasonal migrations of numerous species (i.e. Resplendent Quetzal – *Pharomachrus mocinno*).

This study focused on three main areas under different management (control, use restrictions) and visitation categories (Human presence for tourism, hunting, harvest, etc.): Valle del Silencio Sector of La Amistad International Park (PILA), Chirripó National Park (PNCh), Cerro Pittier (CP) a privately owned property and Las Tablas Protected Zone (ZPLT) a private farm dedicated to conservation (Table 1).

Methods

Data collection method employed a systematic camera-trap array survey to estimate presence-absence using cameras with heat-in-motion sensors (Gonzalez-Maya *et al.*, 2008). This methodology has been successfully used for the estimate of relative densities and absolute abundances of cryptic species, and it has also been used to estimate relative abundances of other non-cryptic species, and as a useful tool for detecting rare or elusive species (Karanth *et al.* 2004, Maffei *et al.*, 2002, Maffei *et al.*, 2004).

The aim of this project was to estimate the absolute densities of jaguar and their prey (including tapir) along an elevation gradient and to estimate the relative abundance of prey species in the greater Talamanca Region (surrounding PILA). In addition, camera-trap surveys were established along different elevations to estimate the presence of different species for modeling habitat suitability.

Camera traps were used to collect data on tapir both incidentally and targeted towards appropriate habitats and along trails used by the species.

Cameras were active continuously (24 hours) in a two month period at each site. Each photograph includes a date and hour stamp, allowing us to estimate the principal activity patterns, and also to divide the two months in 60 sampling periods (days), to estimate both relative and absolute densities of species.

A relative abundance index was built in order to standardize and compare among sites (Maffei *et al.*, 2002, Karanth & Nichols, 2002), and the index was constructed as the number of captures (individuals) per 1,000 trap nights. Trap nights 24 hour periods calculated as number of days by number of cameras.

In addition, we characterized every camera area by slope, distance to water bodies, forest cover, and vegetation composition using an extrapolation of field data into a Geographical Information System (GIS). Camera surveys were carried out in four places, with systematic arrays of cameras in three of them, and a presence-absence survey in the other (see Figure 1).

Results

A total trap effort of 2,160 trap-nights were completed and timing was distributed equally among the four sites, with arrays of 20 paired cameras in the systematic sites (PILA, CP and ZPLT) and 6 stations for PNCh for a total of 36 stations.

From a total of 628 pictures at 4 sites, 87 were of Baird´s tapir (Table 2), with a notable high capture rate for the PILA site. The greatest number pictures were at PILA at 2,560 m of elevation, on a ridge with

Table 1. Survey sites, elevation and characteristics.

Site	Elevation range (m)	Control	Human presence
PILA	2400 - 2800	Passive	Low
PNCh	3500 - 3800	Active	High
CP	1900 - 2300	Passive	Low
ZPLT	800 - 1200	Active	High

10 degrees of slope dominated by *Chusquea sp.*, with approximately 80% of forest cover. The distribution of relative abundance on the elevation gradient was highly differentiated with a heterogeneous distribution from lowlands to páramo (Figure 2).

The distribution across the elevation gradient showed a pattern with an abrupt change as evidenced by the high abundance in PILA, however, in general terms it shows a greater abundance in the higher elevations. For the entire study tapir was the second most abundant species after the American opossum, *Didelphis virginianus*, and showed an important relationship with elevation and slope (Gonzalez-Maya *et al.*, 2008).

In this study, a total of 13 photographs containing 2 or more individuals were captured at PILA, showing a high number of breeding pairs in the zone, also a low number of young individuals were captured (15.5 %) compared with the total number of photographed individuals.

The distribution showed a marked preference for low visitation (low human presence) sites, even when hunting control was not as active as other areas; also, the site with the highest abundance was the most isolated parts of the park. There was a preference for night activity with peaks around 1900-2000 hours and 2300-0000 hours, and no activity during the day (Figure 3).

Discussion

Conservation planning, site protection and biodiversity assessment are among of the most important issues to consider in order to retain biodiversity in tropical landscapes, however, in many areas even basic information on species occurrence and distributions is lacking. Improving knowledge of species ecology and distribution can contribute greatly to improved priority setting for conservation interventions and in park management.

Tapir appears to have disappeared from both the Caribbean and Pacific lowlands surrounding PILA, thus creating a virtual habitat island (Schipper *et al.*, 2005). This is inferred on the Pacific slope of Cordillera Talamanca by the lack of any major forest fragments below 1,000 m and mainly because of its discontinuity (Cespedes *et al.*, 2007), and observed on the Caribbean slope mainly by hunting, habitat loss/ fragmentation and over-exploitation (Schipper, unpub. data.).

Previous studies had reported capture frequencies for tapir; Noss *et al.* (2003) with 11-60 ind/1000 trap-nights in Bolivian dry forests, Wallace *et al.* (2002) with 7 ind/1000 trap-nights for Bolivian lowland moist tropical forest in Madidi, Kelly (under review) with

Table 2. Total number of pictures and tapir pictures and frequency.

Site	Total pictures	Tapir captures	Frequency	Relative abundance (captures/1000 trap-nights)
PILA	99	77	77.78	35.65
PNCh	53	5	9.43	2.31
CP	98	3	3.06	1.39
ZPLT	378	2	0.53	0.93
Total	**628**	**87**	**13.85**	**40.28**

12 ind/1000 trap-nights in the rainforest of Belize for *T. bairdii* and Holden *et al.* (2003) with 4-19 ind/1000 trap-nights for Malayan tapir (*Tapirus indicus)* in lowland rainforest of Sumatra, Indonesia. This study documents a range from 0.93 to 35.65 ind/1000 trap-nights, which represent a high frequency for the species and for the methodology, especially at the elevations sampled.

Continued threats in surrounding lowlands demonstrates the increasing isolation of populations and a continued retreat of the species to more remote montane habitats with less human influence and more continuous habitat or forest. Remaining suitable montane habitats are also spatially limited with much of the Cordillera being extremely steep and broken terrain – likely resulting in a meta-population structure. Even though the species is reported to be associated primarily with lowland forests, the situation in the Cordillera Talamanca region indicates an emerging problem for these and other species, where isolation in upper elevations could represent better suitable habitats for area-dependent species such as tapir.

Based on this analysis, the mountain forests are not only suitable habitat for the species, but seem to be preferred habitats as reflected in the high abundances and density, likely a result of loss of habitat at low and middle elevations combined with a high incidence of hunting. Even in the most isolated portions of La Amistad National Park hunting still takes place, which suggests that there is no place left in Costa Rica where it the tapir can thrive without some degree of persecution. Additionally, due to the continued loss of lowland forests and the increasing exploitation of oak *Quercus* forests the future looks bleak for large mammals in this region unless current and existing laws are enforced. Where corridors exist between habitat blocks hunting activities often increase because the corridors often funnel the animals through a human dominated landscape (Bennet, 2004).

There is some evidence suggesting that tropical forests species behavior has been shown to change when they occur in human dominated areas; evidence suggests that animals abandon the area or change their activity patterns and habitat use by becoming more nocturnal and adapt movement patterns to suit the conditions (Griffiths & van Schaik, 1993). The present study reveals that tapirs were mainly nocturnal and highly abundant in areas far from human habitation. This confirms the suggestion that areas with less human presence represents better suitable habitat for these and other large mammals (Griffiths & van Schaik, 1993). In fact some changes in the natural history of tapir have been observed as an adaptation to human presence such as shifting activity patterns, use of trails and habitat -density relationships (pers. obs.).

Abundance, elevation distribution and activity patterns can represent important inputs for conservation planning and for the understanding of species population dynamics on different environments and response to hunting, habitat modification and human presence generally. Specifically for montane regions we

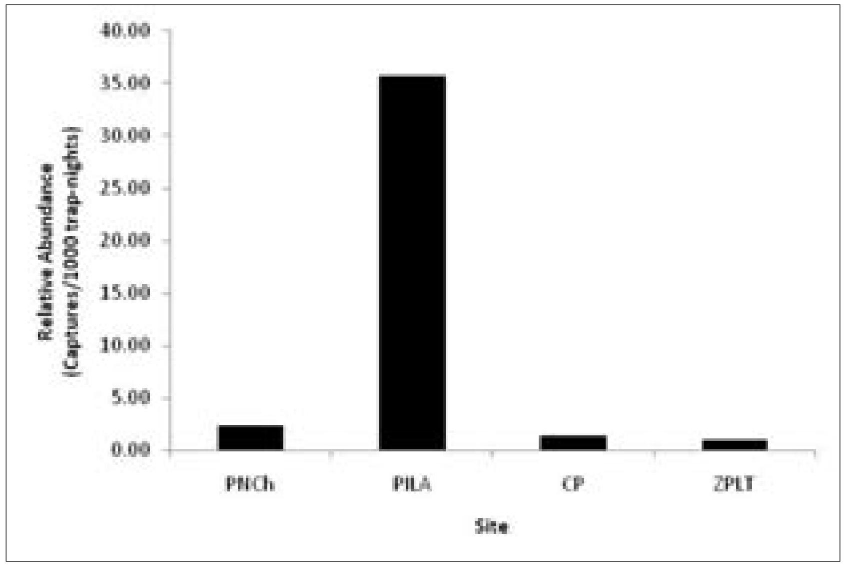

Figure 2. Relative abundance distribution according to elevation.

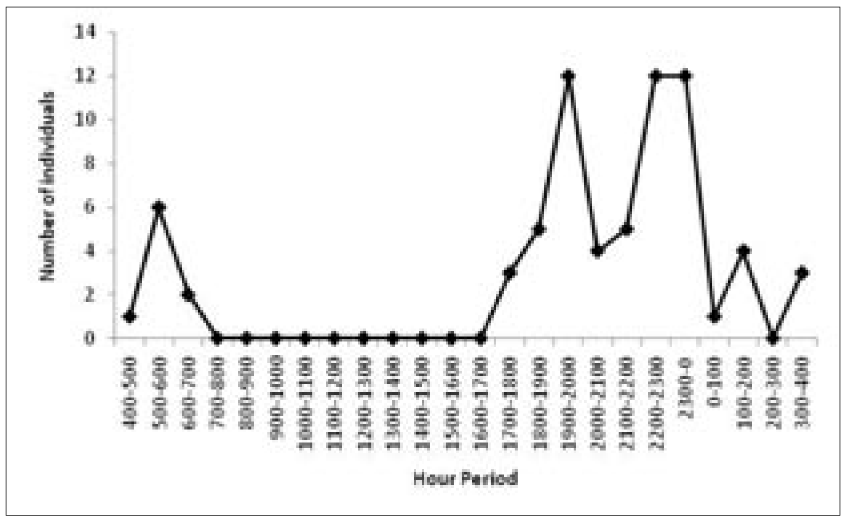

Figure 3. Daily activity patterns accumulative throughout the study.

feel that this data represents a key information to consider during a conservation planning process because subsequent policies and actions should include ecological information to support management decisions. In addition there is an urgent need for additional support to the park systems, which is the largest but most understaffed in the country, to prevent hunting, illegal logging and mining activities from taking place in the region.

Recommendations

Feeding habits and diet need further investigation for tapir in these montane habitats in order to understand the differences with known lowland habitats (as in Corcovado National Park). Also basic ecology features such as home range, daily movements and habitat use must be investigated at higher elevations as nearly everything that is currently known is derived from data in lowland areas. The future for long term conservation of the species, however, must include these remnant montane habitats which we know next to nothing about. Provide connectivity and ensure habitat continuity from lowlands to highlands, and within them, is also one of the current conservation needs for these conservation-dependant species in the region. We therefore want to encourage scientist to work towards filling the data gaps, habitat restoration and landscape connectivity, so we can effectively plan for their long term survival.

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Cerro Negro: An Important Mountain Tapir Conservation Area in the Piuran Andes, Piura and Cajamarca States, NW Peru

Craig C. Downer [1]

1 Wildlife Ecologist, President: Andean Tapir Fund
P. O. Box 456, Minden, Nevada 89423 USA
Email: ccdowner@yahoo.com

Abstract

Local Peruvians along with the Andean Tapir Fund are working together to establish a nature sanctuary in the Piuran Cordillera (a.k.a. *Cordillera de las Lagunillas*) of NW Peru, but must counter the designs of large mining companies. The sanctuary would center around Cerro Negro mountain and be located in both Piura and Cajamarca states. This area contains Peru's most crucial remaining occupied habitat for the endangered mountain tapir. It is also in the ecologically significant Huancabamba Depression, a region of high species endemism that provides a vital water source for a vast region whose rivers extend east to the Amazon and west to the Pacific, to parts of Ecuador as well as Peru. This sanctuary would provide a biological corridor connecting the mountain tapir population here found, and those of other rare/declining species, by means of free passage to the north, to Ecuador and beyond.

Keywords: Andes, biological corridor, endangered species, mining, mountain tapir, nature sanctuary, Peru, Piura

Introduction

One of the most important reasons populations of mountain tapirs are decreasing is loss of habitat. This loss is not localized but widespread, resulting in many small and unconnected tapir populations, rather than a few large ones. This problem, known as habitat fragmentation, is a compounding effect of habitat loss: the small fragmented populations are, individually, more susceptible to other causes of extinction, including catastrophes (e.g., large fires) and foibles linked to inbreeding depression, such as disease and genetic drift resulting in fixation of lethal alleles in the population (Brack Egg & Vargas, 2004).

Fragmentation is a particularly important concern for the endangered mountain tapir (*Tapirus pinchaque*), because this species inhabits „natural islands" located in mid- to high-elevations of the Andes of northern Peru, Ecuador and Colombia. Loss of habitat at all elevations within its range has created isolated „refuges" of tapir populations restricted to a few small areas, some higher, some lower (Downer, 1997, 1996). Hence, one of the most urgent conservation actions for mountain tapirs is to designate and legally protect natural corridors that connect the species' known populations in order to enhance genetic flow. Here I describe one such important area that has the potential to connect at least two known populations. I address what makes this area an important conservation target, its other conservation values, and potential conflicts with economic interests – the conservation challenge.

The Area

A recent study by biologists Diego Lizcano and Aivi Sissa (2003) reveals 206,000 hectares of remaining Andean forest and *páramo* (high northern Andean moorland above the treeline; also Spanish/English scientific name for this unique biome in the northern Andes [Davis, 1997]). This is suitable habitat for the endangered mountain tapir and includes areas around Cerro Negro, NW Peru, where the Andean Tapir Fund is proposing to create a nature sanctury (see Map 1). A recent WWF-Peru-sponsored evaluation by biologist Jessica Amanzo et al. (2003) recommends the conservation of 57,144 hectares as an extension of the existing 29,500-hectare Tabaconas-Namballe National Sanctuary (TNNS - see Map 2). Including the WWF-proposed extension of Andean forests and páramos and more, the proposed Cerro Negro Nature

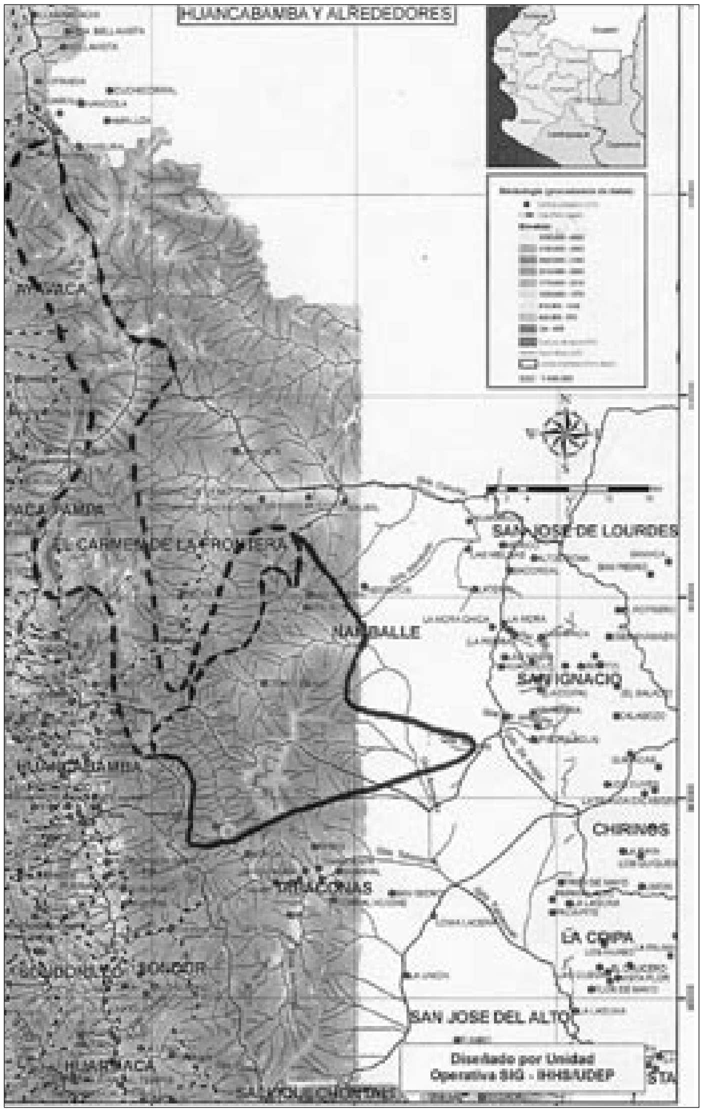

Figure 1. 57,144 ha Cerro Negro Sanctuary (dashed line).

Sanctuary would connect TNNS with areas in Ecuador. This would include areas already identified for reserve status in the provinces of Ayabaca and Huancabamba, Piura state, Peru, as well as adjacent areas to the east in Cajamarca state (or *departamento*). This area would be at least 150,000 hectares in size (see Map 3) and would include all areas recommended by Lizcano and Sissa (2003), and Amanzo et al. (2003). Given adequate protection and public cooperation, the proposed nature reserve could potentially become a biological corridor of great significance. It would link tapir populations in both TNNS and Ecuador. The Andean Tapir Fund is currently working with northern Peruvian communities, conservationists and government agencies to legally and professionally establish this *Santuario Natural Cerro Negro* (CEPA, 2006).

Conservation Value

Workers currently associated with the Andean Tapir Fund have made several expeditions and numerous observations in the area of Cerro Negro between 1988 and 2005; and they have also borrowed from the observations and reports of natives and local biologists familiar with this region (Downer, 2006, 2005, 2001, 1997, 1996, 1988, 1988-2006,; Zegarra-Pezo, 2006, 1985-2006). Resulting from these efforts are extensive species lists for four vertebrate classes - birds, mammals, reptiles and amphibians - as well as for major classes of plants. These lists contain annotations as to the degree of endemism and special conservation status of many of the species, and demonstrate the high degree of biodiversity and endemism that render the Cerro Negro area of high conservation value. Corroborating this, both local, or alpha, and regional, or beta, diversity were found to be high in the 57,144-hectare area proposed by WWF-Peru (Amanzo et al., 2003). Our combined results indicate that many species are specific to one particular habitat type of local occurrence, and that the biodiversity of the region as a whole is extraordinarily high.

For four vertebrate classes, percentages of species that are threatened with extinction are as follows: Birds: 23.7%, Mammals: 12.8%, Amphibians: 48.1%, and Reptiles: 57.1%. For these same classes, percentages of species that are considered endemic to this region of the Huancabamba Depression are: Birds: 8%, Mammals: 6.6%, Amphibians: 37%, and Reptiles: 42.9% (see Table 1) (CEPA, 2006).

The protected corridor in the form of the nature sanctuary would provide a connection along the entire northern Andes for the migration and genetic interchange of such seriously endangered species as the mountain tapir, the spectacled bear and the pacarana (both Spanish and English name, Family Dinomyidae). Furthermore, Cerro Negro is at the heart of a vital sub-ecoregion lying at the southern limit of the North Andes Ecoregional Complex. This complex has been identified as one of the 200 most important ecoregions in the world by a recently held World Forum for Nature (Torres-Guevara, 2006, p. 50 ff; see also Davis et al., 1997).

The Challenge

Around 700,000 hectares in the mountains and valleys of Piura and Cajamarca states have recently been tentatively designated to companies as mining concessions by Peru's national government, pending environmental assessments. The biggest concession was to the London-based Monterrico Metals plc, whose

Table 1. Taxonomic/Conservation Categories for Animal/Plant Species Lists for Proposed Cerro Negro. Special Conservation Status = Rare, Threatened, Endangered, Restricted Range, Focal Species.

Taxonomic Category	Orders	Families	Genera	Species	% Endemic Spp (Numbers)	% Special Conservation Status Spp (Numbers)
Birds	18	42	267	439	8% (35)	24% (104)
Mammals	10	38	142	196	7% (13)	13% (25)
Amphibians			13	27	37% (10)	48% (13)
Reptiles			11	14	43% (6)	57% (8)
Vascular plants, ferns & mosses		67	189	217	3% (7)	7% (16)

Peruvian company is Majaz (Downer, 2006). Massive mining projects are planned in and around the Cerro Negro mountain area where tens of thousands of hectares of cloud forest and treeless paramo provide a last refuge for the endangered mountain tapir and many other rare, endemic, and/or endangered species of plants and animals. Monterrico and other companies have plans to mine copper, molybdenum, gold, silver and zinc using the ecologically devastating process of open pit mining combined with heap leaching using cyanide and other noxious chemicals to extract the metals from the crushed ore. The rivers at risk include *Rios* Chira, Piura, Blanco, and Chipillico, of which the latter fills the agriculturally important San Lorenzo Reservoir. Also at risk are the Rio Quiroz, which fills the equally important Poechos Reservoir, and the important *Rios* Huancabamba and Chinchipe. The latter supplies the only nature reserve in the area, the 295,000-hectare *Santuario Nacional Tabaconas-Namballe*, home to the mountain tapir. The headwaters of the Rio Quiroz are affected by mining concessions originally designated for Newmont-USA, while the headwaters of Rio Chinchipe are seriously compromised by concessions designated to Monterrico Metals-Majaz, according to Piuran plant ecologist Fidel Torres Guevara (2006, 2003).

The millions of tons of waste rock that would be generated would continue to leach caustic sulfuric and nitrous acids for generations, releasing heavy metals that become incorporated into the food chain. The livelihoods of many thousands of peasants and townsfolk would be negatively impacted, as would Peru's 231,402-hectare Man and the Biosphere Site (*El Nor-Oeste* – Sp.) to the northwest. Many Peruvian laws should prohibit these mining activities, including those prohibiting the devastation of endangered species such as the mountain tapir, watersheds and the compromising of national security and the very welfare of future generations.

Due to imminent disappearance of glaciers from the Andes of Peru (as elsewhere), this nation's remnant forests and paramos have become all the more vital to the future of agricultural production in the Andes; and there is no more important region of forest and paramo in Peru than that now jeopardized by the mining concessions here in question (Appenzeller, 2007; Torres-Guevara, 2006, 2003).

Though appropriate habitat for 350-375 mountain tapirs was estimated to exist in 2003 for northern Peru (Lizcano & Sissa, 2003), due to uncontrolled hunting combined with habitat destruction, it is estimated that only about half this number still survive (Lizcano et al, in press). If Monterrico-Majaz' Rio Blanco and other pending mining projects are allowed to proceed, a final death blow could be dealt to that ecologically important seed disperser and ancient living fossil in Peru known variously as *danta negra, gran bestia*, and „Ah-Ha!" for the sound it emits when surprised, i.e. the mountain tapir (Downer, 2001, 1997, 1996).

The nationally promoted Rio Blanco mining project was rejected by 95% in a referendum by local communities (ENS, 2007), whose citizens cited among their reasons the preservation of the endangered mountain tapir. However, preliminary exploration in the project area has already caused significant ecological damage, according to a study by the University of Texas at Austin. This study projects very serious threats should the planned 1,000-hectare open pit mine proceed (Salazar, 2007). Though ca. 500 local jobs for several years might result, the true price that future generations would pay in terms of long-term sustainability, general water supply, ecological integrity and general quality of life would prove devastating (Appenzeller, 2007). It should finally be mentioned that this natural Andean region is culturally important as a center of folk healing and spiritual refreshment (Downer, 2006). Currently (7/2009) a General Assembly of Andean communities is being organized where a map of the future sanctuary should be collectively defined and approved and a vote taken on whether or not to democratically establish this unique and crucially important nature reserve.

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TSG MEMBERSHIP DIRECTORY

TAPIR SPECIALIST GROUP

Currently, the TSG has 116 members, including field researchers, educators, veterinarians, governmental agencies and NGO representatives, zoo personnel, university professors and students, from 27 different countries worldwide (Argentina, Australia, Belize, Bolivia, Brazil, Canada, Colombia, Costa Rica, Denmark, Ecuador, France, French Guiana, Germany, Guatemala, Honduras, Indonesia, Malaysia, Mexico, Myanmar, Republic of Panama, Paraguay, Peru, Thailand, The Netherlands, United Kingdom, United States, and Venezuela).

ABD GHANI, SITI KHADIJAH (Malaysia)
PERHILITAN Bukit Rengit, Krau Wildlife Reserve
E-mail: cobra7512081@hotmail.com

AMANZO, JESSICA (Peru)
Seccion Ecologia, Sistematica y Evolucion, Departamento Academico de Ciencias Biologicas y Fisiologicas, Facultad de Ciencias y Filosofia, Universidad Peruana CayetUmano Heredia
E-mail: jessica_amanzo@yahoo.com

AÑEZ GALBAN, LUIS GUILLERMO (Venezuela)
D.V.M. Gerente de Operaciones, Fundación Parque Zoológico Metropolitano del Zulia
E-mail: galbanluis70@hotmail.com; galbanluis97@yahoo.com

ANGELL, GILIA (United States)
Senior Designer, Amazon.com
E-mail: gilia_angell@earthlink.net; gilia@tapirs.org

ARIAS ALZATE, ANDRÉS (Colombia)
Biológo, Researcher, Grupo de Mastozoologica-CTUA, Instituto de Biología, Universidad de Antioquia
E-mail: andresarias3@yahoo.es

AYALA CRESPO, GUIDO MARCOS (Bolivia)
M.Sc. Biólogo, Investigador de Vida Silvestre, WCS - Wildlife Conservation Society, Northern La Paz Living Landscape Program
E-mail: gayala@wcs.org; guidoayal@gmail.com

BARONGI, RICK (United States)
Director, Houston Zoo Inc.
Former Chair / Member, Association of Zoos & Aquariums (AZA) Tapir Taxon Advisory Group (TAG)
E-mail: RBarongi@aol.com; rbarongi@houstonzoo.org

BAUER, KENDRA (United States)
Ph.D. Graduate Student, University of Texas at Austin Integrative Biology, 1 University Station
E-mail: kendrabauer@mail.utexas.edu

BECK, HARALD (Germany / United States / Peru)
Ph.D. Assistant Professor & Curator of the Mammal Museum
Department of Biological Sciences, Towson University
E-mail: hbeck@towson.edu

BENEDETTI, ADRIÁN (Republic of Panama)
Director, Protected Areas and Wildlife, Republic of Panama
E-mail: panasummit@gmail.com

BERMUDEZ LARRAZABAL, LIZETTE (Peru)
General Curator / Jefe de Fauna, Parque Zoologico Recreacional Huachipa
E-mail: lizettelarrazabal@yahoo.com

BERNAL RINCÓN, LUZ AGUEDA (Colombia)
D.V.M. Mountain Tapir Project - Colombia (Diego Lizcano)
E-mail: aguedabernal@gmail.com, aguedabernal@yahoo.es

BLANCO MÁRQUEZ, PILAR ALEXANDER (Venezuela)
D.V.M. Director Técnico, Fundación Nacional de Parques Zoológicos e Acuários (FUNPZA) - Ministerio del Ambiente (MARN)
E-mail: pblanco@minamb.gob.ve; albla69@yahoo.com.mx; albla69@hotmail.com

BODMER, RICHARD E. (United Kingdom)
Ph.D. Lecturer in Biodiversity Conservation, Durrell Institute of Conservation and Ecology (DICE), University of Kent
E-mail: R.Bodmer@ukc.ac.uk

BOSHOFF, LAUTJIE (Costa Rica)
Rafiki Safari Lodge
E-mail: lautjie@gmail.com

BROWN, QUINN (United States)
San Francisco Zoo
E-mail: QuinnB@sfzoo.org

CALVO DOMINGO, JOSÉ JOAQUÍN (Costa Rica)
Coordinador de Vida Silvestre, Sistema Nacional de Áreas de Conservación, Ministerio del Ambiente y Energía (MINAE)
E-mail: joaquin.calvo@sinac.go.cr

CAMACHO, JAIME (Ecuador)
Coordinator, Dry Forest Conservation and Development Initiative, The Nature Conservancy / Fundación Natura
Associate Researcher, Fundación Ecuatoriana de Estudios Ecológicos - EcoCiencia
E-mail: tulias@hotmail.com

CARBONELL TORRES, FABRICIO (Costa Rica)
Coordinador de Proyectos Ambientales, Asociación Meralvis
E-mail: carbon_f@yahoo.com.mx

CARTES, JOSÉ LUIS (Paraguay)
M.Sc. Coordinador de Conservación de Sítios, Guyra Paraguay
E-mail: jlcartes@guyra.org.py

CASTELLANOS PEÑAFIEL, ARMANDO XAVIER (Ecuador)
Director, Andean Bear Project, Fundación Espíritu del Bosque
E-mail: iznachi@yahoo.com.mx; zoobreviven@hotmail.com

CHALUKIAN, SILVIA C. (Argentina)
M.Sc. Proyecto de Investigación y Conservación del Tapir Noroeste Argentina
E-mail: schalukian@yahoo.com.ar; tapiresalta@argentina.com

COLBERT, MATTHEW (United States)
Ph.D. Research Associate, Jackson School of Geological Sciences, University of Texas at Austin
E-mail: colbert@mail.utexas.edu

CONSTANTINO, EMILIO (Colombia)
E-mail: econch@gmail.com

CRUZ ALDÁN, EPIGMENIO (Mexico)
M.Sc. Researcher, Instituto de Historia Natural y Ecología
E-mail: pimecruz5910@hotmail.com; ecruz5910@prodigy.net.mx

CUARÓN, ALFREDO D. (Mexico)
Ph.D. Departamento de Ecología de los Recursos Naturales, Instituto de Ecología, UNAM
E-mail: cuaron@oikos.unam.mx

DEE, MICHAEL (United States)
E-mail: mjdrhino@yahoo.com

DELLA TOGNA, GINA (Panama)
Investigadora Asociada, Instituto de Investigaciones Científicas Avanzadas y Servicios de Alta Tecnología (INDICASAT)
E-mail: gdellat@hotmail.com; gtogna@indicasat.org.pa

DESMOULINS, AUDE (France)
Assistant Director, ZooParc de Beauval
Lowland Tapir Studbook Keeper, European Association of Zoos and Aquaria (EAZA) Tapir Taxon Advisory Group (TAG)
E-mail: aude.desmoulins@zoobeauval.com

DINATA, YOAN (Indonesia)
Assistant Director, ZooParc de Beauval
Field Manager, Fauna & Flora International - Indonesia Program
E-mail: y1_dinata@yahoo.com

DOWNER, CRAIG C. (United States)
BA, M.Sc., President, Andean Tapir Fund
E-mail: ccdowner@terra.es; ccdowner@yahoo.com

ESTRADA ANDINO, NEREYDA (Honduras)
M.Sc. USAID - MIRA
E-mail: nereyda.estrada@gmail.com

FLESHER, KEVIN (Brazil)
Michelin Brasil
E-mail: kevinmflesher@yahoo.com.br

FLOCKEN, JEFFREY (United States)
Director of Washington DC Office, International Fund for Animal Welfare
E-mail: JFlocken@ifaw.org

GARCÍA VETTORAZZI, MANOLO JOSÉ (Guatemala)
Licenciado, Investigador, Centro de Estudios Conservacionistas, Universidad de San Carlos de Guatemala
E-mail: manelgato@gmail.com

GARRELLE, DELLA (United States)
D.V.M. Director of Conservation and Animal Health, Cheyenne Mountain Zoo
E-mail: dgarelle@cmzoo.org; dgarelle@yahoo.com

GEMITA, ELVA (Indonesia)
Field Manager, Fauna & Flora International /
Durrell Institute of Conservation and Ecology (DICE)
E-mail: elvagemita@gmail.com

GLATSTON, ANGELA (The Netherlands)
Ph.D. Curator of Mammals, Rotterdam Zoo
Member, European Association of Zoos and Aquaria (EAZA) Tapir Taxon Advisory Group (TAG)
E-mail: a.glatston@rotterdamzoo.nl

GOFF, DON (United States)
Assistant Director, Beardsley Zoological Gardens
Lowland Tapir Studbook Keeper, Association of Zoos & Aquariums (AZA) Tapir Taxon Advisory Group (TAG)
E-mail: dgoff@beardsleyzoo.org

GONÇALVES DA SILVA, ANDERS (Canada)
Ph.D. Postdoctoral Research Fellow, Unit of Biology and Physical Geography, Irving K. Barber School of Arts and Sciences,
University of British Columbia Okanagan
E-mail: anders.goncalvesdasilva@ubc.ca

GREENE, LEWIS (United States)
Assistant Director, Columbus Zoo,
E-mail: Lewis.Greene@columbuszoo.org

GUERRERO SÁNCHEZ, SERGIO (Mexico)
El Colegio de la Frontera Sur (ECOSUR)
Unidad San Cristóbal De Las Casas
E-mail: ekio@yahoo.com; sguerrero@ecosur.mx

GUIRIS ANDRADE, DARIO MARCELINO (Mexico)
D.V.M. M.Sc. Jefe de Operaciones, UN.A.CH., Policlinica y Diagnóstico Veterinario
E-mail: dmguiris@hotmail.com

HANDRUS, ELLIOT (United States)
E-mail: ebh12345@hotmail.com

HERNANDEZ DIVERS, SONIA (United States)
D.V.M. Adjunct Professor, College of Veterinary Medicine, University of Georgia
E-mail: shernz@aol.com

HOLDEN, JEREMY (Indonesia)
Photographer, Flora and Fauna International
E-mail: pop@padang.wasantara.net.id; jeremy_holden1@yahoo.co.uk

HOLST, BENGT (Denmark)
M.Sc. Vice Director and Director of Conservation and Science, Copenhagen Zoo
Convener, IUCN/SSC Conservation Breeding Specialist Group (CBSG) - Europe Regional Network
Chair, European Association of Zoos and Aquaria (EAZA) Tapir Taxon Advisory Group (TAG)
E-mail: beh@zoo.dk

JANSSEN, DONALD L. (United States)
D.V.M. Ph.D. Director, Veterinary Services, San Diego Wild Animal Park
E-mail: djanssen@sandiegozoo.org

JULIÁ, JUAN PABLO (Argentina)
Ph.D. Coordinador, Reserva Experimental Horco Molle Universidad National de Tucumán, Facultad de Ciencias Naturales,
E-mail: jupaju@yahoo.es

KAEWSIRISUK, SUWAT (Thailand)
Chief, Hala-Bala Wildlife Sanctuary - Department of National Parks, Wildlife and Plant Conservation, Royal Forest Department of Thailand
E-mail: king@btv.co.th

KASTON FLÓREZ, FRANZ (Colombia)
D.V.M. Scientific Director, Fundación Nativa
E-mail: tapirlanudo@hotmail.com

KAWANISHI, KAE (Malaysia)
Ph.D. Technical Advisor, Division of Research and Conservation
Department of Wildlife and National Parks (DWNP)
E-mail: kae@wildlife.gov.my; kae2000@tm.net.my

LIRA TORRES, IVÁN (Mexico)
D.V.M. M.Sc. Subdirector de Salud Animal, Dirección Técnica y de Investigación (DGZVSDF), Zoológico de Chapultepec
E-mail: ilira_12@hotmail.com

LIZCANO, DIEGO J. (Colombia)
Ph.D. Professor, Universidad de Pamplona
E-mail: dj.lizcano@gmail.com

LUÍS, CRISTINA (Portugal)
Ph.D Post-Doctoral Researcher, CIES-ISCTE
Centro de Biologia Animal, Departamento de Biologia Animal, Faculdade de Ciências, Universidade de Lisboa
E-mail: cmluis@fc.ul.pt

LYNAM, ANTONY (Thailand)
Ph.D. Associate Conservation Scientist & Regional Advisor, Wildlife Conservation Society - Asia Program
E-mail: tlynam@wcs.org

MANGINI, PAULO ROGERIO (Brazil)
D.V.M. M.Sc. Associated Researcher, Lowland Tapir Conservation Initiative, IPÊ - Instituto de Pesquisas Ecológicas (Institute for Ecological Research)
Scientific Coordinator, Vida Livre - Medicina de Animais Selvagens
E-mail: pmangini@uol.com.br; pmangini@ipe.org.br

MARTYR, DEBORAH (Indonesia)
Team Leader, Flora and Fauna International
E-mail: ffitigers@telkom.net

MATOLA, SHARON (Belize)
Director, Belize Zoo and Tropical Education Center
E-mail: matola@belizezoo.org

MAY JR, JOARES A. (Brazil)
D.V.M. Wildlife Veterinarian
M.Sc. Student, University of São Paulo (USP)
IPÊ - Instituto de Pesquisas Ecológicas (Institute for Ecological Research)
E-mail: joaresmay@ig.com.br

MEDICI, PATRÍCIA (Brazil)
M.Sc. Wildlife Ecology, Conservation and Management
Research Coordinator, Lowland Tapir Conservation Initiative
IPÊ - Instituto de Pesquisas Ecológicas (Institute for Ecological Research)
Ph.D. Candidate, Durrell Institute of Conservation and Ecology (DICE), University of Kent, United Kingdom
E-mail: epmedici@uol.com.br; skype: patricia.medici

MENDOZA, ALBERTO (United States)
D.V.M. Member, IUCN/SSC Tapir Specialist Group (TSG)
E-mail: alumen@aol.com

MOLLINEDO, MANUEL A. (United States)
Director, San Francisco Zoological Gardens
E-mail: manuelm@sfzoo.org

MONTENEGRO, OLGA LUCIA (Colombia)
Ph.D. Universidad Nacional de Colombia (UNAL)
E-mail: olmdco@yahoo.com; olmontenegrod@unal.edu.co

MORALES, MIGUEL A. (Paraguay / United States)
Ph.D. Protected Areas Management Advisor
People, Protected Areas and Conservation Corridors, Conservation International (CI)
E-mail: mamorales@conservation.org

NARANJO PIÑERA, EDUARDO J. (Mexico)
Ph.D. El Colegio de la Frontera Sur (ECOSUR)
E-mail: enaranjo@ecosur.mx

NOGALES, FERNANDO (Ecuador)
Instituto Ecuatoriano de Propiedad Intelectual (IEPI)
Professor, Escuela de Gestión Ambiental de la Universidad Técnica Particular de Loja
E-mail: fernogales@yahoo.com; fbnogales@utpl.edu.ec

NOVARINO, WILSON (Indonesia)
Lecturer, Jurusan Biologi FMIPA, Universitas Andalas
E-mail: wilson_n_id@yahoo.com

NUGROHO, AGUNG (Indonesia)
Field Team Leader / Field Researcher, Fauna & Flora International - Indonesia Program
E-mail: Pithecellobium98@yahoo.com; info@ffi.or.id

O'FARRILL, GEORGINA XoXo (Mexico / Canada)
Ph.D. Graduate Student, Biology Department, McGill University
ECOSUR-Chetumal, Mexico
E-mail: elsa.ofarrill@mail.mcgill.ca

ORDÓÑEZ DELGADO, LEONARDO (Ecuador)
Coordinator, Proyecto Corredores de Conservación, Fundación Ecológica Arcoiris
E-mail: leonardo@arcoiris.org.ec; tsg.ecuador@gmail.com

PAVIOLO, AGUSTÍN (Argentina)
Biologist, Ph.D. Graduate Student, CONICET- LIEY, Universidad Nacional de Tucumán
E-mail: paviolo4@arnet.com.ar

PEDRAZA PEÑALOSA, CARLOS ALBERTO (Colombia)
Instituto de Investigación de Recursos Biológicos «Alexander von Humboldt»
E-mail: cpedraz@gmail.com

POÓT, CELSO (Belize)
Education Director, The Belize Zoo and Tropical Education Center
E-mail: celso@belizezoo.org

PRASTITI, SHARMY (Indonesia)
Animal Curator, Taman Safari Indonesia
International Studbook Keeper, Malayan Tapirs
E-mail: tamansafari@indo.net.id; amicurator@tamansafari.com

PRIATNA, DOLLY (Indonesia)
Project Co-Manager, ZSL Indonesia - c/o WCS Indonesia Program
E-mail: dolly.priatna@zsl.org

PUKAZHENTHI, BUDHAN (United States)
Ph.D. Ungulate Biologist, Smithsonian National Zoological Park
Conservation & Research Center,
E-mail: pukazhenthib@si.edu

QUSE, VIVIANA BEATRIZ (Argentina)
D.V.M. Coordinator, TSG Zoo Committee
E-mail: vivianaquse@gmail.com

RESTREPO, HECTOR FRANCISCO (Colombia)
M.Sc. Fundación Wii
E-mail: restrepof@gmail.com

RICHARD-HANSEN, CECILE (French Guiana)
Ph.D. Direction Etudes et Recherches
ONCFS - Office National de la Chasse et de la Faune Sauvage (National Hunting Wildlife Agency)
E-mail: Cecile.Richard-Hansen@ecofog.gf

RODRÍGUEZ ORTIZ, JULIANA (Colombia)
Instituto de Ciencias Naturales,
Universidad Nacional de Colombia (UNAL)
E-mail: mjuli2@gmail.com

ROJAS ALFARO, JUAN JOSÉ (Costa Rica)
Director, Zoocriadero de Dantas La Marina
E-mail: rescatela@yahoo.com; galouno@racsa.co.cr

ROMAN, JOSEPH (United States)
Curator, Virginia Zoological Park
Baird's Tapir Studbook Keeper, Association of Zoos & Aquariums (AZA) Tapir Taxon Advisory Group (TAG)
E-mail: Joseph.Roman@norfolk.gov

RUBIANO, ASTRITH (Colombia / United States)
University of Connecticut / Conservation and Research Center, Smithsonian Institution, Natural Resources Department,
E-mail: astrith.rubiano@uconn.edu; astrithrubiano@yahoo.com

RUIZ FUAMAGALLI, JOSÉ ROBERTO (Guatemala)
Professor & Researcher, Escuela de Biologia,
Universidad de San Carlos de Guatemala
E-mail: rruizf@yahoo.com

RUSSO, KELLY J. (United States)
Manager of Interactive Marketing, Web Communications Department, Houston Zoo Inc
E-mail: krusso@houstonzoo.org

SALAS, LEONARDO (United States)
Ph.D. Animal Population Biologist, Post-Doctoral Fellow, Redwood Sciences Laboratory
E-mail: leoasalas@netscape.net

SANDOVAL ARENAS, SERGIO (Colombia)
Vice-President, Tapir Preservation Fund (TPF)
E-mail: tpflatin@gmail.com

SANDOVAL CAÑAS, LUIS FERNANDO (Ecuador / Brazil)
Programa de Pós-Graduação em Ecologia e Conservação,
Universidade Federal de Mato Grosso do Sul (UFMS)
E-mail: luissandoval79@gmail.com

SARMIENTO DUEÑAS, ADRIANA MERCEDES (Colombia)
M.Sc. Ciencias, Universidad Nacional de Colombia (UNAL)
Member, IUCN/SSC Tapir Specialist Group (TSG)
E-mail: adrianasarmi@hotmail.com; adriana-s@wildmail.com

SARRIA PEREA, JAVIER ADOLFO (Colombia / Brazil)
D.V.M. M.Sc. Genetics & Animal Improvement
Departamento de Genética e Melhoramento Animal,
Universidade Estadual de São Paulo (UNESP)
E-mail: jasarrip@fcav.unesp.br, jasarrip@yahoo.com

SCHWARTZ, KARIN (United States)
M.Sc. Animal Behavior, Ph.D. Candidate, Conservation Biology,
George Mason University, FairFAX, VA, United States
Biological Database Manager, Chicago Zoological Society - Brookfield Zoo
Registrar Advisor, Association of Zoos & Aquariums (AZA) Tapir Taxon Advisory Group (TAG)
Member, IUCN/SSC Conservation Breeding Specialist Group (CBSG)
Member, IUCN/SSC Re-Introduction Specialist Group (RSG)
E-mail: karin.schwartz@czs.org

SCHWARTZ, RICHARD (United States)
President, Nashville Zoo at Grassmere
E-mail: rschwartz@nashvillezoo.org

SEITZ, STEFAN (Germany)
Ph.D. Captive Research on Tapirs: Behavior and Management,
4TAPIRS Information Centre
E-mail: tapirseitz@web.de; dr.stefan.seitz@online.de

SHEFFIELD, RICHARD (Mexico)
Curador General, Parque Zoológico de León
Miembro, Asociación de Zoológicos, Criaderos y Acuarios de México (AZCARM)
Coordinador, Programa de Recuperación de Especies del Tapir Centroamericano de AZCARM, MEXICO
E-mail: curador@zooleon.org

SHEWMAN, HELEN (United States)
Collection Manager, Woodland Park Zoo
E-mail: helen.shewman@zoo.org

SHOEMAKER, ALAN H. (United States)
Permit Advisor, Association of Zoos & Aquariums (AZA)
Tapir Taxon Advisory Group (TAG)
E-mail: sshoe@mindspring.com

SMITH, DIORENE (Republic of Panama)
D.V.M. Parque Municipal Summit
E-mail: dsmithc@gmail.com

STAHL, TIM (United States)
Owner, Stahl Photographics
E-mail: tim11@cox.net

STANCER, MICHELE (United States)
Animal Care Manager, San Diego Zoological Society
Chair, Association of Zoos & Aquariums (AZA) Tapir Taxon Advisory Group (TAG)
Malayan Tapir Studbook Keeper, Association of Zoos & Aquariums (AZA) Tapir Taxon Advisory Group (TAG)
E-mail: mstancer@sandiegozoo.org

SUÁREZ MEJÍA, JAIME ANDRÉS (Colombia)
Jardin Botanico, Universidad Tecnológica de Pereira
E-mail: suarmatta@yahoo.com; jsuarezmejia@gmail.com

TAPIA, ANDRÉS (Ecuador)
Centro Tecnológico de Recursos Amazónicos de la Organización de Pueblos Indígenas de Pastaza (OPIP) - CENTRO FÁTIMA
E-mail: centrofatima@andinanet.net; centrofati@panchonet.net

THOISY, BENOIT DE (French Guiana)
D.V.M. Ph.D. Kwata Association
E-mail: thoisy@nplus.gf; bdethoisy@pasteur-cayenne.fr

TOBLER, MATHIAS (Peru / United States)
Ph.D. Andes to Amazon Biodiversity Program,
Botanical Research Institute of Texas (BRIT)
E-mail: matobler@gmx.net

TODD, SHERYL (United States)
President, Tapir Preservation Fund (TPF)
E-mail: tapir@tapirback.com; oregontapir@yahoo.com

TORRES, NATALIA (Ecuador)
Departamento de Educación, Zoológico de Quito, Ecuador
E-mail: ntorres@quitozoo.org; naty175@yahoo.com; naty175@hotmail.com

TRAEHOLT, CARL (Malaysia)
Ph.D. Research Coordinator, Malayan Tapir Project,
Krau Wildlife Reserve, Copenhagen Zoo
E-mail: ctraeholt@pd.jaring.my

UNDERDOWN, POLLY (United Kingdom / Costa Rica)
Rafiki Safari Lodge
E-mail: pollyunderdown@yahoo.co.uk; pollyunderdown@gmail.com

VARELA, DIEGO (Argentina)
Licenciado Ciencias Biologicas, Ph.D. Graduate Student,
Universidad de Buenos Aires / Conservación Argentina
E-mail: diegomv@arnet.com.ar

VIEIRA FRAGOSO, JOSÉ MANUEL (United States)
Ph.D. Associate Professor, Botany Department,
University of Hawaii at Manoa
E-mail: fragoso@hawaii.edu

WALLACE, ROBERT B. (Bolivia)
Ph.D. Associate Conservation Ecologist,
Wildlife Conservation Society (WCS) - Madidi
E-mail: rwallace@wcs.org

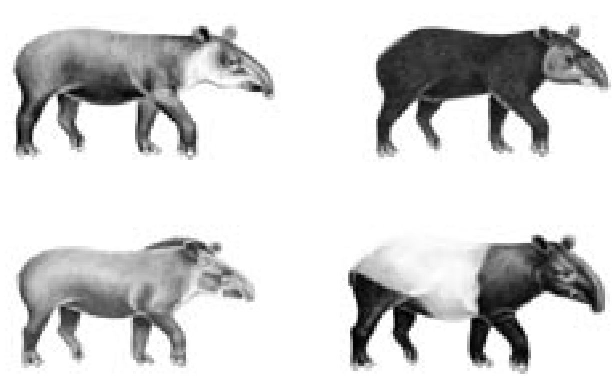
WILLIAMS, KEITH (Australia)
Ph.D. Private Consultant
E-mail: kdwilliams56@yahoo.co.uk

WOHLERS, HUMBERTO (Belize)
General Curator, Belize Zoo
E-mail: animalmgt@belizezoo.org; humbertowohlers@yahoo.com

ZAINUDDIN, ZAINAL ZAHARI (Malaysia)
Malaysian Department of Wildlife and National Parks (DWNP)
E-mail: rhinosrcc@hotmail.com; zainal@wildlife.gov.my

ZAVADA, JEANNE (United States)
Director, East Tennessee State University Natural History Museum
E-mail: zavada@etsu.edu

ZAVADA, MICHAEL (United States)
Ph.D. Professor & Chairman, Department of Biological Sciences,
East Tennessee State University
E-mail: zavadam@etsu.edu



Illustrations by Stephen Nash

INSTRUCTIONS FOR AUTHORS

Scope

The Tapir Conservation, the Newsletter of the IUCN/SSC Tapir Specialist Group aims to provide information regarding all aspects of tapir natural history. Items of news, recent events, recent publications, thesis abstracts, workshop proceedings etc concerning tapirs are welcome. Manuscripts should be submitted in MS Word (.doc, at this moment we cannot accept documents in .docx format).

The Newsletter will publish original work by:

- Scientists, wildlife biologists, park managers and other contributors on any aspect of tapir natural history including distribution, ecology, evolution, genetics, habitat, husbandry, management, policy and taxonomy.

Preference is given to material that has the potential to improve conservation management and enhances understanding of tapir conservation in its respective range countries.
The primary languages of the Newsletter are English and Spanish. Abstracts in English are preferred.

Papers and Short Communications

Full Papers (2,000-5,000 words) and Short Communications (200-2,000 words) are invited on topics relevant to the Newsletter's focus, including:

- Research on the status, ecology or behaviour of tapirs.
- Research on the status or ecology of tapir habitats, including soil composition, mineral deposits (e.g., salt licks) and topography.
- Husbandry and captive management.
- Veterinarian and genetic aspects.
- Reviews of conservation plans, policy and legislation.
- Conservation management plans for species, habitats or areas.
- Tapirs and local communities (e.g., hunting, bush meat and cultural aspects).
- Research on the ecological role of tapir, for example, seed dispersers, prey for predators and facilitators of forest regrowth.
- Natural history and taxonomy of tapirs (e.g., evolution, palaeontology and extinction).

How to Submit a Manuscript

Manuscripts should be submitted in ***electronic format*** by e-mail to the contributions editor at the email provided. Hard copies will not be accepted.
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Carl Traeholt
e-mail: ctraeholt@pd.jaring.my

In the covering e-mail, the Lead Author must confirm that:

a) the submitted manuscript has not been published elsewhere,
b) all of the authors have read the submitted manuscript and agreed to its submission,
all research was conducted with the necessary approval and permit from the appropriate authorities and adhere to appropriate animal manipulation guides.

Review and Editing

All contributors are strongly advised to ensure that their spelling and grammar is checked by native English or Spanish speaker(s) before the manuscript is submitted to the Contributions Editor. The Editorial Team reserves the right to reject manuscripts that are poorly written.

All manuscripts will be subject to peer review by a minimum of two reviewers. Authors are welcome to suggest appropriate reviewers; however, the Contributions Editor reserves the right to appoint reviewers that seem appropriate and competent for the task.

Proofs will be sent to authors as a portable document format (PDF) file attached to an e-mail note. Corrected proofs should be returned to the Editor within 3 days of receipt. Minor corrections can be communicated by e-mail.

The Editorial Team welcomes contributions to the other sections of the Newsletter:

News

Concise reports (<300 words) on news of general interest to tapir research and conservation. This may include announcements of new initiatives; for example, the launch of new projects, conferences, funding opportunities, new relevant publications and discoveries.

Letters to the Editor

Informative contributions (<650 words) in response to material published in the Newsletter.

Preparation of Manuscripts

Contributions in English should make use of UK English spelling [if in doubt, Microsoft Word and similar software can be set to check spelling and grammar for "English (UK)" language]. The cover page should contain the title and full mailing address, e-mail address and address of the Lead Author and all additional authors. All pages should be numbered consecutively, and the order of the sections of the manuscript should be: cover page, main text, acknowledgement, tables, figures and plates.

Title

This should be a succinct description of the work, in no more than 20 words.

Abstract

Full Papers only. This should describe, in 100-200 words, the aims, methods, major findings and conclusions. It should be informative and

INSTRUCTIONS FOR AUTHORS

intelligible without reference to the text, and should not contain any references or undefined abbreviations.

Keywords
Up to five pertinent words, in alphabetical order.

Format
For ease of layout, please submit all manuscripts with a minimum of formatting (e.g. avoid specific formats for headings etc); however, the following is needed:

- Manuscripts should be double-spaced.
- Submissions can be in 'doc, 'rtf' or 'wpd' format, preferably as one file attached to one covering email.
- **Avoid** writing headlines in CAPITAL letters.
- Font type and size should be Times New Roman # 12
- Font type for tables should be Arial and 0.5 dot lines.
- 1 inch (2.54 cm) margins for all margins
- Number pages consecutively starting with the title page , numbers should be on the bottom right hand corner
- Font type for tables should be Arial and 0.5 dot lines.
- Pictures and illustrations should be in as high resolution as possible to allow for proper downscaling and submitted as separate files in EPS or JPG format.

References
References should be cited in the text as, for example, MacArthur & Wilson (1967) or (Foerster, 1998). For three or more authors use the first author's surname followed by *et al.*; for example, Herrera *et al.* (1999). Multiple references should be in *chronological order*. The reference list should be in *alphabetical order*, and article titles and the titles of serial publications should be given in full. In cases where an author is referenced multiple times the most recent publication should be listed first. Please check that all listed references are used in the text and vice versa. The following are examples of house style:

Journal Article
Herrera, J.C., Taber, A., Wallace, R.B. & Painter, L. 1999. Lowland tapir (*Tapirus terrestris*) behavioural ecology in a southern Amazonian tropical forest. Vida Silv. Tropicale 8:31-37.

Chapter in Book
Janssen, D.L., Rideout, B.A. & Edwards, M.S. 1999. Tapir Medicine. In: M.E. Fowler & R. E. Miller (eds.) Zoo and Wild Animal Medicine, pp.562-568. W.B. Saunders Co., Philadelphia, USA.

Book
MacArthur, R.H. & Wilson, E.O. (1967) *The Theory of Island Biogeography*. Princeton University Press, Princeton, USA.

Thesis/Dissertation
Foerster. C.R. 1998. Ambito de Hogar, Patron de Movimentso y Dieta de la Danta Centroamericana (Tapirus bairdii) en el Parque Nacional Corcovado, Costa Rica. M.S. thesis. Universidad Nacional, Heredia, Costa Rica.

Report
Santiapilli, C. & Ramono, W.S. 1989. The Status and Conservation of the Malayan tapir (Tapirus indicus) in Sumatra, Indonesia. Unpublished Report, Worldwide Fund for Nature, Bogor, Indonesia.

Web
IUCN (2007) *2007 IUCN Red List of Threatened Species*. Http://www.redlist.org [accessed 1 May 2009].

Tables, figures and plates
These should be self-explanatory, each on a separate page and with an appropriate caption. Figures should be in black and white. Plates will only be included in an article if they form part of evidence that is integral to the subject studied (e.g., a camera-trap photograph of a rare situation), if they are of good quality, and if they do not need to be printed in colour.

Species names
The first time a species is mentioned, its scientific name should follow without intervening punctuation: e.g., Malay tapir *Tapirus indicus*. English names should be in lower case throughout except where they incorporate a proper name (e.g., Asian elephant, Malay tapir).

Abbreviations
Full expansion should be given at first mention in the text.

Units of measurement
Use metric units only for measurements of area, mass, height, distance etc.

Copyright
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