CONTRIBUTIONS

Iridium/GPS Telemetry to Study Home Range and Population Density of Mountain Tapirs in the Rio Papallacta Watershed, Ecuador

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Abstract

Mountain tapirs are one of the least studied of the large mammals. It wasn't until the 1990's that the first radio telemetry studies were done on the species and huge gaps still exist in the literature regarding mountain tapir population dynamics. In light of recent technological advances in telemetry equipment, it was decided to execute the current study in order to obtain a clearer picture of mountain tapir population ecology. Between June 2012 and February 2013 two female and four male mountain tapirs were captured and equipped with Iridium/GPS collars. The collars recorded between 92 and 278 days of data resulting in 132 to 324 locations. Mean home ranges were estimated using four different methods: minimum convex polygon (MCP), 648 hectares (ha); Kernel 95% and 50%, 397 and 32 ha; nearest-neighbor convex hull (k-NNCH), 310 ha; Brownian bridge movement model (BBMM), 686 ha. Tapir population density was estimated by extrapolating mean tapir home range size (Kernel 95% and k-NNCH) to the size of the study area (25400 ha), both considering and disregarding home range overlap. Using Kernel, a population density of one individual/357 ha and one individual/245 ha was calculated. Using the k-NNCH method densities of one individual/325 ha and one individual/307 ha were calculated.

Keywords: Home range, Iridium/GPS collars, Mountain Tapir, Population Density

Introduction

The mountain tapir (*Tapirus pinchaque*) is one of the least known of any species of large mammal (Thornback & Jenkins, 1982). Its small extant population of no more than three thousand individuals is thinly spread throughout the Andean cordillera between Northern Peru and Central Colombia, and its restricted geographic distribution has led the species to the brink of extinction (Ashley *et al.*, 1996; Tapia *et al.*, 2011).

It is likely the species is naturally rare. However, the populations have been made even smaller through fragmentation and habitat loss caused by agricultural and livestock expansion. As a result, the International Union for Conservation of Nature (IUCN) has listed this species as endangered (EN) throughout its entire range (2009) and critically endangered (CR) in the Red Book of Mammals of Ecuador (Tapia *et al.*, 2011). The species is also included in Appendix I of the Convention on the International Trade of Endangered Species (CITES, 2013).

Between 1966 and 1971, Ecuador went through a peak period of wildlife trafficking. This peak was driven by high demand from European and American zoos for new specimens (Strummer, 1971). During this period, one of the more sought after species was the Mountain Tapir. Groups of Ecuadorians and foreigners alike attempted their capture mainly in the El Placer and Papallacta regions of the Ecuadorian highlands, which are today part of the Sangay and Cayambe Coca National Parks, respectively. Mountain tapir capture and transit are extremely delicate processes, often leading to fatalities due to post-capture myopathy and difficulties in adjusting to captive diets (Wilson & Wilson 1973). Padilla *et al* (2010) reported that between 1967 and 1968 100 mountain tapirs died while being captured by animal traders working for American zoos. Almost certainly more specimens died during transport to the United States.

During this period the most important publication about the mountain tapir was written by Schauenberg (1969), who studied captive specimens and produced a literature review about the species. Downer (1996) described his pioneering work with radio-telemetry in mountain tapirs that began in 1991, outlining some of the first ecological data regarding wild mountain tapirs, and forming the basis for subsequent mountain tapir studies. Castellanos (1994), for instance, used radio telemetry devices to monitor a sub-adult female mountain tapir within the protected cloud forest reserve of Pasochoa.

Mountain tapir ecology studies slowly progressed and between 1998 and 2005, Lizcano & Cavelier (2004) captured and collared two mountain tapirs in Colombia. Both were fitted with GPS collars using the same capture method as Downer (1991) and Castellanos (1994). The study of Lizcano & Cavelier (2004) was the first to use tranquilizer darts for immobilizing wild mountain tapirs in the wild.

In this study, we aimed to quantify tapir home-range size in the Cayambe Coca National Park, and report preliminary estimates of mountain tapir population density. To achieve our goal, we deployed Iridium/GPS satellite telemetry collars on six tapirs within the park. Up until the present day, no Iridium/GPS telemetry studies have been reported on any of the three American tapir species. We document preliminary results using such equipment to monitor mountain tapirs in their natural environment, and discuss the value of GPS technology in studying mountain tapir ecology. The study was part of the Mountain Tapir Conservation Program initiated by EcoCiencia, Fundación Zoológica and IUCN/SSC Tapir Specialist Group/Ecuador, and was financed by the EcoFondo. The study continues to the present day through the Andean Bear and Tapir project and is funded by the Andean Bear Foundation. The entire investigation has been carried out with the full support of the Ecuadorian Ministry of Environment.

Material and Methods

Study Area

The current study was carried out on the eastern slopes of the Ecuadorian Andes, in the Rio Papallacta watershed in the Cayambe Coca National Park, Quijos County, Napo province. Also found in this region is the internationally important Ñucanchi Turubamba Wetland System, classified as a RAMSAR site due to its biological, cultural and hydrological importance. The site is of glacial origin, being formed at the time of the last ice age (around 10,000 years ago), and covers an area of approximately 25.4 km^2 (25,400 hectares) spanning upper montane forest and paramo habitats (Sierra, 1999), ranging from 3,500 to 4,000 masl. The Ñucanchi Turubamba is a unique formation of ecosystems, and is home to a wide diversity of species, many of which are endangered and endemic, including birds such as the Andean Condor (*Vultur gryphus*), the Grey-breasted Mountain Toucan (*Andigena hypoglauca*), and the Torrent Duck (*Merganetta armata*). Endangered and endemic mammal species include the Andean bear (*Tremarctos ornatus*), pampas cat (*Felis colocolo*), the puma (*Puma concolor*) and the pudu (*Pudu mephistophiles*) amongst others.

Despite a recent increase in abrupt weather patterns leading to more unpredictable climatic conditions, the study area exhibits relatively stable seasonal weather patterns. From June to August there is a very short wet period where rainfall is constant and often torrential. Between February and May there is another wet period with moderate rainfall, and between September and January exists a dry season with little rainfall.

The study area is bisected by the busy Inter Oceanica highway that connects the Ecuadorian Andes to the Amazon region, and a network of minor dirt tracks mainly used by the Municipal Potable Water Company of Quito, sport fishermen and tourists visiting the Papallacta, Baños, Loreto and Mogotes Lagoons, and trails encircling the Sucus and Parca Cocha Lagoons.

Tapir captures

Six adult mountain tapirs were captured (one of the six was recaptured at a later date) using the pursuit techniques successfully implemented by various investigators in Ecuador and Colombia (Downer, 1996; Castellanos, 1994; Lizcano & Cavelier, 2004). However I adapted another approach, incorporating the techniques proposed by Castellanos & Tapia (2010), and implemented a contingency plan designed by Castellanos *et al*. (2011) which consisted of security and safety protocols for the capture and management of tapirs.

Anesthesia of the animals was under the supervision of Ecuadorian veterinarians. Each captured tapir was immobilized using darts launched from a plastic tube, or from an air pistol (Daninject, USA). The tapirs were immobilized using a mixture of xylazine hydrochloride (0.4 mg /kg, AnaSed®, Lloyd, Shenandoah, Iowa,USA) and butorphanol tartrate (0.2 mg/kg, Turbogesic®, Fort Dodge, Iowa, USA). Once the animal was recumbent, ketamine hydrochloride (0.7 mg/kg, Ketamine HCL, Bioniche Teo, Galway, Ireland) was intramuscularly administered to maintain anesthesia as needed. Yohimbine hydrochloride (0.14 mg/kg, Yohimbine Vet, Holliday-Scott S.A., Buenos Aires, Argentina) was intramuscularly administered as a reversing agent.

Morphological measurements of immobilized tapirs were recorded, and specimen weight and age was estimated based on the experience of the local guides. Blood samples were taken for genetic, hematology and serum biochemical analysis, and to inspect for hemoparasites. All samples were immediately placed in a cooler at 10ºC, and were transported to LIVEX laboratories, (Quito, Ecuador) for processing within 24 hrs. Samples that showed signs of hemolysis were

Table 1. Basic data on and tracking duration from six Mountain tapirs captured in the Rio Papallacta watershed, Cayambe Coca National Park.

Animal ID	Sex	Estimated age (years)	Estimated Weight (Kg)	Start Date	End Date
Panchita	Female	8	220	8/22/2011	10/24/2011
Marisol	Female	5	200	8/26/2011	6/18/2011
Melchor	Male	15	180	8/29/2011	12/13/2011
Dante	Male	5	150	9/27/2011	5/18/2012
Juanito	Male	2	130	9/28/2011	1/27/2012
Panchita[2]	Female	10	240	1/28/2013	n/a
Meshi	Male	6	180	2/6/2013	2/23/2013

Start date indicates the capture data.End date indicates the date the collar stopped collecting data.

[2]Recapture of previously collared tapir

not considered for analysis. Captured tapirs were fitted with Iridium/GPS collars (G2110E model, Advanced Telemetry Solutions, AT, USA) and monitored from a safe distance until they recovered.

The satellite collars used in this study weighed 0.825 kg, which is less than 0.5% of the weight of an adult mountain tapir. Each collar had a VHF transmitter, an activity sensor, an environmental temperature sensor, and a drop-off mechanism to be activated once the collar's main battery runs out. Collars were programmed to take eight daily positional readings for a period of 18 months. Data points were sent via an ATS server to my email account.

The quality and quantity of data points were variable, depending on climatic and physical conditions like cloud cover, vegetation density and satellite position and angle. Only GPS points taken from a minimum of 3 satellites and with a margin of error < 30m were considered for analysis. For home range analysis, I only included two daily GPS locations at 12-hour intervals to reduce temporal autocorrelation.

Home-range and population density analysis

Using the GPS localizations, home ranges were calculated using four different estimation models: (1) Minimum convex polygon 100% (MCP), (2) Kernel 95%, 50%, (3) nearest-neighbor convex hull (k-NNCH), (4) Brownian bridge movement model 95% with a 100 m grid cell size (BBMM) (Mohr 1947, Seaman & Powel, 1996; Getz & Wilmers, 2004; Horne *et al.*, 2007).

ArcView GIS 3.2 (Environmental Systems Research Institute, ESRI, Redlands, CA, USA) software was used for home range estimations. The Animal Movement Extension (Hooge *et al.*, 1999) was used to calculate MCP and Kernel, and the local convex hull extension was used to calculate k-NNCH (Getz & Wilmers, 2004). ArcGis 9 and the ArcGis extension Hawths tool 3.6 (ESRI, 2008) and R program (2008) were used to estimate BBMM.

To estimate mountain tapir population density, I used the analytical methods used by Medici (2010) for *Tapirus terrestris* populations, based on home range size. These methods are described as following:

a.) Tapir population was estimated by extrapolating mean tapir home range size obtained by both Kernel 95% and k-NNCH to the area of 25, 400 ha of Páramo. The density estimates obtained through this method did not consider home range overlap.

b.) Tapir population was estimated by subtracting mean home range overlap (k-NNCH and Kernel 95%) from mean tapir home range size (k-NNCH and Kernel 95%). The value obtained was then extrapolated to the area of 25,400 ha of Páramo in the Papallacta River watershed to obtain a density estimate.

Results

In the current study six mountain tapirs of different ages were captured and fitted with Iridium/GPS collars. During the first capture phase (between June and September 2010), three males (Melchor, Dante and Juanito) and two females (Panchita and Marisol) were captured and collared. One tapir captured in this phase suffered a serious yet not fatal accident during anesthesia (2/6/2010). During the second capture phase (between January and February 2013) we recaptured the female tapir Panchita, and also captured a new male named Meshi (Table 1).

Although the Iridium/ GPS collars were programmed to take data points for a period of 18 months, many had much shorter life times. The collar with the shortest life spans stopped transmitting after just 17 days. The rest of the collars endured significantly longer time periods of 92, 106, 259, and 278 days (Table 1). The collar of the recaptured female, Panchita, continued to send data 369 days after collar deployment.

Home range size varied widely between individuals and estimation method. Using the k-NNCH estimator, home ranges were between 71 and 653 hectares (ha), with a mean area of 310 ha. Using the 95% Kernel method, the home ranges were estimated to be between 62 and 916 ha with a mean of 397 ha. Using the 50% Kernel method, home ranges were estimated to be between 9 and 67 ha with a mean of 32 ha. Using the BBMM method, home ranges were estimated to be between 201 and 1150 ha, reaching a mean of 686; the highest estimate across all the calculation methods. Finally, using the MCP method, home range estimations were greater, being between 125 and 1813 ha with a mean home range of 648 ha (Table 2). Four of the five tapirs monitored in this study showed home range overlap indicating significant intraspecific tolerance. (Fig 1).

Using the k-NNCH to estimate population density in the study area, a density of one individual per 325 ha was estimated without considering range overlap. Taking into account home range overlap a population density of one individual per 307 hectares was calculated.

Using the Kernel method, population density was estimated as one tapir for every 357 ha discarding home range overlap, whilst taking into account home range overlap the population density was estimated as one tapir per 245 ha.

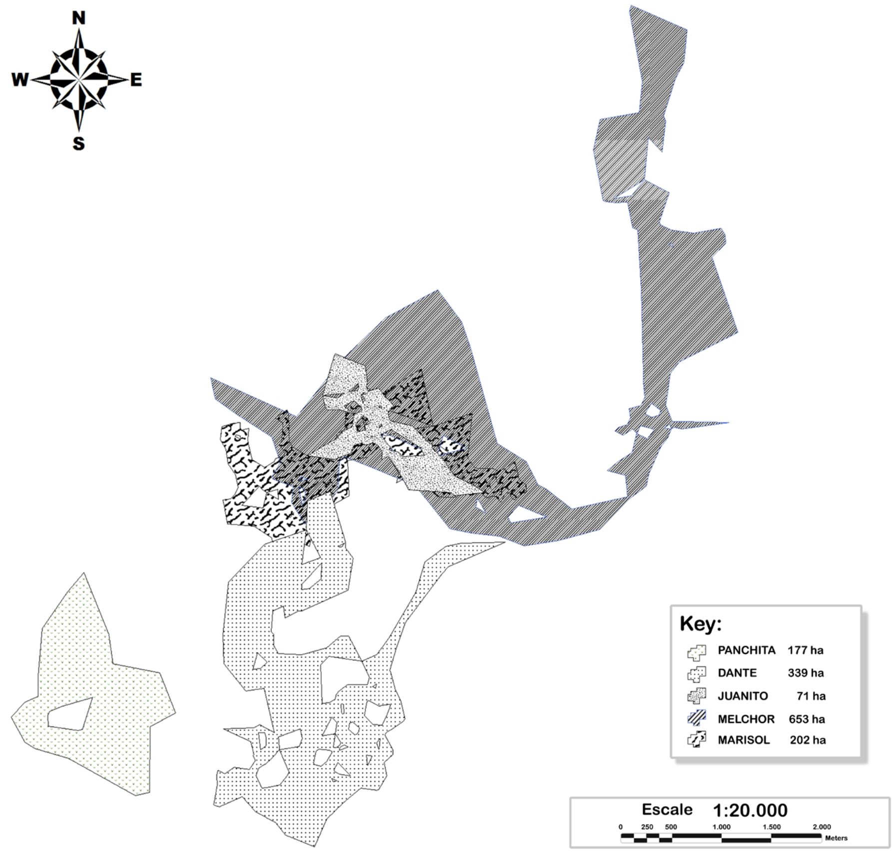

Figure 1. Home range nearest neighbor convex hull (k-NNCH) of five mountain tapir (two female and three male), in the Rio Papallacta watershed, Cayambe Coca National Park, Ecuador. Each different style of polygon represents an individual tapir.

Table 2. Estimates of home range size for five mountain tapirs in the Rio Papallacta watershed, Cayambe Coca National Park, Ecuador.

Animal ID	GPS Locations	Tracking time (days)	Home Range				
			k-NNCH	Kernel 95%	Kernel 50%	BBMM	MCP 100%
Melchor	173	106	653	916	48	1150	1813
Dante	278	259	339	437	67	632	678
Juanito	136	151	71	62	9	395	125
Panchita	132	92	177	173	25	201	225
Marisol	324	278	202	222	11	569	400
Mean			310	397	32	686	648

Discussion

The first tapir trapped in June 2012 suffered an accident whilst recuperating from anesthesia. Still under the influence of the anesthetic she fell into a lagoon and the team acted hastily to rescue her. Showing no vital signs, we initially believed she had drowned, however hours later she regained consciousness. The individual had undergone an acute form of 'diving reflex' exhibited by all mammals during prolonged periods with the head submerged in cold water. After this incident we decided to create a Contingency and Safety Protocol for Animal Management and Capture (Castellanos *et al.*, 2011), which was tested successfully in the following seven tapir capture events that transpired without accidents or problems.

The Iridium/ GPS collars manufactured by Advanced Telemetry Solutions (USA) failed to send GPS localizations as they had been programmed. The intense humidity of the study area caused severe corrosion of the GPS antenna and other electronic components leading to premature malfunctioning of the apparatus. Nonetheless the collars succeeded in sending sufficient information to obtain more accurate data than those reported by Downer (1996) and Lizcano & Cavelier (2004).

Although no sexual dimorphism is exhibited by this species, the body mass estimated for the tapirs in this study correspond to the observations of Barongi (1986) and Medici *et al.* (2007) in that female mountain tapirs are heavier than males.

I considered k-NNCH analysis the best method for delineating areas inhabited and traversed by mountain tapirs in landscapes with deep ravines, lagoons and enormous rock faces such as those across the study area. In contrast to the MCP method it doesn't take into account areas not used by tapirs such as flat plains, large open pastures and villages.

In this study, mean home range estimates using Kernel 95% and 50% were calculated to be 397 and 32 ha. These estimates are slightly larger than the 260 and 60 ha reported by Lizcano & Cavalier (2004) who monitored one male and one female tapir over a period of 6 months using GPS telemetry. Downer (1996) reported a mean home range estimate of 880 ha in his radio telemetry study of mountain tapirs in which he used the MCP estimator to calculate home ranges. Using the same MCP method Lizcano & Cavalier (2004) obtained a home range estimate of just 350 ha. The home range estimate determined from the present study using the MCP estimation tool (686 ha) was within the values reported in those studies. This variation can be explained by the diverse levels of habitat conservation and threats that exist in the different study areas. These factors in turn influence the carrying capacities of such areas and hence account for different home range sizes between tapir populations spanning the species distribution range (Medici, 2010). The current study area, though it is within a national park, is intersected by a series of dirt tracks and trails that may be influencing home range sizes of the native tapir population, possibly even to the extent of defining the areas in which the tapirs inhabit. There are areas where there are lots of evidence of tapir presence, and there are also areas where no evidence of tapir presence is found, as if there were vast stretches unoccupied by tapirs in this type of paramo.

The elderly male tapir, Melchor, exhibited a larger home range size in comparison to those of the females. This may be related to aspects of social organization and mating system. It is predicted that a single male can mate with several females, without any restriction in the number of females per male. As a consequence, home ranges of male tapirs may incorporate larger areas so that they overlap with the home ranges of two or more females (Medici, 2010).

Population density data obtained from this study using the k-NNCH method (One Individual (I) /325 ha, I/307 ha), and the Kernel method (I /357 ha, I / 245 ha) are similar to those observed in mountain tapir studies carried out in Colombia by Acosta *et al* (1996); I / 400 ha, and by Lizcano & Cavelier (2000); I / 551 ha. In the Sangay National Park on south Ecuador, Downer (1996) obtained a population density of I / 587 ha. Contrasting to all other estimates, Urgiles *et al.* (2013) reported a population density of 1.09 individuals/10000 ha in a study using camera traps in the Oyacachi region, which is adjacent to the current study area. There are numerous variables that may explain discrepancies and variation in population density estimations, among these are the differences in environments and habitat types, as well as the different levels of habitat conservation, which in turn reflects different carrying capacities in different habitats found within the species' distribution range. The variation can also be attributed to the different methods used to estimate density, the timeframe of monitoring, and the number of individuals monitored (Medici, 2010).

The MCP home range estimator (Mohr, 1947) was not used to calculate population densities as the study area included sections where the tapirs did not traverse. For example the tapirs in this study completely avoided large open plains where livestock were grazing, where they could potentially have been easy prey for predatory animals. Mountain tapirs predominantly use steep slopes often close to forested areas where they can escape more easily from potential attacks.

Castellanos (2011) encountered similar difficulties using the MCP method to estimate home ranges of the Andean Bear (*Tremarctos ornatus*), where the bears were avoiding populated and agricultural areas in a fragmented cloud forest habitat. To avoid the problem of providing inaccurate home range models in this instance I reverted to use the Kernel and k-NNCH methods to analyses the data. The BBMM method could potentially be a better estimation tool for determining mountain tapir home ranges, however it is relatively new and requires more testing on large Andean mammals.

The use of satellite collars in this study allowed us to establish that mountain tapirs of different ages and sexes in the Cayambe Coca National Park spend most of their time in the Páramo high grassland habitat, occasionally entering *Polylepis* forest patches to browse and seek refuge. Although the study animals moved very close to the upper montane forest, there were no GPS localizations registered in this habitat type. This observation contradicts the hypothesis that mountain tapirs carry out large altitudinal migrations (Stummer, 1971; Acosta *et al.*, 1996; Lizcano & Cavalier, 2000) and supports the observation of Castellanos (1994) of no altitudinal movement of tapirs in the Sangay National Park.

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