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ORIGINAL ARTICLE

Ecology and local knowledge of the Baird's tapir (*Tapirella bairdii*) in the Sierra Madre de Oaxaca, Mexico

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Abstract

As well as being of global cultural importance (from local tribal folklore to being an iconic species for conservation), the tapir plays an important role in its ecosystem as a herbivore and seed disperser. However, the ecology and ethnozoology of the endangered Baird's tapir in the north of Oaxaca, Mexico is poorly understood. We used camera traps to estimate its relative abundance and density and to describe the activity patterns of the northernmost population of Baird's tapir in the Sierra Madre de Oaxaca. Local knowledge concerning the tapir was also documented, along with the conservation strategies undertaken by the 2 indigenous communities that own the land where the study site is located. Only adult tapirs were photographed, and these were active 14 h per day, but were mainly nocturnal and crepuscular. The estimated relative abundance (12.99 ± 2.24 events/1000 camera days) and density values (0.07–0.24 individuals/km^2) were both similar to those found in another site in Mexico located within a protected area. Semi-structured interviews revealed that people have a basic understanding of the eating habits, activity and main predators of the tapir. There were reports of hunting, although not among those respondents who regularly consume bush meat. Thus, the relative abundance and density estimates of tapir at the study site could be related to the favorable condition of the forest and the absence of hunting and consumption of tapir meat. Fortunately, the local people are conducting initiatives promoting the conservation of this ungulate and its habitat that combine to constitute a regional trend of habitat and wildlife protection.

Key words: camera-trapping, density estimation, random encounter model, tapir conservation

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INTRODUCTION

The family *Tapiridae* (Mammalia: Tapiridae) is represented in America by 3 living species: *Tapirus pinchaque* (Roulin, 1829) in the montane forests and *paramos* of the Andes in Peru, Ecuador and Colombia (Padilla *et al*. 2010); *Tapirus terrestris* (Linnaeus, 1758) in the tropical forests of the lowlands east of the cordillera of the Andes, and in northern and central South America to the north of Argentina; and *Tapirella bairdii* (Gill, 1865) in the tropical forests of southern Mexico to Central America, Colombia and Ecuador (Grubb 2005; Naranjo 2009; Groves & Grubb 2011).

Given their body size, local inhabitants in many regions in their distribution range regularly hunt these ungulates as bush meat (Lizcano & Cavelier 2000a; Naranjo & Bodmer 2002; Townsend 2002; Koster 2006; Carbonell & Torrealba 2007; Naranjo 2009) and less frequently to use their body parts as adornments or for medicinal purposes (Naveda-Rodríguez & López 2006). At present, they are categorized as vulnerable (*T. terrestris*) or endangered (*T. bairdii* and *T. pinchaque*) (IUCN 2015), because they present low rates of reproduction, are susceptible to hunting and are exposed to the loss and fragmentation of their habitat. Their absence in ecosystems can have repercussions on vegetation dynamics (Mendoza & Dirzo 2007; Wright *et al*. 2007). Their herbivorous and frugivorous habits help to regulate the growth of plants (Tobler 2002), and they can act as effective seed dispersers (Fragoso 1997; Fragoso & Huffman 2000; Downer 2001; Galetti *et al*. 2001; O'Farrill *et al*. 2006; Talamoni & Assis 2009; O'Farrill *et al*. 2012; Capece *et al*. 2013).

Baird's tapir (*T. bairdii*) currently has the most northern distribution of the family in the Americas, and its range was once continuous from the coastal plains of central Mexico to northern Ecuador (March & Naranjo 2005). At present, populations are maintained in conserved areas and areas with low human presence in Mexico, Belize, Guatemala, Honduras, Costa Rica and Panama (Matola *et al*. 1997; Tobler 2002; Naranjo 2009). In Mexico, the known distribution areas of the tapir are found on the Yucatán Peninsula (Sian Ka'an and Calakmul), the state of Chiapas (El Ocote Biosphere Reserve, Selva Lacandona and the Sierra Madre de Chiapas) and, in the state of Oaxaca in the coastal region (Chacahua), the region of the Tehuantepec isthmus (Los Chimalapas) (Lira-Torres *et al*. 2006, 2014) and recently in the Sierra Madre de Oaxaca (Villa Alta and the Sierra Mixe) (Lavariega *et al*. 2013; Botello *et al*. 2014). The population of Sierra Madre de Oaxaca (SMO), the northernmost in it distribution, was estimated by extrapolation in the range of between 16 and 71 tapirs (Lira-Torres *et al.* 2006; Naranjo 2009), but these numbers should be confirmed with field observations as in this study. In other sites it has been observed that abundance of tapirs is low in sites with high pressure from hunting or high disturbance (Matola *et al*. 1997; Naranjo & Bodmer 2002; Tobler 2002; Noss *et al*. 2003; Naranjo 2009; Tejeda-Cruz *et al*. 2009), while activity patterns are determined by climatic conditions associated with presence of disturbance (Foerster & Vaughan 2002; Restrepo & Betancourt 2006).

In Oaxaca, especially in the SMO, there are numerous voluntary biodiversity conservation initiatives conducted by local indigenous communities. These include the establishment of formally recognized community conservation initiatives known as "voluntary conservation areas" (Martin *et al*. 2010; Durán *et al*. 2012). A payment for hydrological services program combined with emerging conservation attitudes on the part of community leaders are 2 of the motives behind the adoption of these local conservation initiatives (Bray *et al*. 2012). While these factors are central to regional conservation, further biological and social data are still needed to direct and consolidate efforts directed towards the care and monitoring of threatened species, including Baird's tapir (Downer 1996; Van Holt *et al*. 2010; Cozzoul *et al*. 2014). Because there is little knowledge about the ecology and conservation of the population of Baird's tapir in the SMO the objective of the present study was therefore to determine the relative abundance, density and patterns of activity of the population of Baird's tapir in the SMO and to integrate the knowledge and perception of the conservation of this species held by the local inhabitants.

MATERIALS AND METHODS

Study area and local human population

The study area was approximately 60 km^2 (17°27′–17°32′N and 96°06′–96°16′ W), located in the SMO, Mexico (Ortiz *et al.* 2014; Fig. 1). The elevation varied from a low of 200-m a.s.l. in the north and a high of 2400-m a.s.l. in the south. The main climate types are warm humid and semi-warm humid, with mean annual precipitation between 3800 and 4000 mm (Trejo 2004; Lavariega *et al.* 2012). The main vegetation types in the region are coniferous forest, montane cloud forest and tropical evergreen broad-leaf forest (Torres-Colín 2004).

The study area was located in a remote rural region with low population density where common property land tenure prevails (Bray 2012). Specifically, our study was made in 2 contiguous Zapotec indigenous communities: Santiago Camotlán (792 inhabitants; 20.93 km^2) and Santa Catarina Yetzelalag (391 inhabitants; 43.74

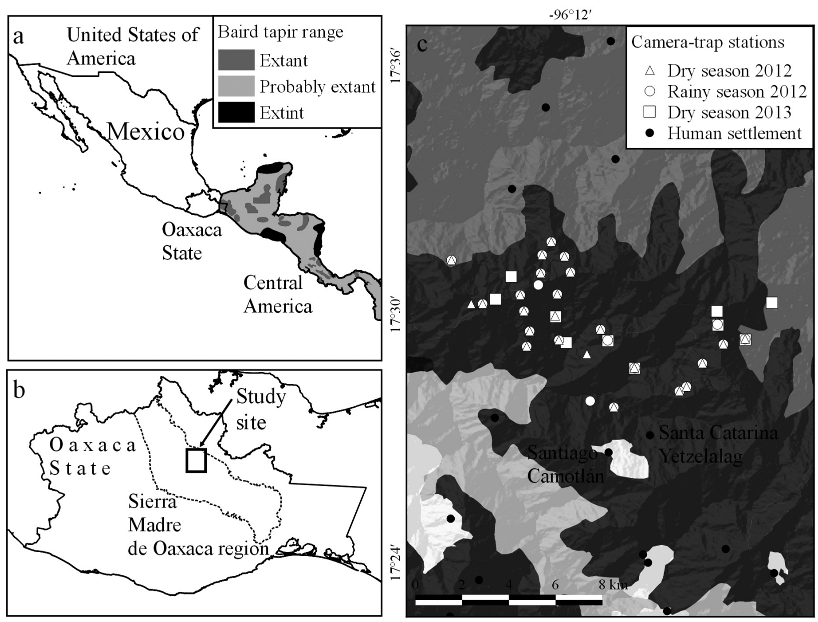

Figure 1 (a) Range of Baird's tapir (Castellanos *et al*. 2008); (b) location of the study area in the region of the Sierra Madre de Oaxaca, Mexico; and (c) location of the camera traps in the study area. Type of vegetation: light grey, tropical evergreen broad-leaf forest; light grey and dots, coniferous forest; dark gray, montane cloud forest.

km^2), both with a high degree of socioeconomic marginalization (CONAPO 2012). Traditional agriculture was the main economic activity, followed by extensive and semi-intensive livestock production (Lavariega *et al.* 2012). In both indigenous communities, local governance for land uses, forest management, and decision such as the recent banning of wildlife hunting is based on assembly agreements.

The study was part of a longer-term and broader research project (Lavariega *et al*. 2012; Lavariega 2013). The focus of this document is on wildlife mammals in general, and the local knowledge, perception and conservation initiatives in the SMO region.

Data collection

The sampling design is the same as that used to estimate the abundance of jaguars ([*Panthera onca* (Linnaeus, 1758)], pumas [*Puma concolor* (Linnaeus, 1771)] and their prey [Silver *et al*. 2004; Harmsen *et al*. 2010]), and consisted of setting 23 *Cuddeback* camera traps (18 model *Capture*; 5 model *Expert*). Both of these camera models utilize movement and heat sensors. The camera traps were set from March to October 2012 and from January to June 2013. Three periods each of 70 days were used to estimate the relative abundance and density of Baird's tapir: (i) dry season, 18 March to 26 May 2012, with 22 stations and 1384 trap-days; (ii) rainy season, 1 June to 9 August 2012, with 19 stations and 1251 trap-days; (iii) dry season, 21 January to 31 March 2013, with 10 stations and 580 trap-days. Sampling was conducted in areas recognized in the field as montane cloud forest, at between 800 and 1900-m a.s.l. (Fig. 1c).

With the help of topographic maps and a global positioning system (GPS [Garmin model 76]), sampling stations were established at distances of 1 to 3 km apart, depending on the physical characteristics of the site (e.g. slope and plant cover) and the probable passage of animals (paths, water bodies and places suggested by local guides). In each station, a camera trap was set at a height of between 30 and 50 cm above ground level. The camera traps were programmed to be active 24 h per day, with the shortest allowable time interval between photographs (30 and 60 s for the *Capture* and *Expert* models, respectively). All photos taken included a date stamp, geographic coordinates and elevation data. The stations were visited every 45 days to change the batteries, download the images or, in certain cases, to change damaged camera traps.

Information from the stations and the photo-captures of tapirs was compiled in a database with information regarding the time and date and, where possible, the age and sex of the animal. The functioning of each camera (start and finish of operation) was recorded.

Relative abundance, density and activity

For analyses we used only independent photo-capture events, defined according to one of the following criteria: (i) consecutive photographs of different individuals; (ii) consecutive photographs of individuals of the same species separated by more than 24 h; or (iii) nonconsecutive photographs of individuals of the same species (Monroy-Vilchis *et al.* 2011). Relative abundance data were obtained using the coefficient of the number of independent photo-capture events and the sampling effort (measured as the number of days on which the cameras were active), multiplied by 1000. Density was estimated with the equation proposed by Rowcliffe *et al*. (2008) for species that do not present markings unique to each individual. The variables of distance and angle of detection of the camera were determined in the field by repeatedly passing in front of the camera at different distances and speeds (Rowcliffe *et al*. 2008). There is no published information regarding the mean displacement speed of the Baird's tapir, so instead we used that of the mountain tapir (0.6 km/h: Lizcano & Cavelier 2004; Carbajal-Borges *et al*. 2014). Due to the fact that there was variation in the angle and distance of detection of the cameras, density was calculated using a range of 18 to 21° in the angle and 9 to 11 m in the distance of detection. In the same manner, different displacement speeds (0.5–0.7 km/h) were tested; these were multiplied by the 14 h of daily activity typical of the Baird's tapir observed in the study zone. For comparison, tests were conducted using the parameters of displacement used by Carbajal-Borges *et al*. (2014) in the montane cloud forest of El Triunfo Biosphere Reserve, Chiapas, in Mexico. Special attention was given to the quantification of the days in which the cameras were active, eliminating those days where the cameras ceased to function due to draining of the batteries (Rowcliffe *et al*. 2008).

Activity pattern was obtained to quantify the frequency of the photo-captures in every type: diurnal (0631–1700 hours), nocturnal (1831–0500 hours), crepuscular (1701–1830 hours and 0501–0630 hours) and cathemeral (potentially activity during both day and night) (Weckel *et al*. 2006).

A χ^2-test was used to test the levels of significance of the number of independent photo-capture events among seasons and to determine independence among the hours of tapir activity. Comparisons made with a Kruskal–Wallis test (H) were used to determine the variation in the relative abundance and density of the Baird's tapir among seasons. Activity pattern was analyzed with a rhythm analysis performed with Chronos-Fit (Zuther *et al*. 2009). Rhythm analysis fits each harmonic separately and checks the significance by F-test for each. The most significant harmonic is included in the model if it improves the existing model significantly. Activity was computed in 2-h segments and a significance of $P = 0.05$ was used.

Local knowledge and perception

Since 2005 informal interviews on local knowledge and perception on wildlife in the region have been conducted among local leaders and fieldwork guides (Lavariega *et al*. 2012). However, considering the importance of community-based conservation and local knowledge and culture about wildlife in general and tapirs in particular, in 2013 we conducted 68 semi-structured interviews in the 2 study communities (Bernard 1995): Santiago Camotlán ($n = 40$) and Santa Catarina Yetzelalag ($n = 28$). The interview used was similar to that of another study conducted in the region with Chinantec indigenous peoples (Figel *et al*. 2011), where an important community base-conservation initiative is occurring (Bray *et al*. 2012; Durán *et al*. 2012). Interviews included questions on knowledge about mammals in general (mammalian carnivores and their prey, tapir among them), temporal and spatial behavior (feeding, reproduction and refuge), hunting (customs and uses) and folklore as well as questions on community perception on wildlife status and conservation agreements.

By decision of the community assembly, interviews were only applied to community members who volunteered to take them, all farmers with no history of migration and who self-identified as frequent visitors to the forest. Information exclusively for tapirs, plus perceptions regarding the status of wildlife and local conservation agreements was compiled on a computer spreadsheet, where the main trends were identified. Considering that both study communities were small, contiguous and with shared ethnicity, land tenure, governance systems and productive activities, they did not exhibit any notable contrast in the answers given during interviews; thus, answers were analyzed as only one set.

RESULTS

Relative abundance and density of the Baird's tapir

With a total sampling effort of 3215 camera-trap days, 65 independent photographs of tapirs were obtained: 26 in the dry season of 2012; 16 in the rainy season of 2012; and 23 in the dry season of 2013. Of 40 independent photo-capture events, 17 occurred in the dry season of 2012, 14 in the rainy season of 2012 and 9 in the dry season of 2013. No significant differences were found in the number of independent photo-capture events per season ($\chi^2 = 0.231$, df = 2, $P = 0.891$)

Relative abundance throughout the study was 12.44 events/1000 camera-trap days. During the dry season of 2012, there were 12.28 events/1000 camera-trap days, while during the rainy season of 2012, there were 11.19 events/1000 camera-trap days. Finally, during the dry season of 2013, there were 15.51 events/1000 camera-trap days. No significant differences were found among seasons ($H = 1.519$, df = 2; $P = 0.467$).

All independent photo-capture events are for adults; in total, 6 males and 11 females were identified, while in 23 of the photographs it was not possible to determine the sex. During the dry season of 2012, 4 male and 3 female individuals were identified while the sex was indeterminate in 10 photographs; in the rainy season of 2012, 2 males, 4 females and 8 indeterminate cases were recorded. During the dry season of 2013, no males were identified, but there were 4 females and 5 indeterminate cases (Fig. 2).

Throughout the sampling period, tapir density ranged from 0.077 to 0.242 individuals/km^2. Density was greatest during the dry season of 2013 (0.097 to 0.299 individuals/km^2). The maximum density among seasons ranged from 0.216 individuals/km^2 (rainy season 2012) to 0.299 individuals/km^2 (dry season 2013). Minimum density ranged from 0.07 to 0.097 individuals/km^2, in the same seasons (Table 1). The densities were high when the greatest angle of detection (21°), the lowest number of hours of activity (8 h) and the lowest speed of movement (0.5 km/h) and distance of detection of the cameras (9 m) were considered. A statistically significant difference was found among seasons ($\chi^2 = 20$, df = 2, $P \leq 0.001$) and the Tukey test showed that the only significant difference was found between the rainy season of 2012 and the dry season of 2013.

Over the entire study, the densities estimated with the speeds of displacement differed significantly ($\chi^2 = 648$, df = 9; $P < 0.001$). The Tukey test revealed statistically significant differences in the different distances of movement evaluated, except between those that were contiguous (7 and 7.2 km; 7.2 and 8.4 km; 8.4 and 9.6 km; 9.6 and 9.8 km; 9.8 and 12 km; 12 and 14.4 km; 14.4 and 16.8 km; 16.8 and 19.2 km; 19.2 and 21.6 km).

Statistically significant differences ($\chi^2 = 21$, df = 3, $P < 0.001$) were found between the densities calculated by Carbajal-Borges *et al*. (2013) in El Triunfo Biosphere Reserve and those estimated in the 3 seasons of the present study. The Tukey test identified a difference between the density obtained in El Triunfo Biosphere Reserve and those obtained in the rainy season of 2012 in the SMO ($P < 0.05$).

Activity pattern

The tapirs had a nocturnal (86.54%) and crepuscular activity pattern (11.54%). There was only 1 photo-capture event during the day (1.92%). Differences between

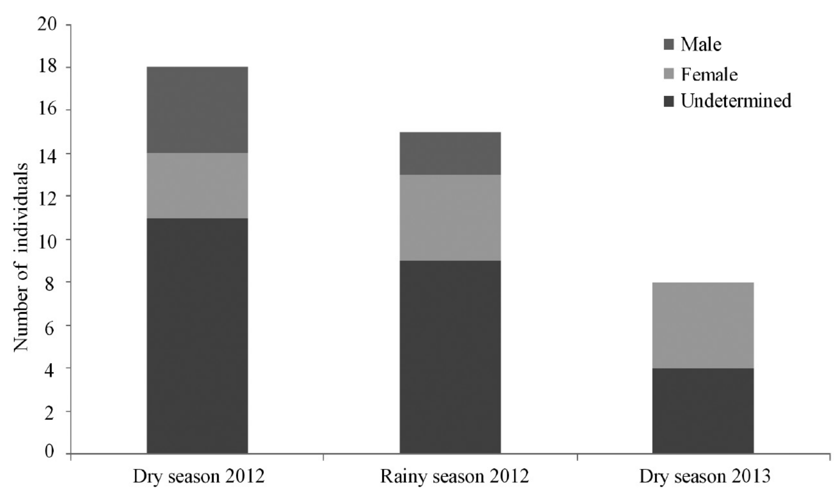

Figure 2 Recognition of the sex of tapirs in the 40 independent photo-capture events in the study in the Sierra Madre de Oaxaca, Mexico.

Table 1 Population density of Baird's tapir with a random encounter model in the montane cloud forest of Sierra Madre de Oaxaca, Mexico

	Density (individual/km^2)			
	Dry season 2012	Rainy season 2012	Dry season 2013	Total
Number of independent events	17	14	9	40
Daily range of movement (km/14 h: based on data from this study)				
7 km	0.237	0.216	0.299	0.242
8.4 km	0.197	0.180	0.249	0.202
9.8 km	0.169	0.154	0.213	0.173
Daily range of movement (km/24 h; data from Carbajal-Borges *et al*. 2013)				
7.2 km	0.230	0.210	0.291	0.233
9.6 km	0.172	0.157	0.218	0.175
12 km	0.138	0.126	0.174	0.140
14.4 km	0.115	0.105	0.145	0.116
16.8 km	0.098	0.090	0.124	0.100
19.2 km	0.086	0.078	0.109	0.087
21.6 km	0.076	0.070	0.097	0.077

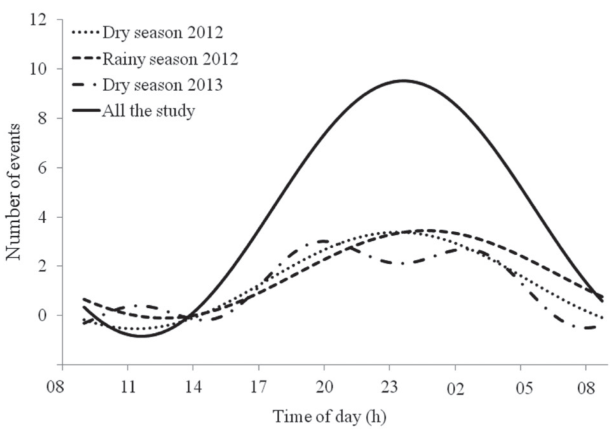

Figure 3 Pattern of activity of Baird's tapir in a montane cloud forest in Sierra Madre de Oaxaca, Mexico.

the times were statistically significant ($\chi^2 = 25.906$, df = 11, $P = 0.007$). Tapir activity occurred between 1600 and 0600 hours, with the acrophase at 2338 hours (Fig. 3) and a significant rhythm (84.28% rhythm; $F = 24.13$, $P < 0.05$). Activity showed a similar pattern between seasons. In the dry season in 2012, events were nocturnal (100%), with the acrophase at 2337 hours and significant rhythm (85.50% rhythm; $F = 26.54$, $P < 0.05$). In the rainy season in 2012, the events were mainly nocturnal (80%), with occurrence in crepuscular (15%) and diurnal (5%); the acrophase was at 0040 hours with significant rhythm (54.03% rhythm; $F = 5.29$, $P < 0.05$). Finally, in the dry season in 2013, events were diurnal (80%) and crepuscular (20%); in this season 2 acrophases were identified, 1 at 2248 hours ($F = 17.70$) and another at 0319 hours ($F = 11.45$), with no significant rhythm (95.25% rhythm; $F = 35.11$, $P = 0.1$)

Local knowledge and perception

Informal interviews had suggested historic tapir presence in the study communities, but with only sporadic direct sightings. Tapir was not a major target of subsistence hunting for bush meat, in contrast with the collared peccary (*Dicotyles* spp.), the white-tailed deer [*Odocoileus virginianus* (Zimmermann, 1780)], the brocket deer [*Mazama temama* (Kerr, 1792)] and the coati [*Nasua narica* (Linnaeus, 1758)]. Local people did not recognize myths or folklore related to tapir. A total of 90% (n = 59) of the semi-structured interviews reported knowledge of the tapir, with 44% (n = 30) claiming to have seen their tracks and 19% claiming to have actually seen the animal (Fig. 4). The 7 direct sightings occurred in the morning or afternoon. All of the *campesinos* who had seen the tapir or its tracks indicated that its diet consists of leaves, branches and bark. Of these respondents, 30 stated that the tapir also consumes the fruit of certain plants, while 4 respondents indicated that, in addition to plants, the tapir consumes mud. While the tapir has a name in the Zapotec language (*bëchhi xülhu*), the interviewees indicated that there were no stories or beliefs surrounding these animals in their communities. All of the respondents, however, mentioned the existence of *nahuales* (people with a human and animal spirit; Durán *et al*. 2012), mainly related to the jaguar. A total of 64% of the interviewees stated that they had never hunted, while the remainder commented that they had not hunted in the forest in the past 3–8 years (although some had done so on the way to their crops and within their plots of land). All of the respondents acknowledged their regular consumption of bush meat. The coati and brocket deer, which are hunted more in the agricultural fields, as well as the tepezcuintle [*Cuniculus paca* (Linnaeus, 1766)], which is hunted more in the coffee plantations, were described as the most frequently consumed bush meat species. The respondents also reported the consumption of collared peccary and white tailed deer, albeit less frequently. No one indicated that the tapir was included in the bush meat species that are consumed or among the targets of hunting. A total of 97% of the interviewees perceived that there are currently fewer wild animals in their territory, and this was attributed mainly to hunting. For this reason, all respondents commented that an agreement has been made in their community assemblies to prohibit the practice of hunting in the forest, while still allowing it in the agricultural areas and coffee plantations as a method by which to control the animals that damage their crops. In this way, they consider that they will protect wild animals in general and ensure that they do not disappear from their forests.

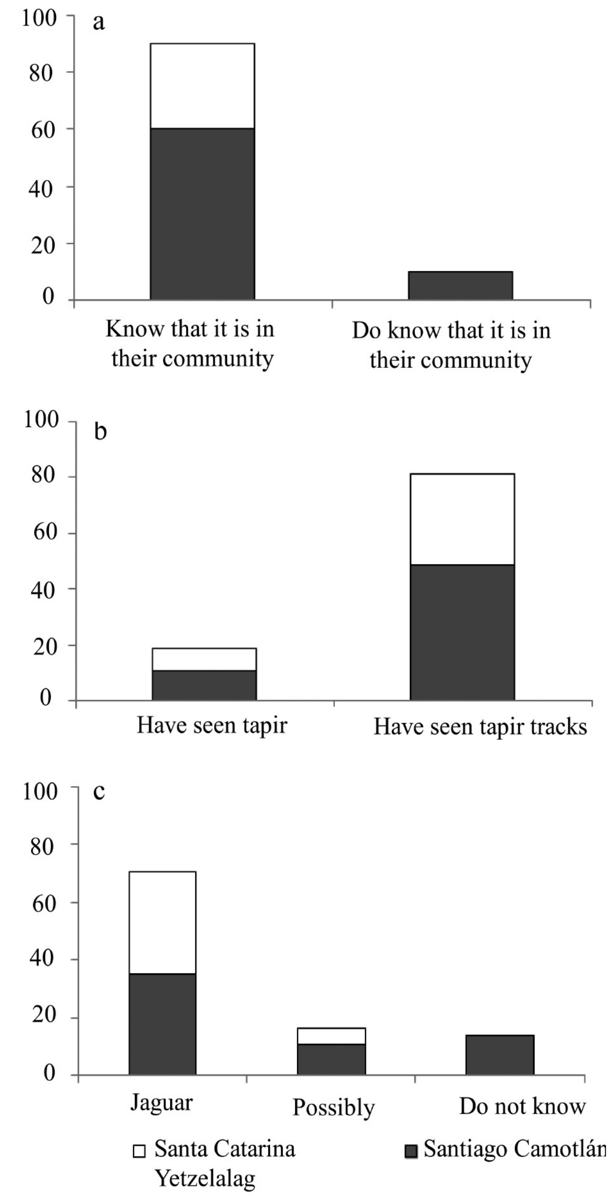

Figure 4 Knowledge of the Baird's tapir in 2 communities of the Sierra Madre de Oaxaca, Mexico. (a) Interviewees who report the presence of the tapir in the territories of their communities (n = 61), (b) those who have directly observed, or have seen evidence of the presence of the tapir (n = 37) and (c) those who can identify the main predator of the tapir (n = 37).

DISCUSSION

Relative abundance and density of Baird's tapir

This study provides information for the first time about the relative abundance and density of the population of Baird's tapir located at the northernmost point of its distribution, and presents data on local knowledge regarding this species. With the 40 independent photo-capture events of Baird's tapir found in the montane cloud forest of the SMO, a relative abundance of

12.44 events/1000 camera-trap days was found. This is a higher relative abundance value than that reported in the Zoque tropical evergreen broad-leaf forest of eastern Oaxaca, which may be the geographically closest population (Lira-Torres & Briones-Salas 2011; Lira-Torres *et al*. 2014). This relative abundance value is also greater than that reported in 3 sites of montane cloud forest in southeast Costa Rica (0.93–2.31 events/1000 camera-trap days; González-Maya *et al*. 2009); and is very similar to the relative abundance of El Triunfo Biosphere Reserve in Chiapas, Mexico (12.57 events/1000 camera-trap days; Carbajal-Borges *et al*. 2013). However, higher relative abundance values of this species have been reported in other montane cloud forest sites in Costa Rica (35.65 events/1000 camera-trap days; González-Maya *et al* 2009; González-Maya 2012) and in the flooded areas of the tropical forest of Calakmul in Campeche, Mexico (37.5 events/1000 camera-trap days; Pérez-Cortez *et al.* 2012). The abundance of tapirs is low in areas where it is hunted, but is often higher in poorly accessible areas or in those that experience little disturbance (Matola *et al*. 1997; Naranjo & Bodmer 2002; Tobler 2002; Noss *et al*. 2003; Naranjo 2009; Tejeda-Cruz *et al*. 2009). In the study site of the SMO, there is continuity of the forest beyond the polygon in which the camera traps were set (Fig. 1b) and no hunting pressure or consumption of tapir meat was reported.

The density estimated for the lowland tapir (*T. terrestris*) ranges from 0.09 to 0.8 individuals/km^2 (Ayala 2002; Noss *et al*. 2003). For the mountain tapir (*T. pinchaque*), these values range from 0.17 to 0.25 individuals/km^2 (Lizcano *et al*. 2002) and for the Baird's tapir they are 0.05 to 0.8 individuals/km^2; Foerster & Vaughan 2002; Naranjo & Bodmer 2002; Lira-Torres *et al*. 2004). In the specific case of Baird's tapir, it has been suggested that the range of its density in Mexico is between 0.2 and 0.5 individuals/km^2 (Naranjo 2009). In this study, the values were between 0.07 and 0.24 individuals/km^2; that is, in the minimum range of estimated density. Nevertheless, this value coincided with the estimates for the species generated using the same data analysis in El Triunfo Biosphere Reserve in Chiapas, Mexico (0.12 individuals/km^2; Carbajal-Borges *et al*. 2014) and coincides with studies conducted in Costa Rica employing other techniques (Foerster 1998). This suggests that the range of density for Mexico may need to be revised downward.

One possible reason for the values of density and relative abundance found in the SMO is the fact that the region presents high ecological integrity, as is argued in the El Triunfo study (Van Vleet 2013; Carbajal-Borges *et al*. 2014). Furthermore, the species is apparently under no pressure from hunting, a practice that is often signaled as one of its main threats.

Minimum tapir densities in the study area were higher in both dry seasons compared to those of the rainy season. This seems to reflect local movements related to seasonality, as observed by Williams (1984, unpublished data) in Costa Rica, where the tapirs moved to a new site once their current site had been intensively used. In the present study, the flooded areas of the landscape increased during the rainy season, potentially prompting the dispersion of individuals to a new site. For this reason, it may be necessary to seek sites that include the entire range of this population to understand all of the requirements for protection of tapirs in SMO.

The density of the population of Baird's tapir estimated in the present study should be validated with the use of radio telemetry and a greater intensity and amplitude of sampling. Regardless of the status of the population in the study site, its conservation and continued study is important given that this is the most northerly group of tapirs within their overall area of distribution and also because the presence of females and the recent report of a young individual in an area neighboring the study site (Camarillo-Chávez *et al*. 2015) suggest that this is a population that is reproducing.

The results presented here in terms of the relative abundance and density of Baird's tapir represent a starting point for understanding the population ecology of this population, but there is a considerable need to continue collecting information concerning population parameters and the ecological role of this species in the still extensive montane cloud forests of this region of Oaxaca (CONABIO 2010). Such data could help scientists, land managers and community members to develop a broader biological and ecological foundation from which to direct conservation efforts. It is also important to thoroughly explore a regional vision and to promote connectivity among the populations of Baird's tapir present in the southeast of Oaxaca and Mexico (Naranjo 2009).

Activity pattern

Tapirs in SMO showed a similar activity pattern to those reported in other studies, with more activity nocturnal and crepuscular than diurnal, and with peaks between 1900 and 0300 hours (Foerster 1998; Lizcano & Cavelier 2000b; Ayala 2002; Noss *et al*. 2003). Foerster and Vaughan (2002) suggested that this activity pattern of the Baird's tapir is an adaptation to avoid the hottest hours of the day. However, Wallace *et al*. (2002) and Ayala (2002) mentioned that human presence and hunting can limit the tapir diurnal activity. In this sense, in a site with absence of human disturbance in Colombia, Baird's tapir had diurnal and nocturnal activity (Restrepo & Betancourt 2006). The activity patterns of tapir in SMO may be a reflection of hunting occurring in previous years.

A tapir population under no hunting pressure

This is the first study in Mexico in which biological and social data about Baird's tapir, which is an endangered species (SEMARNAT 2010; IUCN 2015), have been integrated. Despite the fact that its threatened status is attributed largely to pressure from hunting (Naranjo 2009; Van Holt *et al*. 2010), this does not appear to be the case in the SMO. While the majority of interviewees reported the regular consumption of bush meat, no one reported hunting the tapir or eating its meat. This apparent lack of current hunting pressure could, therefore, be an important factor explaining the relative abundance and density values recorded (Van Holt *et al*. 2010). Moreover, it appears that any hunting in the past occurred at low rates and was opportunistic in nature (the most recent report was from 5 years before). Opportunistic hunting of the lowland tapir has been observed in Honduras (Flesher 1999) and in Venezuela (Naveda-Rodríguez & López 2006). While tapirs may be among the most important of game animals in some parts of its range, for example, for the Kichwa ethnic group in Ecuador (Tapia & Machoa 2006), and among the Mayangna, Miskitos of Nicaragua (Koster 2006), and the Guarayo indigenous community in the Bolivian Amazon (Van Holt *et al*. 2010), in the communities of this study, hunting focused more on animals of medium size that damage the *milpa* (agricultural fields) and on animals that are common in the coffee plantations (e.g. red brocket deer and coati). It is also probable that hunting of the Baird's tapir is discouraged by the topography of the terrain; the prevailing steep and abrupt slopes make it very difficult to transport the body of an animal weighing more than 200 kg. This argument has also been made to explain the rarity of hunting of Baird's tapir in Calakmul, Campeche, Mexico (Reyna-Hurtado & Tanner 2005). Another aspect that may influence the low pressure of hunting of Baird's tapir in the study site is that no local cultural or symbolic influence appears to surround the animal. It is also not considered to be of medicinal value, nor are its body parts used as amulets or adornments. This situation is in contrast to the recognition given to the tapir in other cultures, where it is considered a sacred animal (Naveda-Rodríguez & López 2006).

Prohibition and regulations in terms of the hunting of wild animals within the communities of the SMO are common (Bray *et al*. 2012) and, while they prevail in those communities that have formalized voluntary conservation areas recognized by the Mexican government (Martin *et al*. 2010), they do not appear to be exclusive (Van Vleet 2013, unpublished data). Consequently, the local people often perceive an increase in the fauna that were scarce prior to the regulation (Durán *et al*. 2012); nevertheless, it is necessary to conduct systematic monitoring in order to evaluate the impact of local restrictions on the recuperation of wild populations of animals that were historically subjected to pressure by hunting.

Implications for conservation

Considering that along the distribution range of tapirs there are inhabited areas, Downer (1996) emphasized that "no attempts to conserve tapirs can be made without the involvement of local people." Thus, this study where local people have rights of ownership over the land and the resources of the forest, we document a baseline on local knowledge, status of tapir hunting and cultural values related with the northern Baird's tapir population.

Although conservation biologists often deemphasize the importance of social and cultural perceptions of mammals, these can serve as a baseline for documenting and encouraging behavior to protect wildlife in indigenous communities (Gadgil *et al*. 1993; Dickman 2010; Van Holt *et al*. 2010; Medeiros *et al*. 2013; Cozzuol *et al*. 2014). Here, we found that on the basis of the local perception of the reduction in wildlife, people from the study communities have formed the first conservation agreements, expressed in the self-imposed hunting ban that restricts hunting of the tapir and other wildlife species. In addition, communities answered positively to the opportunity to participate in biological monitoring with camera traps promoted by the Mexican National Commission for Protected Areas (CONANP). This monitoring involves working together with 6 other neighboring communities, which may improve local knowledge and strengthen the awareness about wildlife at the landscape level. This is very important for a species like Baird's tapir and other endangered species that coexistent in the region, including jaguar, spider monkey (*Ateles geoffroyi* Kuhl, 1820), margay [*Leopardus wiedii* (Schinz, 1821)], crested guan (*Penelope purpurascens* Wagler, 1830) and great curassow (*Crax rubra* Linnaeus, 1758) (Lavariega 2013). Experiences of involvement in active wildlife and habitat conservation, based on local perceptions of reductions in wildlife, have been documented among the Chinantec indigenous communities (Bray *et al*. 2012) in the SMO region, and in other places in Oaxaca (Durán *et al*. 2012; Durán 2014).

The SMO region, where common property prevails (Bray 2013), forms part of a larger *hotspot* of biodiversity, given the presence of additional species indicative of extensive areas of high quality natural habitat (Figel *et al*. 2011), including the jaguar (Briones-Salas *et al*. 2012) and the spider monkey (Ortiz-Martínez *et al*. 2008). Thus, the regional trend for having the greatest area of formal "Voluntary Initiatives for Conservation" and informal community conservation areas, based on agreements reached by the local people (Martin *et al*. 2010; Bray *et al*. 2012; Durán *et al*. 2012; Van Vleet 2013) is positive for Baird's tapir, as well as many other species. However, it is important to recognize that conservation initiatives based on social participation are not focused solely on ecological goals. In contrast their aims include consideration of the possible uses of natural resources and alternative land uses (Bray *et al*. 2012). Thus, this approach would conciliate social goals and habitat and species protection, which may allow the recovery and maintenance of viable populations to not only help the tapir, but populations of other threatened species of wildlife (Ortiz-Martínez *et al*. 2008; Rabinowitz & Zeller 2010). The ideal scenario will be to integrate wider-scale actions to promote connectivity between populations of tapirs at the regional level (Naranjo 2009) with the south-eastern regions (Isthmus and Coastal) of Oaxaca where other populations are located (Lira-Torres *et al*. 2006, 2014). Maintaining the extensive cover continuity to the north (the Chinantec region; Van Vleet 2013; Velasco-Murguia *et al*. 2014), which is potential habitat for tapir, is also important.

For this reason, public policies for wildlife conservation must provide incentives for local inhabitants, and promote more sustainable practices among the communities in terms of the use of resources such as timber, incentives for environmental services and activities such as ecotourism, traditional agriculture or the production of shaded coffee (Durán *et al*. 2012; Van Vleet 2013; Durán 2014). Finally, to encourage tapir conservation in inhabited regions, more efforts to promote its adoption as a distinctive charismatic fauna for environmental education programs (Downer 1996; Van Holt *et al*. 2010), or the use of its image on labels of local products and in ecotourism are indicated, as is already the case with the jaguar (Durán *et al*. 2012). In this way, the local people could strengthen their bonds of identity and actions for the conservation of this species.

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