Evaluación de la condición corporal del tapir centroamericano (Tapirus bairdii) mediante el uso de cámaras trampa y...

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Evaluación de la condición corporal del tapir centroamericano (*Tapirus bairdii*) mediante el uso de cámaras trampa y material fotográfico histórico

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Jonathan Sechaly Pérez Flores

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A mi mamá Cristina (qepd) que es mi angel guardian que siempre está a mi lado.
A mi madre que me ha enseñado a nunca darme por vencido.
A toda mi familia y en especial a mis hermanos, con los que he compartido grandes momentos de alegría.

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"*Every individual matters. Every individual has a role to play. Every individual makes a difference*"

Jane Goodall

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Índice

I. Introducción

En los últimos años se han reportado varias enfermedades infecciosas y no infecciosas que afectan a los animales domésticos, fauna silvestre y al ser humano (Daszak et al., 2007). Estas enfermedades se presentan en una gran variedad de especies y poblaciones, lo que podría generar graves consecuencias ecológicas (Mörner et al., 2002). Las enfermedades pueden tener un efecto devastador en las especies con distribución restringida o que están en peligro de extinción, debido al aislamiento y fragmentación de sus poblaciones, pérdida de diversidad genética, incremento en la tasa de contacto con especies exóticas e invasivas y mayor, vulnerabilidad a factores ambientales (Young et al., 1999; Ferreras, 2001; Wisely et al., 2002).

La intervención humana ha jugado un papel trascendental en el surgimiento de ciertas enfermedades, ya que los cambios en el ecosistema son de los principales factores que provocan epizootias en los animales silvestres y domésticos (Mangini et al., 2012). La fragmentación y destrucción del hábitat han provocado una concentración de especies e individuos en las áreas remanentes, lo que aumenta la tasa de transmisión de agentes infecciosos, reduce el estado nutricional e incrementa el estrés, provoca que las especies sean más susceptibles a las enfermedades y otras presiones poblacionales y facilita el contacto entre especies domésticas con silvestres (Scott, 1988; Patz et al., 2000; Deem et al., 2001).

Desde el punto de vista ecológico, un ecosistema saludable es aquel que no presenta una disminución en la abundancia y diversidad de especies, degradación del ambiente, contaminación, enfermedades emergentes y reemergentes, intoxicaciones con implicaciones negativas para la salud de los humanos y la vida silvestre; además, no se presenta mortalidad excesiva de especies clave e indicadoras (Aguirre et al., 2002). Por lo tanto, es necesario llevar a cabo monitoreos epidemiológicos en las especies que tienen un papel significativo en el mantenimiento e integridad del ecosistema (Karesh et al., 1997). Este tipo de estudios son importantes, ya que se tiene información que las enfermedades tienen efectos en el sistema inmune, condición corporal, diversidad genética, comportamiento, depredación, selección sexual, éxito reproductivo, fecundidad, ecología, estructura de las comunidades, diversidad de especies y poblaciones (Spalding y Forrester, 1993).

El tapir centroamericano (*Tapirus bairdii*) es considerado una especie en peligro de extinción e indicadora de la salud de los ecosistemas tropicales (Medici et al., 2006). Sin embargo, en los últimos años su distribución geográfica en México se ha reducido considerablemente (Naranjo, 2009; Mendoza-Ramírez y Carbajal-Borges, 2011) (Fig. 1). Esta reducción en su distribución se debe principalmente a la sensibilidad de estos mamíferos a la destrucción y fragmentación del hábitat, ya que generalmente requieren de ambitos hogareños amplios y bosques en buen estado de conservación (Medici, 2010). Naranjo y Bodmer (2002) mencionan que los tapires, prácticamente han desaparecido en localidades donde los bosques y la vegetación nativa han sido severamente fragmentados. Es por esto que en algunas regiones de México los tapires se encuentran ahora concentrados en cañadas profundas y otras áreas de difícil acceso que les ofrecen refugio, alimento y agua (Naranjo y Cruz, 1998; Cruz, 2001). Este aislamiento poblacional ocasiona que se interrumpa el flujo genético, con consecuencias potencialmente graves para la población a largo plazo, y además, que disminuya el tamaño de las poblaciones, lo que hace a dichas poblaciones más susceptibles a la extinción por eventos climáticos y epidemias (Hernández-Divers et al., 2005). Adicionalmente, la deforestación y el avance de las actividades agropecuarias incrementan las posibilidades de contacto entre el tapir y los animales domésticos, y produce una mayor probabilidad de transmitir enfermedades y parásitos entre éstos.

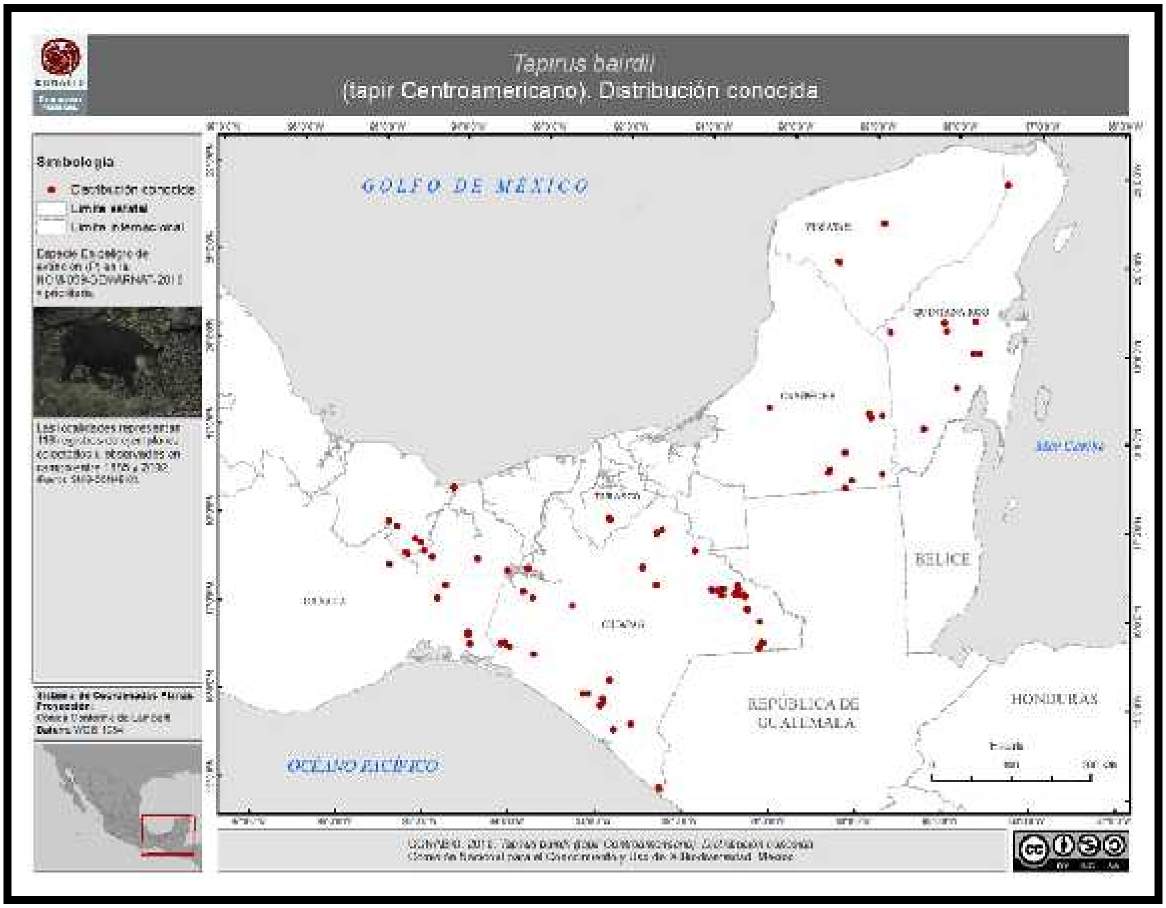

Figura 1. Mapa de distribución del tapir centroamericano en México (Ceballos et al., 2006).

Si bien, el efecto de las enfermedades en la dinámica poblacional del tapir aún es desconocido, existen otros factores que pueden repercutir en su estado de salud en vida libre. La escasez de agua y alimento repercuten en la presencia, movimientos y densidad de muchas especies silvestres como ha sido demostrado para el pecarí de labios blancos (*Tayassu pecari*) (Reyna-Hurtado et al., 2009) y para el tapir (O'Farrill et al., 2007). Este último necesita ingerir un volumen de aproximadamente 15 litros de agua al día para cubrir sus necesidades metabólicas (MacFarlene y Howard, 1972). Además, esta especie es básicamente forrajera/frugívora y los volúmenes y diversidad de alimento consumido varían dependiendo de los cambios estacionales (Eisenberg, 1989; Emmons y Feer, 1997). El consumo de frutos aporta una gran cantidad de las calorías requeridas diariamente por los tapires y es mayor durante la época de lluvias, en comparación con la de secas (Bodmer, 1990; Pérez-Cortez, 2011). En estudios con el tapir centroamericano y amazónico (*Tapirus terrestris*), se ha encontrado que la escasez de frutos, plantas y agua provoca una reducción en su ámbito de acción obligándolo a estar más cerca de las fuentes de agua (Foerster y Vaughan, 2002; Noss et al., 2003; Trolle et al., 2008). Esta disminución de los recursos posiblemente provocaría una mayor competencia inter e intraespecífica, lo que traería como consecuencia una disminución de la condición corporal y, por lo tanto, un aumento en la mortalidad y presencia de enfermedades.

La condición corporal (CC de aquí en adelante) es uno de los parámetros que nos ayuda a evaluar el estado de salud de un individuo y ha sido utilizado como una herramienta fundamental en el manejo de fauna silvestre (Ezenwa et al., 2009). La CC se define como la estimación del estado nutricional de un individuo, a través de la observación del tamaño de los sitios donde se albergan las reservas energéticas, como la grasa y proteínas (Peig y Green, 2009). Los cambios en la CC se relacionan con la nutrición y las condiciones del hábitat (Riney, 1982). Los animales que viven en ambientes estacionales y sufren cambios entre temporadas secas y húmedas, tienen variaciones en la CC debido a la calidad y disponibilidad de agua y alimentos (Desai, 1991; Sukumar, 1992). Cuando disminuye la CC, las reservas de grasa se movilizan y los músculos comienzan a emaciarse al tratar de compensar la demanda de energía requerida. Para evaluar la CC es necesario calificar la cantidad de grasa subcutánea y el volumen de musculatura, lo que reflejará cambios en la masa corporal y nos brindará una estimación del estado físico y nutricional (Reuter y Adcock, 1998).

Ezenwa y colaboradores (2009) mencionan que la CC, al correlacionarse con el índice de grasa renal y el porcentaje del volumen total de sangre (hematocrito), puede ser un buen indicador del estado nutricional y de la acumulación de reservas grasas en un animal. El promedio de la CC en una población nos indicará la respuesta de los individuos al medio ambiente; sin embargo, existen diferencias individuales basadas en el comportamiento y sexo de los animales (Atkinson y Ramsay, 1995). La pérdida de CC se puede relacionar no solamente con cambios en la abundancia de recursos, sino con la presencia de una enfermedad crónica; por lo tanto, es indicativo de la respuesta de un individuo a las enfermedades y a las condiciones climatológicas (Reuter y Adcock, 1998).

Elaborar un sistema para evaluar de manera indirecta la CC de los tapires es sumamente importante, ya que son mamíferos tímidos, solitarios y que normalmente evitan los encuentros con humanos, lo que complica su captura y hace difícil una evaluación integral del estado de salud de las poblaciones silvestres. El escaso éxito obtenido al tratar de capturar tapires en vida silvestre nos ha obligado a estudiar a los individuos silvestres a través de otros métodos indirectos, tales como el fototrampeo y la consecuente determinación de la CC, además de determinar la CC en individuos que se alojan en las colecciones zoológicas.

La poca eficiencia al aplicar los métodos invasivos (captura) para generar esta información nos obliga a usar métodos no invasivos que nos ayuden a entender el por qué de la reducción del 50% de sus poblaciones en los últimos 30 años (Mendoza-Ramírez y Carbajal-Borges, 2011). El uso de cámaras trampa es un método no invasivo, es decir, permite obtener información sin tener que capturar al animal (Fig. 2), registrar la presencia de la especie (e.g. Maffei et al., 2002), estimar el patrón de actividad (e.g. Mendoza-Ramírez y Carbajal-Borges, 2011), área de acción, uso de hábitat (e.g. Pérez-Cortez, 2011), abundancia relativa, densidades poblacionales (Karanth et al., 2004) y modelar la densidad en especies que no se pueden reconocer (Rowcliffe et al., 2008). Sin embargo, nunca se ha hecho una evaluación de la CC de las poblaciones de tapir centroamericano con la finalidad de observar si la estacionalidad y su consecuente reducción de recursos (agua y frutos) ocasionan un decremento en el estado físico de los tapires.

Figura 2. Tapir centroamericano captado por cámara trampa en la Reserva de la Biosfera de Calakmul.

En esta investigación, se modificó el método diseñado originalmente para evaluar la CC en cautiverio del tapir malayo (*T. indicus*) y amazónico (*T. terrestris*) en zoológicos del Reino Unido (Clauss et al., 2009) y que consistía en aplicar una calificación del 1 al 5 a la apariencia de diferentes partes del cuerpo del animal (costillas, espalda, cuello, hombros, base de la cola y caderas). El presente estudio permitió mejorar la descripción de las regiones anatómicas que se pueden observar al llevar a cabo la evaluación de la CC en el tapir centroamericano tanto en vida silvestre como en cautiverio. Se comparó la CC de los tapires en vida libre en las temporadas de lluvias y secas en la región de Calakmul, Campeche, México, donde las investigaciones previas han obtenido material fotográfico importante de tapires silvestres (Reyna-Hurtado y colaboradores sin publicar).

Área de estudio

La Reserva de la Biosfera Calakmul (RBC) se encuentra ubicada al sureste del estado de Campeche, México (Fig. 3). Limita al este con el estado de Quintana Roo y al sur con la República de Guatemala. Sus coordenadas son 19º15' y 17º45'N; 90º10' y 89º15' W. El clima es cálido subhúmedo, con una temperatura media anual de 25ºC (oscilando entre 4-40º C), y con precipitación media anual de 750 mm (Morales y Magaña, 2001). La RBC es el área de bosque tropical protegido más grande del país, con una superficie de 7,238 km^2, decretada área natural protegida en 1989 y donde no ha existido asentamiento humano importante durante los últimos 1000 años desde que los Mayas abandonaron la región (Turner, 1983). La parte sur de la RBC actualmente está protegida por dos puestos de control que limitan la presencia humana, y solamente permiten actividades turísticas en la zona arqueológica. Los tipos de vegetación predominantes son las selvas mediana subperennifolia, mediana caducifolia, baja inundable y baja subperennifolia. También se encuentra representada, en menor medida, las selvas alta perennifolia y baja caducifolia (Pérez-Cortez y Reyna-Hurtado, 2008). Debido a su inaccesibilidad, escasez de agua y suelo, la región de Calakmul se ha mantenido como una de las áreas menos deforestadas en toda la península y es la que conserva la mayor extensión de bosque tropical en México. La reserva de la biosfera de Calakmul junto con las reservas adyacentes de Guatemala y Belice, conforman el bosque tropical más grande de todo Mesoamérica (Galindo-Leal, 1999).

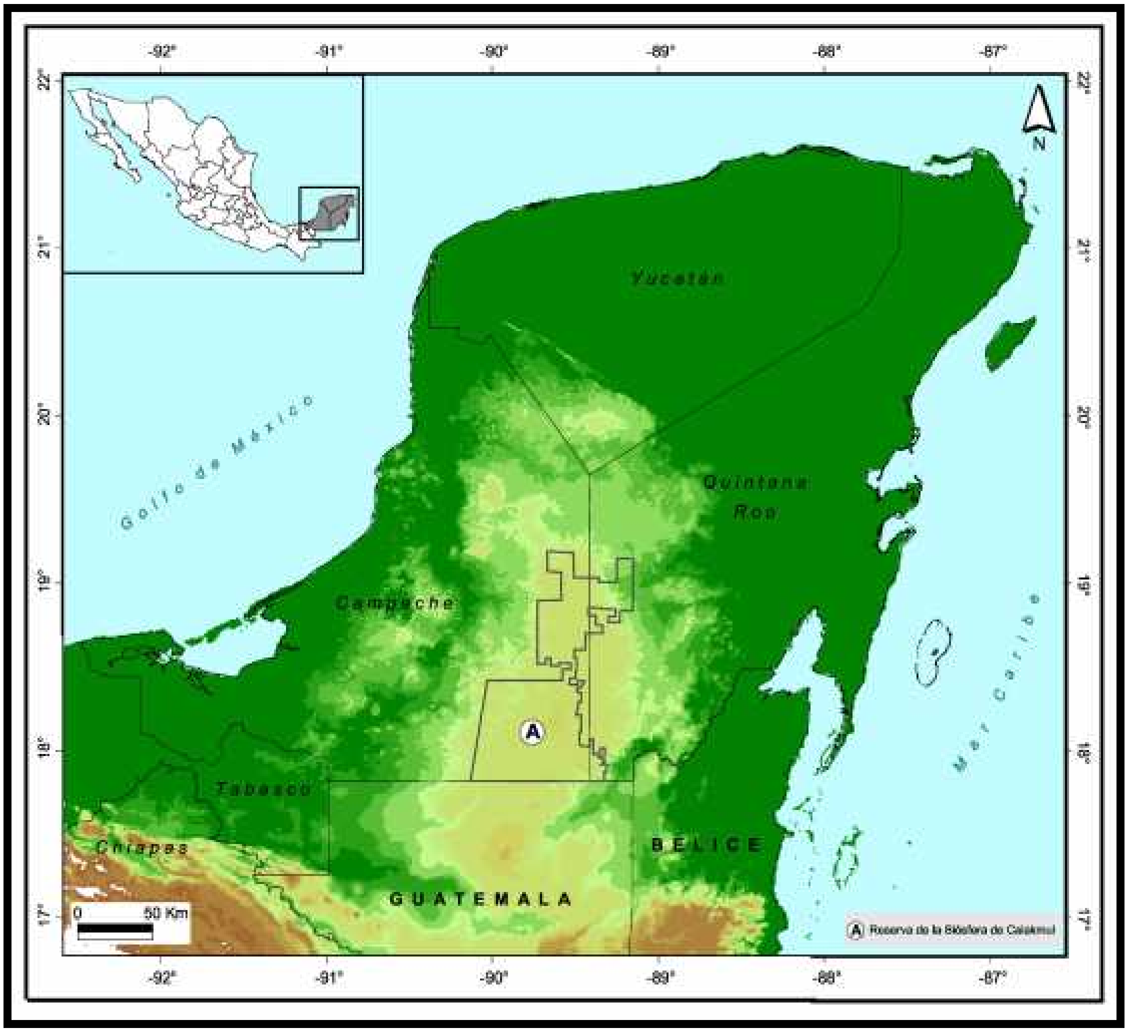

Figura 3. Ubicación de la Reserva de la Biosfera Calakmul (A)

Dada la información anterior, surgen por lo tanto las siguientes preguntas de investigación:

¿Cuál es el estado de salud de los tapires en la RBC de acuerdo con el sistema de evaluación de la CC?

¿Qué diferencias existen en la CC de los tapires en la RBC durante las épocas de secas y lluvias?

¿Existe una relación entre las calificaciones asignadas a las regiones anatomicas y las medidas corporales obtenidas?

¿Existen diferencias en la condición corporal de los tapires que habitan en la RBC y los que se encuentran en cautiverio?

OBJETIVOS

Elaborar un sistema de evaluación viable para medir la CC del tapir centroamericano (*Tapirus bairdii*) que pueda ser aplicable a la población silvestre a través de registros de fototrampeo.

Evaluar la CC de los tapires que viven en la Reserva de la Biosfera de Calakmul, mediante el uso de cámaras trampa y registros fotográficos históricos.

Identificar si existen cambios en la CC de los tapires, debidos a la estacionalidad.

Evaluar la CC de algunos individuos en cautiverio, mediante el uso de fotografías y compararla con la de los ejemplares silvestres.

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II. “Scoring body condition in wild Baird´s tapir (*Tapirus bairdii*) using camera traps and opportunistic photographic material”

Manuscrito enviado a Tropical Conservation Science como:

Research article

Scoring body condition in wild Baird´s tapir (*Tapirus bairdii*) using camera traps and opportunistic photographic material

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Abstract

Body condition (BC) scoring systems have been used in wild and domestic animals, as a technique to evaluate the health status of animals that are difficult to capture or observe in their habitat. In this study, we modified a BC score assessment created for other tapir species, and applied it to a set of photos of wild Baird´s tapir (*Tapirus bairdii*) obtained over 6 consecutive years in a protected area in southern Mexico. The Baird´s tapir is an endangered Mesoamerican species whose population is estimated to have been halved over the past 30 years. We compared morphometric measurements and muscle and fat deposited in anatomical regions to test for the robustness of our BC scoring system, and tested for its consistency among observers. We also evaluated changes in BC between seasons for individuals recaptured on several occasions in the Calakmul region of Mexico. Our results indicate that BC scoring can be used as an indicator of individuals' general health. Moreover, camera trap records and opportunistic photographic material can be a tool to track changes in BC over time. Our scores confirm that in our study region tapirs are able to maintain an excellent body condition throughout the year.

Keywords: Baird´s tapir, body condition, camera trap, Calakmul, seasonal changes.

Resumen

La evaluación de la condición corporal (BC por sus siglas en inglés) ha sido utilizada en animales silvestres y domésticos, como una técnica para evaluar el estado de salud de los animales que son difíciles de capturar u observar en su hábitat. En este estudio, hemos modificado un método de evaluación de la BC utilizado en otras especies de tapires, y lo aplicamos a los registros fotográficos de tapires centroamericanos en vida libre obtenidos durante 6 años consecutivos en un área protegida del sur de México. El tapir centroamericano (*Tapirus bairdii*) es una especie Mesoamericana en peligro de extinción y se estima que su población se ha reducido a la mitad en los últimos 30 años. Se compararon algunas medidas morfométricas, el músculo y la grasa depositada en ciertas regiones anatómicas para darle solidez y consistencia a nuestro sistema de evaluación a través de los observadores. Además, se evaluaron los cambios de BC entre temporadas en los individuos fotografiados en repetidas ocasiones en la región de Calakmul, México. Nuestros resultados indican que la evaluación de la BC se puede utilizar como un indicador del estado de salud de un individuo. Por otra parte, los registros fotográficos obtenidos por medio de cámaras trampa y el material fotográfico oportunista pueden ser una herramienta útil para observar los cambios de BC a lo largo del tiempo. Nuestras evaluaciones confirman que en nuestra área de estudio los tapires de la región son capaces de mantener una excelente BC durante todo el año.

Palabras clave: Tapir centroamericano, condición corporal, foto-trampeo, Calakmul, cambios estacionales.

Introduction

Wild animals need to maintain an optimal condition to survive and face daily risks. A low nutritional status may compromise the immune system, causing a weak host response to viral, bacterial and parasitic infections. The ingestion of low quality food may cause nutritional and metabolic disorders (e.g. hypovitaminosis, nutritional hyperparatyiroidism, mineral deficiencies), and triggers the consumption of energetic reserves, starting with the glycogen stored in liver and muscles, then fat deposits and finally proteins [1]. Animals with larger fat reserves may have better fasting endurance and higher survival than individuals with smaller reserves [2], and a low body mass has been associated with decreased survival and fertility [3]. For these reasons, wildlife researchers consider catabolism and weight loss as essential components of the life strategies of many wild animals [4, 5]. Festa-Bianchet et al. (1997) [6] argued that individual mass plays an important role in the life history and population dynamics of ungulates.

Body condition (BC) is defined as a direct measurement of the nutritional status of an individual, especially the relative size of energy reserves such as fat and proteins [7]. BC is of considerable importance in many ecological studies and as a wildlife management tool, which is the reason why many noninvasive techniques have been developed to measure BC in livestock [8] and, more recently, in wild ungulates [9]. Scoring BC is an essential technique to evaluate the health status of animals that are difficult to capture or observe or that live in seasonal environments, where the availability and quality of food varies among seasons [10, 11]. Morphological metrics used to estimate BC are indicative of health or quality of individual animals and assumed to be related to fitness [7].

The Baird´s tapir (*Tapirus bairdii*) is a browser and frugivorous perissodactyl species that is distributed from Southeastern Mexico to the Northwestern Andes [12]. Several populations have been decimated due to forest loss and hunting. Currently, Southern Mexico is estimated to hold 50% of the global population of Baird´s tapir; however, in areas where forests and native vegetation have been severely fragmented these organisms have virtually disappeared [13]. The isolation of small populations in fragmented areas makes the Baird´s tapir susceptible to extinction when facing natural disturbances and epidemic diseases [14]. However, the lack of knowledge about the health of individuals hinders our efforts to protect the species. Tapirs are predominantly nocturnal and crepuscular and often inhabit areas of difficult access; capturing them in the field is therefore challenging as exemplified by our four-year effort that lead to the capture of a single individual. For these reasons, the use of non-invasive techniques has become essential for monitoring the health of terrestrial mammals like tapirs. One such technique is camera trapping which has been used to record the presence of rare or secretive species [e.g. 15], to estimate population density [e.g. 16, 17], and document activity patterns [e.g. 18], and habitat use [19].

In this paper we use a previously described technique developed to assess BC in captive Malayan (*Tapirus indicus*) and lowland tapirs (*T. terrestris*), which uses scores attributed to several body parts to built a final score for BC [20]. We modified the technique and added a score for the head, using captive individuals that we were able to weight and to measure. Due to the fact that we had a good number of individuals with poor BC, we were able to define better scoring criteria for these cases. We tested the correlation between morphometrics measurements (head length, neck circunference, trunk length, thorax circunference and abdomen circunference) and the muscular mass and fat deposited in anatomical regions (head, neck, shoulder, ribs, spine and pelvis) in captive Baird´s tapirs. This helped us scoring BC of wild tapirs, contrasting them with photos of captive individuals of known BC. The procedure was repeated with different observers to test its consistency. In this paper we applied the technique to a set of Baird´s tapir photos obtained with camera traps over 6 years in a protected area in southern Mexico to evaluate the BC of wild tapirs for the first time. We also discuss, how this technique could be an important conservation tool to improve the assessment of Baird´s tapir populations.

Materials and methods

Tapir specimens

Wild tapirs - As part of ongoing studies on wildlife species in the Calakmul region we have obtained 81 records of tapirs between 2008 and 2013. This region surrounds the Calakmul Biosphere Reserve (CBR), located in Southeastern Campeche, Mexico (17°45’-19°15’N and 89°15’-90°10’W). The climate is warm subtropical with an annual average temperature of 25° C (ranging from 4 to 40° C), and an average annual precipitation of 750 mm. The dominant vegetation types are semi-deciduous tropical forest, deciduous tropical forest, lowland floodplain and lowland evergreen; also represented by a lesser extent high evergreen forest and deciduous forest [21].

From 2008 to 2010 the NGO Pronatura Peninsula de Yucatán, A.C. placed 45 camera traps in 15 waterbodies (3 per waterbody) within the CBR. They used four different camera models (17 Deer Cam, 19 Wild View, 7 Stealth Cam and 2 Cam Trakker). In 2012-2013, we used three different models of cameras: PC800 Hyperfire professional Reconix, Moultrie Game Spy I-65 and Cuddeback Capture IR digital scouting camera. These cameras were placed in nine waterbodies (2 per waterbody) of the Calakmul region. Each year, the cameras remained active 24 hours a day and were checked every 15 to 30 days, to change batteries and empty memory cards. The cameras remained installed and active from April to August, to encompass the rainy and dry seasons.

In addition to these photographic records, since 1997 we have documented the intrusion of tapirs in villages surrounding protected areas in the Southern Yucatán Peninsula. In most cases, tapirs were injured and showed a poor body condition. These weak animals were easily captured by people, and kept in captivity for a few days. Lots of pictures were taken by village people, biologists, veterinarians, researchers and rangers, trying to record these events. From all these records (from unknown authors and different protographic equipments) we have used only those of good quality.

Of the 81 photographic records, 16 were not included, either because they corresponded to a same individual in a photographic sequence or because the body was not in full. Therefore, we used a total of 65 independent records, of which 27 were from males, nine from females and 29 from individuals with undetermined sex. In some cases, photos of the same tapir were obtained on different dates, allowing us to score their BC over time. These individuals were identified using distinguishable marks (wounds, marks, spots). Two tapirs could be clearly identified with such marks: an adult male with a large cut in its right ear and a young male, which we had equipped with a telemetry collar.

Zoo specimens - Five zoos from Mexico and one from Belize allowed us to take photos and measure the tapirs in their collection. A total of 15 tapirs in captivity were photographed, of which eight were also measured: Africam Safari (one adult male and one adult female), Payo Obispo (one adult male), Xcaret (one adult male and one adult female), Aluxes ecoparque (one adult male and one juvenil female), Chapultepec (one adult male) and Belize (three adult and two juvenile males, one adult female and one male calf).

Assessing body condition

Clauss et al. (2009) [20] developed a technique for scoring BC in the Malayan and the lowland tapir in zoos from the United Kingdom. We used this technique, which we slightly modified, and added one criterion (the head). The criteria by which we conducted this evaluation were visual. We used the fact that fat and muscle are reduced when an animal has low BC. Therefore, we observed the mass (fat and muscles) associated with skeletal structures, such as head, neck, shoulders, ribs (flank area), spine (lumbar vertebrae) and pelvic bones (Fig. 1). These regions have already been used to visually estimate BC in African buffalo (*Syncerus caffer*), Asian elephant (*Elephas maximus*), impala (*Aepyceros melampus*), black rhinoceros (*Diceros bicornis*), caribou (*Rangifer tarandus*), elk (*Cervus* *canadensis*) and mule deer (*Odocoileus hemionus*) [9, 22-27]. For each anatomical region, we made a description of bones and muscles forming it, mainly in those sites where the species stores fat and proteins (Table 1).

FIGURE 1

Table 1

To improve accuracy and reduce subjectivity, anyone assessing BC must be familiar with the anatomy and the range of conditions that a Baird's tapir may present (Fig. 2-6). Scores are given on the basis of six body regions using three or four criteria for each body region. The six scores are then totaled to obtain the body score condition. The total score can vary from a minimum of six up to 30 points.

FIGURES 2-6

We then tested for the relationship between the scores of those body parts where fat reserves accumulate and/or that present large muscular masses, namely the head, neck, trunk (thorax and abdomen), and respectively head length, neck circunference, trunk legth, thorax and abdominal circunference. Eight captive and three wild Baird's tapirs were fully measured and scored for body condition. All measures were taken with a tape to the next millimeter (Table 2).

Table 2

The ease of use and consistency of the evaluation criteria were tested during the meeting of the Mexican Tapir Specialist Group (MTSG) held in Zoh Laguna, Campeche in November 2013. Three pictures of three tapirs (wild and captive) ranging from obese to thin, were shown to each of the 20 participants. Based on the established criteria (Table 1), each participant then scored the BC of the three tapirs.

Data analyses

A Pearson's test was performed to determine the correlations between body measures and the corresponding body condition scores for each anatomical region. All data were normally distributed. After being scored, all the pictures of tapirs photographed in the CBR were ordered according to the month in which the pictures were taken to test for differences in body condition between the dry (February to May) and the rainy season (June to October). Assessments of BC during the dry vs. rainy season and within CBR vs. zoos were conducted using a Mann-Whitney *U*-test, because data were not normally distributed.

Results

Assessing body condition

Head and body lengths were not significantly correlated with any of the body scores of the six anatomical regions deemed important for fat deposition and/or muscle masses (Table 3). Conversely, neck and thorax circumferences were significantly correlated with all the body scores associated with these anatomical regions. Abdomen circumference was significantly correlated with half of the body scores, and marginally correlated with the other half (Table 3).

Table 3

The evaluation performed at the MTSG showed that some anatomical regions may be easier to qualify than others. In the first individual (a skinny animal) most anatomical regions were qualified as 2-3, being the shoulder region the most difficult to qualify. The second individual (obese) had most qualifications between 4 and 5, with 5 being the most common in all anatomical regions. For the third individual, photographed by camera trap, scores ranged 3-5, with 4 being the most common score for most anatomical regions. According to the similarities between the scores given by participants to the head, neck, thoracic and pelvic areas, we estimate that scoring these anatomical regions can be used reliably. The spinal vertebrae and shoulder may need to be evaluated more carefully to differentiate anatomical structures that compose them (Fig. 7).

FIGURE 7

Body score of wild tapirs

BC was scored as excellent (18-25 points) in 80%, poor (7-16 points) in 15%, and slightly obese (26-30 points) in only 5% of photos (Fig. 8). One tapir captured in a village during the rainy season showed a BC score of only 6 at that moment but reached 26 points seven months after having been traslocated to a Wildlife Rescue Center in Bacalar, Quintana Roo.

FIGURE 8

There was no significant difference in BC between the rainy (n=19) and dry (n=46) seasons (U = 416.0, P=0.75). The seasonal BC scores of the two males with distinctive marks indicated that scores remained stable over more than two years (Fig. 9).

FIGURE 9

Body score of captive tapirs

Of the 16 tapirs evaluated in captivity (11 males, four females, one calf), 38% were extremely obese (30 points), 19% slightly obese (25-29 points), 37% excellent (18-24 points) and only 6% had a poor BC (6-12 points) (Fig. 8). A tapir from Payo Obispo Zoo, which had been confiscated by wildlife authorities at the end of the dry season of 2011 and had a total BC score of 15 points, reached the highest score (30 points) after 6 months in the zoo. There was no significant difference in the body condition of captive *vs.* wild tapirs (U = 399, P=0.042).

Discussion

Assessing body condition

Many authors have studied the relationship between BC, body weight and body measurements (especially heart girth) in domestic [28-31] and non-domestic animals [32, 33], as a useful indicator of a population's general health. For Baird's tapirs we found that scores were positively correlated with their corresponding body measurements. The high and significant correlations between body measurements and scores (Table 3) indicate that scores are appropriate estimators of BC in Baird's tapirs. If we accept that individuals with larger fat reserves have better fasting endurance [2], these results indicate that BC scoring in Baird's tapir can be used as an indicator of an individual's general health.

Clauss et al. (2009) [20] is the only previous study where the BC of tapirs was estimated. However, these authors scored captive and obese animals, which prevented them from defining scores to assess animals with poor physical condition. In our study 56% of the captive animals were obese (from slightly to extremely obese), due to either inadequate, high energy diets [20, 39], and to a lack of space to move [39], which make them more vulnerable to colic and constipation [40]. In the wild 15% of the individuals were slim or even cachectic (compared to only one in captivity, an old animal), allowing for a wider range of body condition. Our study thus describes a method for scoring BC in Baird´s tapir, whatever their condition, from cachectic (BS=6) to obese (BS=30).

We recognize that scoring systems include subjectivity; but errors are not necessarily serious, results are often repeatable independently of the experience of the observers and have a minimum variation between observers [8]. In our study, some anatomical regions required that observers be familiarized with tapir anatomy (e.g., the spinal vertebrae and shoulders), but other body parts were similarly scored by all observers.

Body score of wild tapirs of Calakmul

In six years of intensive monitoring of tapirs by camera trap, 80% of photographic records showed animals with an excellent body condition (18-25 points). Despite statistically not different from the BCs of captive tapirs, wild tapirs never reached the maximum score (BC= 30) as happened with captive animals. Tapirs in Calakmul are thus apparently healthy, similar to the wild populations of lowland tapir found by Medici et al. (2014) [34] in the Atlantic forest (77% of individuals with a good body condition), and better than those found in Pantanal (68% of individuals with a good body condition).

Despite the strong contrast between the rain (June to October) and the dry season in the region of Calakmul (February to May) [35], no significant differences were found in the body condition of wild tapirs during both seasons. The harsh dry season would suggest that tapirs, like other herbivores, suffer a decrease in body condition during that season due to the lack of both water and high quality food [36]. In the Calakmul region tapirs probably have large home ranges (e.g. 18.82 km^2 for one male tapir over 2 months in the dry season; Carrillo et al. unpublished data), indicating that they may have to travel a lot to track resources [37]. Travelling such large home ranges might cause variation in fat reserves, especially since males expend a great amount of energy in agonistic interactions related to territoriality [34]. However, the two males we were able to follow over more than two years mantained an excellent body condition throughout the year. The long retention of ingesta by hindgut fermenters such as tapirs increases their digestive efficiency relative to small animals, and allows them to survive on lower-quality foods [38].

Implications for conservation

Non-invasive techniques can help researchers to obtain information about tapirs' health. Because in some parts of Mexico tapirs are now living in areas that are difficult to access [41], it may be complicated to safely capture individuals to obtain direct information about the health of tapirs in the wild. We suggest that visual estimation of BC using photos can be a very valuable tool to asses BC in wild populations of tapir.

Detecting changes in BC of wild, secretive and endangered species, such as tapirs, may allow wildlife managers to detect the early emergence of diseases or very strong seasonal changes (e.g. droughts) that may affect populations. We also expect this tool to help us understanding better the ecological conditions under which the body condition of wild tapirs deteriorates.

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Tabla 1. Criteria and point scores used to assess body condition in Baird's tapir

Region of body	Criteria	BCS	General
	Abundant fat, maxillary edges indistinct, slightly angular, rounded proboscis	5	Obese
	Scarcely distinct jaws, slightly angled edges, rounded proboscis	4	Fat, plump
Head	Moderate amount of fat, moderately distinct maxillary edges, proboscis moderately rounded	3	Moderate/fit
	Small amount of fat, distinct maxillary edges, broad proboscis	2	Thin
	Low fat, very distinct maxillary edges, elongated, proboscis wide and without fat	1	Bony, skeletal
	Thick neck, plenty of fat, vertebrae are not observed	5	Obese
	Thick neck, lower in fat than the previous, inconspicuous vertebrae	4	Fat, plump
Neck	Neck median diameter, moderate amount of fat deposits, more apparent vertebrae	3	Moderate/fit
	"Ewe neck", narrow and slack at base, little fat deposits and more apparent vertebrae	2	Thin
	Marked "ewe" neck, narrow and slack at base, decreased fat deposits and very apparent vertebrae	1	Bony, skeletal
	Rounded shoulders, fat deposits extremely evident	5	Obese
	Slightly rounded, fat deposits evident	4	Fat, plump
Shoulder	Flat and moderately visible the bones structures	3	Moderate/fit
	Thin and the bone structures become more apparent	2	Thin
	Bone structures become extremely visible	1	Bony, skeletal
	Not visible, fatty layer on and between ribs	5	Obese
	Not visible, few fatty layer on and between ribs	4	Fat, plump
Ribs	Few ribs visible towards abdomen; ribs can be felt when performing palpation	3	Moderate/fit
	Visible throughout; all have ridged feel	2	Thin
	Clearly visible with deep depressions between them; very ridged feel	1	Bony, skeletal

Spine	Spine bones not visible. Spine sits in slight depression between fatty bulges left and right of spine	5	Obese
	Spine bones not visible. Spine feels flan; bone and surrounding tissue are on level	4	Fat, plump
	Spine palpable as a slightly elevated bony centre-line	3	Moderate/fit
	Individual spinal vertebrae clearly palpable	2	Thin
	Vertebrae distinguishable by sight and touch (emaciated)	1	Bony, skeletal
Pelvis	Excessive fat around tailhead, hips and pelvic bones very rounded, rotund, skin distended	5	Obese
	Fat around tailhead, hips rounded, pelvic bones covered by soft fat	4	Fat, plump
	Moderate fat around tailhead, hip and pelvic bones, croup well defined	3	Moderate/fit
	Flat tailhead, hip and pelvic bones	2	Thin
	Prominent tailhead, hip and pelvis bones	1	Bony, skeletal

Table 2. Body measurements and body score condition of 11 Baird´s tapir. AS=Africam Safari Zoo, PO*=Payo Obispo 1st immobilization, PO=Payo Obispo 2nd immobilization, CKL=Calakmul, KM20=Calakmul Km20, CZ=Chapultepec Zoo, XT=Xcaret, AE=AluxesEcopark

Individual	Head length (cm)	Neck circunference (cm)	Trunk length (cm)	Thorax circunference (cm)	Abdomen circunference (cm)	Head score	Neck score	Shoulder score	Ribs score	Spine score	Pelvis score	Toral score
Male AS	57	96	174	152	166	4	4	5	5	5	5	28
Female AS	51	83	160.5	169	172	4	5	5	5	5	5	29
Male PO *	48	70.2	134	106	141	3	3	2	3	2	2	15
Male PO	48.5	77	140	135	164	5	5	5	5	5	5	30
Male CKL	42	75	138	120	146	3	3	4	4	3	3	20
Male KM 20	49	62	144	115	132	2	2	2	2	2	2	12
Male CZ	42	84	169	150	140	4	4	5	5	4	4	27
Male XT	50	91.5	158	153	151	5	5	5	5	5	5	30
Female XT	46	85	145	139	150	5	5	5	5	5	5	30
Female AE	50	95	139	150	173	4	4	4	4	4	4	24
Male AE	52	98	162	164	177	5	5	5	5	5	5	30

Table 3. Correlations between body measurements and body scores, and associated p-values (below, within parentheses). Significant correlations are indicated in bold.

Body part	**Body score by anatomical region**					
	Head Score	**Neck Score**	**Ribs Score**	**Shoulder Score**	**Spine Score**	**Pelvis Score**
Head length	0.197 (0.561)	0.240 (0.477)	0.130 (0.703)	0.126 (0.130)	0.376 (0.254)	0.376 (0.254)
Trunk length	0.339 (0.308)	0.381 (0.248)	0.556 (0.076)	0.597 (0.052)	0.573 (0.066)	0.573 (0.066)
Neck circunference	**0.717 (0.013)**	0.683 (0.020)	**0.737 (0.010)**	**0.732 (0.010)**	**0.769 (0.006)**	**0.769 (0.006)**
Thorax Circunference	0.665 (0.026)	**0.768 (0.006)**	**0.774 (0.005)**	**0.813 (0.002)**	**0.842 (0.001)**	**0.842 (0.001)**
Abdomen Circunference	0.592 (0.055)	0.668 (0.025)	0585 (0.059)	0.585 (0.059)	**0.705 (0.015)**	**0.705 (0.015)**

Figures

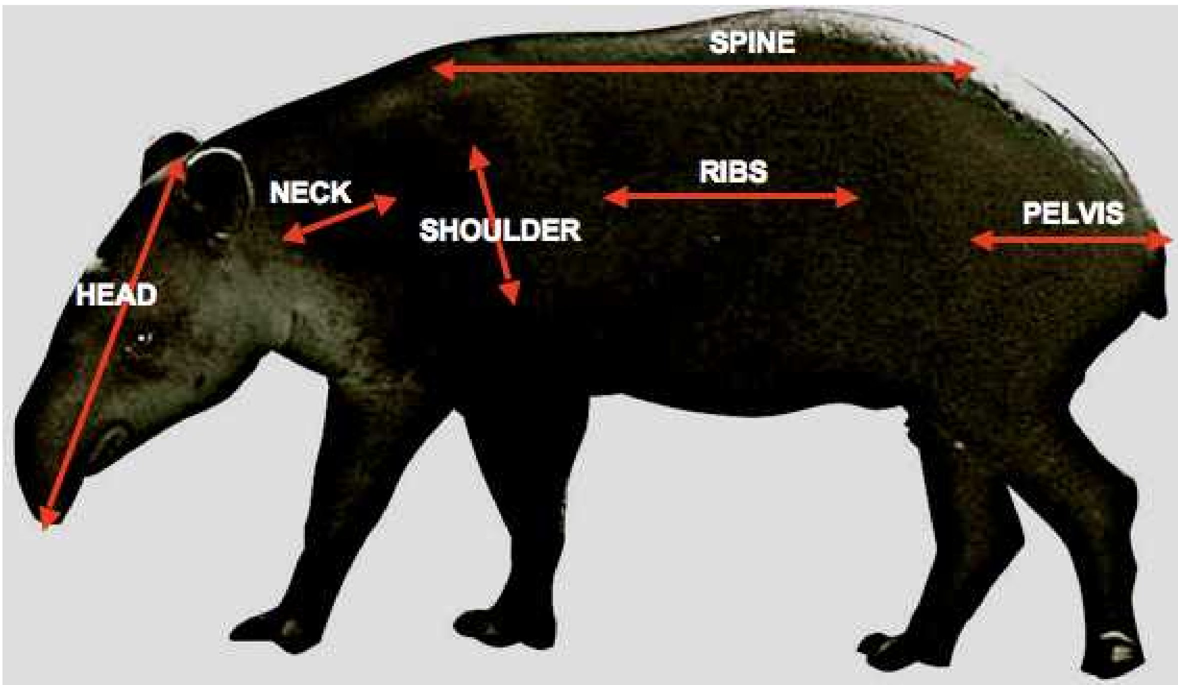

Figure 1. Anatomical regions selected for the assessment of body condition in Baird´s tapir

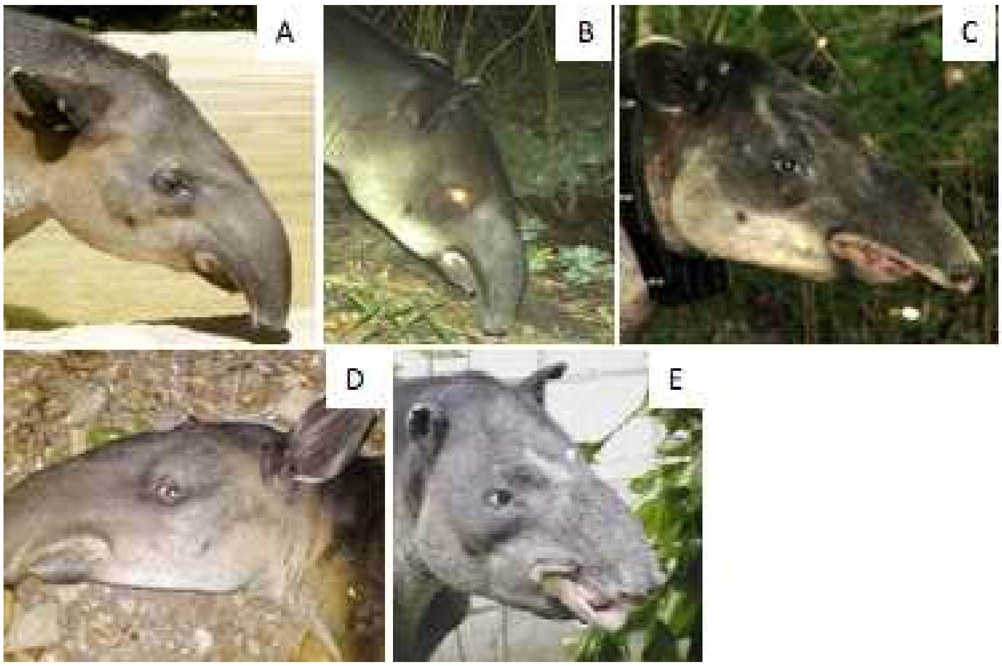

Figure 2. Head configuration of Baird´s tapir showing skull structures and shape of the proboscis. Following table 1, A=5 points. B=4 points. C=3 points. D=2 points and E=1 point.

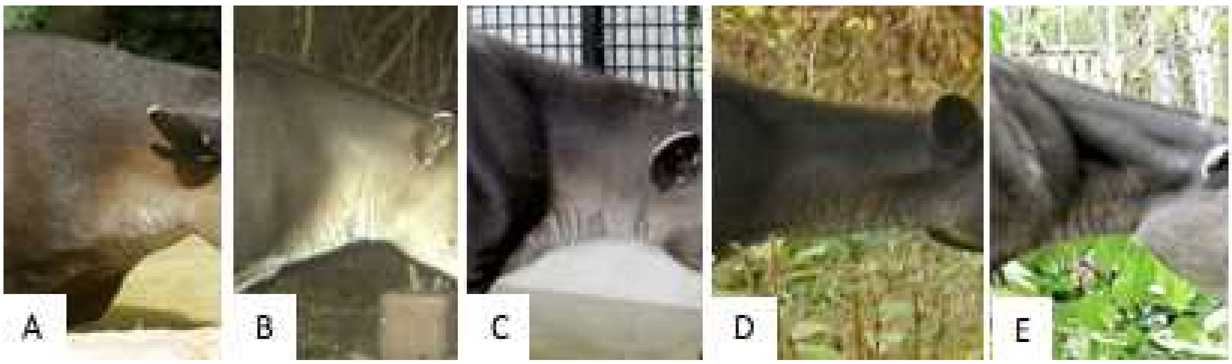

Figure 3. The degrees of visibility of the muscles of the neck of Baird´s tapir, from an obese animal to an emaciated. Following table 1, A=5 points. B=4 points. C=3 points. D=2 points and E=1 point.

Figure 4. The degrees of visibility of the bone structures and muscles of the shoulder, from an obese animal to an emaciated. Following table 1, A=5 points. B=4 points. C=3 points. D=2 points and E=1 point.

Figure 5. The degrees of visibility of the ribs from an obese to an emaciated animal. Following table 1, A= 5 points. B=4 points. C=3 points. D=2 points and E=1 point.

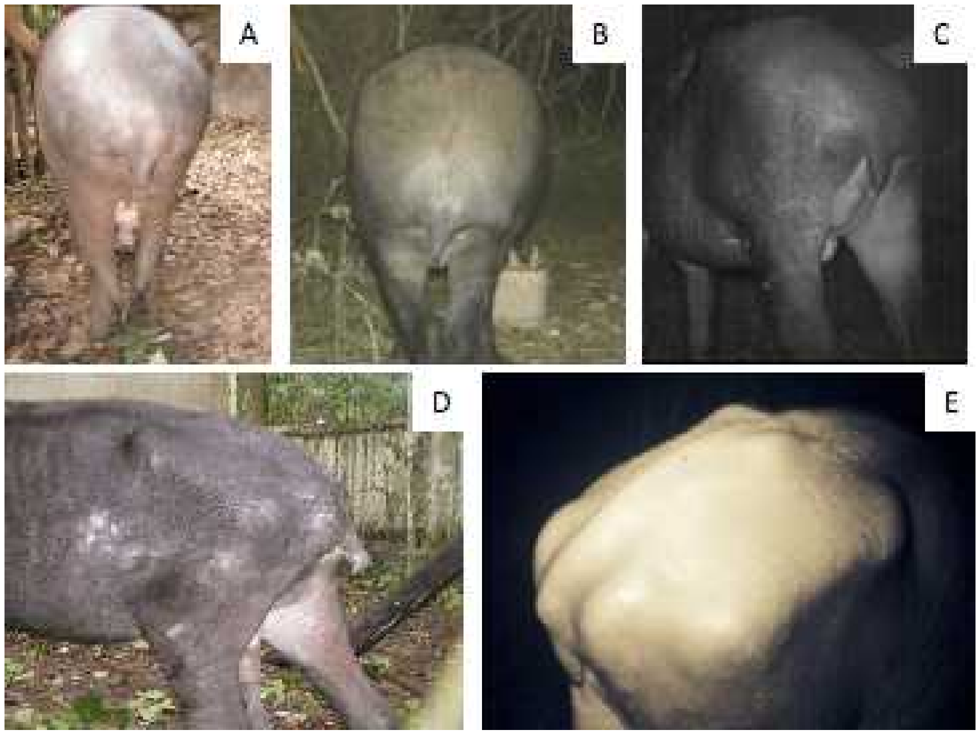

Figure 6. The degrees of visibility of the pelvic bones, tail and the spines of the vertebrae, this area is where tapirs acumulate a great amount of fat deposits. From an obese to an emaciated animal. Following table 1, A=5 points. B=4 points. C=3 points. D=2 points and E=1 point.

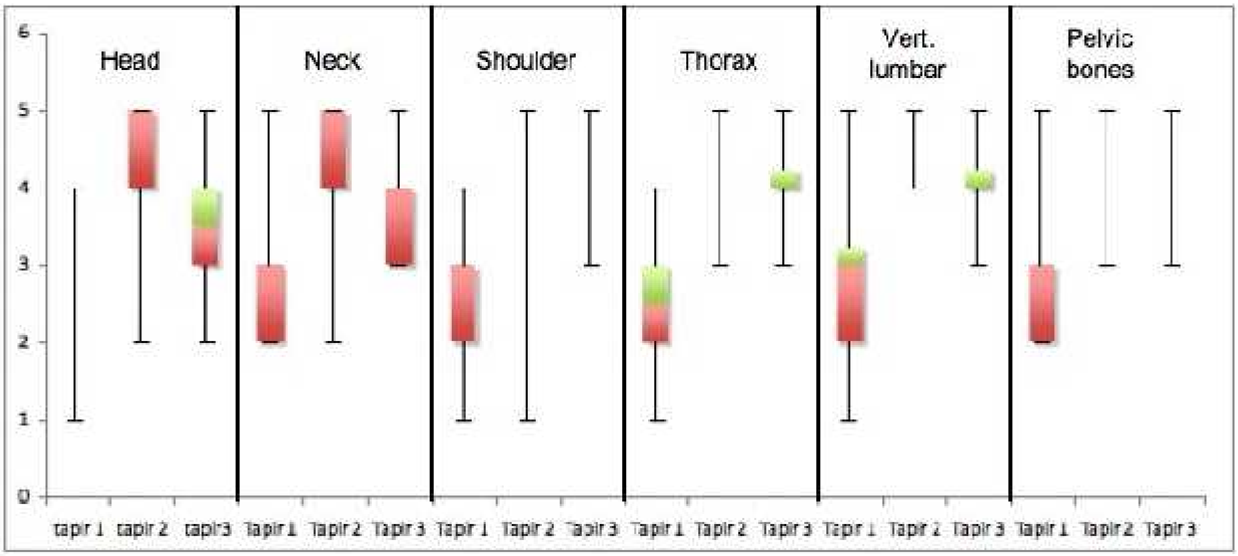

Figure 7. Boxplot of Body Condition Scoring of three Baird´s tapir, results of the exercise performed by the MTSG. Five anatomic regions were evaluated by 20 members. Scores range from 1 to 5.

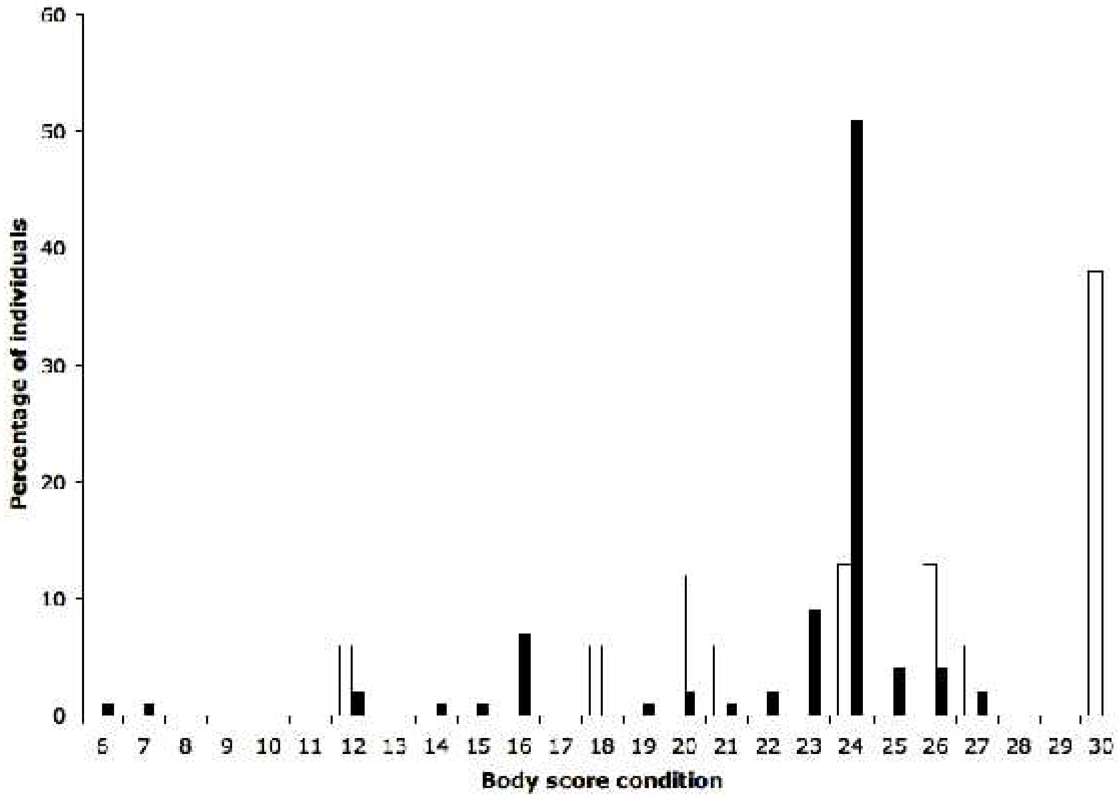

Figure 8. Body score condition of wild (black) and captive (white) tapirs.

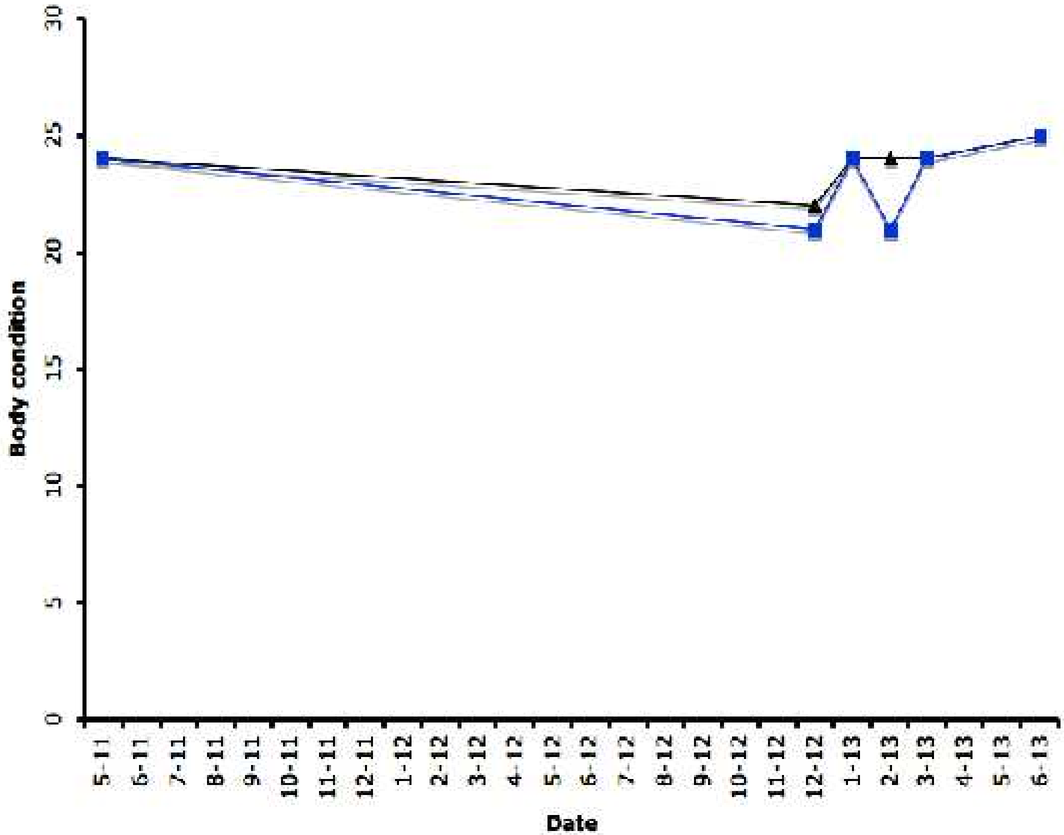

Figure 9. Body score condition of two males through three years of camera trap study in Calakmul region. In black the ear cut male and in blue the radio collares male.

III. Conclusiones

La aplicación del sistema de evaluación de la CC, demostró ser de gran utilidad para observar los cambios en la condición corporal de Ios tapires centroamericanos que habitan la RBC. Este tipo de sistemas han probado ser una herramienta útil para conocer el estado nutricional de especies domésticas (Herd y Sprott 1987; Carroll y Huntington 1988; Honhold et al., 1989; Sanson et al., 1993; Ferguson et al., 1994; Domecq et al., 1995; Ferguson, 1996) y no domésticas (Gallivan et al., 1995; Gerhart et al., 1996; Reuter y Adcock 1998; Cook et al., 2001, 2007; Ezenwa et al., 2009). En nuestro caso, la mayoría de las regiones anatómicas fueron fácilmente calificadas, aunque algunas, como la parte de las vertebras y el hombro, necesitan ser evaluadas por gente que esté familiarizada con la anatomía y el manejo de la especie. De esta manera, fue posible evaluar la CC de los tapires fotografiados por medio de cámaras trampa, mostrando que la evaluación de la CC puede ser usada cómo un indicador del estado de salud de los tapires en la RBC con el uso de técnica no invasivas.

El 80% de los tapires evaluados, por medio del foto-trampeo, presentaron una excelente condición corporal, resultado similar a lo reportado por Medici y colaboradores (2014) en Brasil, quienes por medio de métodos invasivos encontraron un 77% de individuos con buena CC en la Mata Atlántica y 68% en el Pantanal. Nuestro estudio sugiere que los tapires en la RBC están sanos; sin embargo, se recomienda hacer más estudios para comprobar si las enfermedades emergentes afectan la viablidad de la población (Medici et al., 2007), así como aumentar el número de muestras y el área geográfica cubierta. La CC de los tapires en la RBC no cambió a pesar de que en esta zona, la temporada de secas y lluvias son muy diferentes y la primera presenta limitantes para la especie, debido a la escasez de agua y alimentos de buena calidad. Sin embargo existen estrategias ecológicas como la que mencionan Illius y Gordon (1992) donde los fermentadores postgástricos pueden incrementar su eficiencia digestiva y permitirles sobrevivir al alimentarse de comida de baja calidad, lo que sugiere que cuando los tapires ya no encuentran comida de alta calidad, buscan lugares con alimentos de menor calidad. En conclusión, el presente estudio permite suponer que los animales con una pobre CC están afectados por una enfermedad más que por carencia alimenticia ligada a una falta de recursos.

Al llevar a cabo la comparación de la CC entre los tapires de vida libre y los de cautiverio no se detectó ninguna diferencia. Sin embargo, la mayoría de los tapires en cautiverio tienden a la obesidad, debido al alto consumo de dietas ricas en carbohidratos y bajas en fibra (Clauss et al., 2009). Esto indica que la composición de la dieta y la cantidad de espacio requerido para mantener a esta especie en cautiverio no son adecuados, ya que los tapires en vida silvestre recorren grandes distancias en busca de alimentos y gastan una gran cantidad de energía en encuentros agonísticos intra e interespecíficos (Medici et al., 2014).

Las correlaciones encontradas entre las evaluaciones de la CC y las medidas corporales, nos sugieren que la combinación de estas variables puede ser un excelente estimador para predecir la CC en los tapires. Estos resultados nos indican que las técnicas no invasivas pueden ayudar a los investigadores a obtener información acerca de la salud de las poblaciones de tapires que parecen inaccesibles. Es necesario, sin embargo, seguir mejorando esta técnica para que sea una herramienta util para la evaluación de la CC de las poblaciones de tapires en vida libre.

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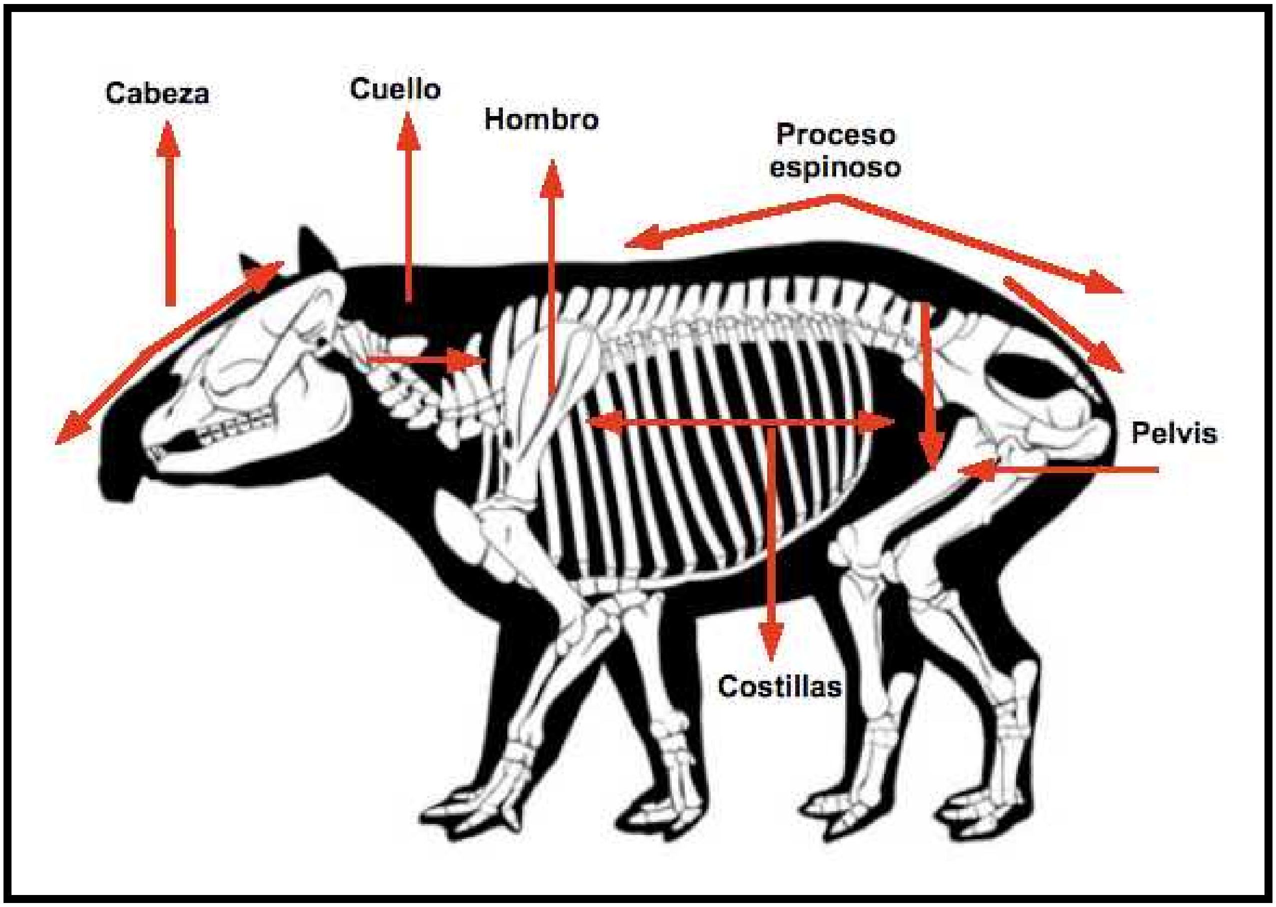
Anexo 1

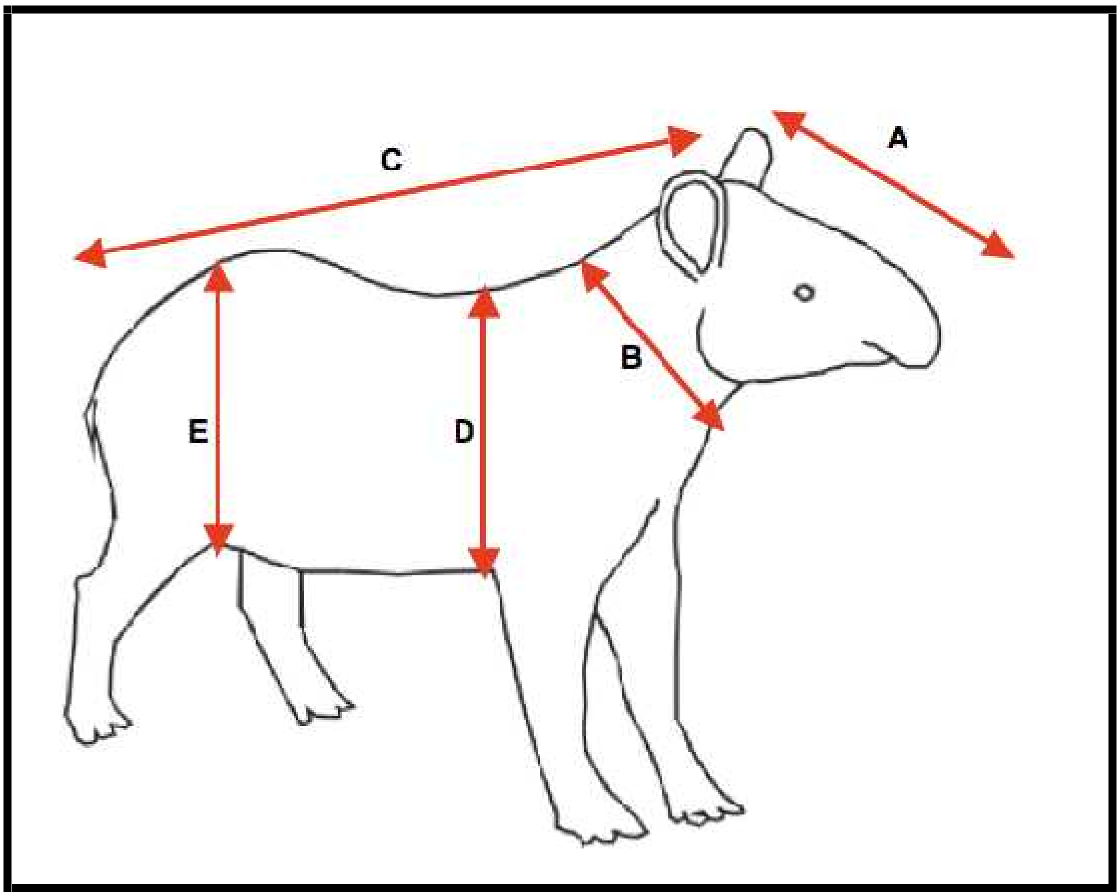
Estructuras óseas donde se almacena el tejido muscular y el adiposo en el tapir centroamericano.



Anexo 2

Regiones anatómicas donde se toman las medidas morfométricas en el tapir centroamericano:

A) Longitud total del cráneo, B) Circunferencia del cuello, C) Longitud total de la base de la cola a donde inicia el cráneo, D) Circunferencia del tórax y E) Circunferencia del abdomen.



Anexo 3

Artículo sometido al Journal Tropical Conservation Science.

Tropical Conservation Science Journal abril 1 a las 5:50 PM

Para Jonathan Perez Flores, johnspf77@yahoo.com.mx

Thank you for submitting your manuscript for possible publication in Tropical Conservation Science. Please use this tracking number - **TCS664-2015** - in all subsequent correspondence with us.

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Best wishes
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