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Jaguar's Predation and Human Shield, a Tapir Story

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Abstract: Despite the risks associated, some species choose to shield behind a predator to decrease predation risk by another predator. In this study, we demonstrate how Baird's tapirs (*Tapirus bairdii*) use humans as a "shield" to reduce the risk of being preyed upon by jaguars (*Panthera onca*). We collected georeferenced photographic records of 23 tapirs (seven of them injured) sighted near human settlements (0 to 5 km) in the Calakmul region of Mexico from 2008 to 2019. Using multidimensional scale analysis, we determined which possible factors (tapir health status, injuries, distance to the settlement, as well as seasonality) are related to the decision of tapirs to approach human settlements. To support our claims of jaguars' attacks, we described the pattern of injuries believed to have been inflicted by jaguars on tapirs, and we analysed photographs and videos of species of the genus *Panthera* attacking larger prey than themselves to establish a pattern of injuries and compare it to the injuries observed on tapirs. Our study shows that tapir sightings near human settlements are related to health deterioration, injuries by jaguars and seasonality. The injuries found on tapirs are similar to those caused by other big cats on large prey, providing strong support for jaguar-inflicted wounds. Further studies should investigate whether the increasing human presence in different habitats in the Neotropical region could be influencing the behaviour and distribution of prey and predators.

Keywords: anti-predator strategy; Calakmul; injury pattern; neotropical ungulate; *Tapirus bairdii*

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1. Introduction

Predators influence the behaviour, life and morphological traits of prey species [1–3]. The behavioural response of prey species to predators is termed "anti-predator behaviour", and such strategy is related to avoid detection, capture and consumption [4,5]. Some strategies are based on developing close interspecific associations, in which organisms of one species seek the protection of organisms of another species to reduce the risk of predation. In African savannas, the conformation of mixed-species herds of wild herbivores reduces the risk of predation through a dilution effect or collective vigilance [6–8]. Another example is the shielding provided by large spiders to microhylids (narrow mouthed frogs) against their predators (snakes, lizards, spiders and other invertebrates) [9–11]. Although they are potential predators, humans may also be used by some species as a "shield" to avoid other predators [12]. This "shield" is an area associated with human presence and activity that is avoided by predators, where the risk of natural predation decreases and prey can obtain resources such as food, water and shelter [13,14]. This strategy is based on large predators' aversion to humans, which is usually related to their past or present persecution [15,16] or even extermination [17,18].

While tropical forests support the greatest biodiversity [19], the most complex food webs [20], and many human populations, no cases of species using a human shield have been reported in these ecosystems. All species for which the human shield hypothesis has been invoked live outside tropical forests: elk (*Cervus elaphus*) and wolves (*Canis lupus*) in the Canadian Rocky Mountains, Canada [21]; moose (*Alces alces*) and grizzly bears (*Ursus arctos horribilis*) in Grand Teton National Park, USA [12]; American black bear (*Ursus americanus*) and grizzly bears in Grand Teton National Park, USA [22]; mule deer (*Odocoileus hemionus*) and coyotes (*Canis latrans*) in Elk Mountains, USA [23]; mountain goats (*Oreamnos americanus*) and grizzly bears in Glacier National Park, USA [24]; roe deer (*Capreolus capreolus*) and lynx (*Lynx lynx*) in southern Norway [25]; and mountain nyala (*Tragelaphus buxtoni)* and spotted hyena (*Crocuta crocuta*) in Bale Mountains National Park, Ethiopia [14].

The apex predators of neotropical forests are crocodiles and big cats, i.e., jaguar (*Panthera onca*) and puma (*Puma concolor*). The jaguar is the biggest terrestrial predator in these ecosystems, preying on up to 85 species, with a preference for large and medium-sized prey [26,27]. Jaguars prey on wild and domestic animals, with tapirs featuring as uncommon prey [27–34]. The anatomical regions that jaguars attack most are the hindlegs and pelvis, as they stalk and ambush, rather than chase their prey [35]. Jaguars attack larger prey from the blind spot, jumping on them and trying to bite the back of their necks [36].

Baird's tapir (*Tapirus bairdii*) is considered the largest natural prey species of jaguar in the tropical forests of Mesoamerica [37,38], but only one record of predation of Baird's tapir by jaguar is reported in the literature [34]. Jaguars usually kill prey weighing in the range of 45–100 kg by biting their skulls to damage the central nervous system or their necks (dorsal, ventral or lateral) to suffocate and drag them [27,34,39–41]. However, there is a lack of information about how jaguars attack larger animals such as tapirs (>200 kg) and the type of wounds they are able to cause. Such knowledge would be helpful to determine if a tapir was attacked by a jaguar or another species (including humans).

The Calakmul region of Mexico hosts presumably the largest population of tapirs and jaguars in this country [38]. In Calakmul, water availability determines the distribution, abundance, movements, activity patterns, interactions and health of several species [42–46]. The only sources of water for wildlife in this region are natural and artificial ponds, a few permanent or semi-permanent streams, and holes in the limestone. Most of these water bodies are seasonal, filling up in the rainy season and drying out or shrinking during the dry season. It is noteworthy that the communal lands surrounding the Calakmul Biosphere Reserve (CBR), after which the whole larger region is named, have more water resources (larger and more permanent waterholes) than the core of the reserve [47].

In recent years, there has been a growing number of low body condition or injured tapirs approaching human settlements in the Calakmul region. Most of the lesions present in the injured tapirs were recent (between 1 and 7 days old, as indicated by red, moist wounds, etc.), so we believe they were inflicted once the animals were already in a low body condition. We hypothesize that these tapirs approached human settlements in search of water and protection. To our knowledge, there is no evidence of any tropical forest species using humans as a shield to reduce the risk of predation. Here, we demonstrate how Baird's tapirs use humans as a shield against predators (jaguars) or to obtain resources (water and food) when they are sick or injured. We also determined if wounds could be caused by jaguars by comparing them with wounds inflicted by species of the genus *Panthera* on prey more than twice their own size and weight.

2. Material and Methods

2.1. Study Site

The Calakmul Region is a tropical forest in the Yucatan Peninsula that comprises the Calakmul Biosphere Reserve (CBR), 157 settlements and one small city (Xpujil) (19°12–17°48′ N, 89°09′–90°28′ W) (Figure 1). As a result of the well-conserved status of its forests, the Calakmul Region is considered key to the conservation of biodiversity in Mesoamerica [48]. Some of the settlements surrounding the CBR have large tracts of well-conserved forest;

however, anthropogenic activities that threaten wildlife also occur [49]. These activities include agriculture, non-timber forest extraction, cattle ranching and subsistence hunting [50].

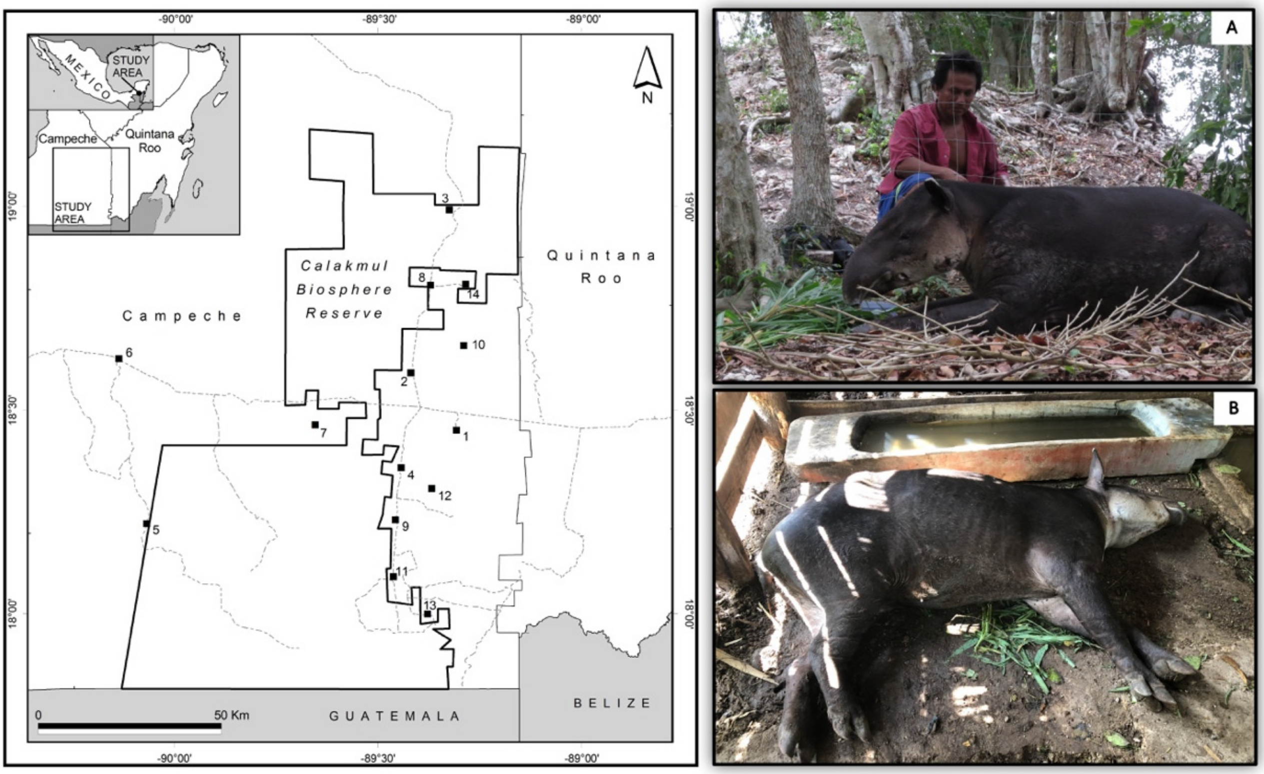

Figure 1. Location of the 14 settlements where Baird's tapirs (*Tapirus bairdii*) were sighted during 2008 to 2019 in the municipality of Calakmul, Campeche, Mexico. (1) 20 de Noviembre, (2) Alvaro Obregón, (3) Bel-ha, (4) Castilla Brito, (5) Concepción, (6) Constitución, (7) Emiliano Zapata, (8) Nueva Vida, (9) Narciso Mendoza, (10) Nuevo Becal, (11) Once de Mayo, (12) El Refugio, (13) Sacrificio, and (14) Unión 20 de Junio. (**A**) People caring for a tapir injured by a jaguar in the community of Nueva Vida; and (**B**) Tapir resting in a pen in the community of Bel ha.

2.2. Tapir Sightings Close to Human Settlements

We started recording sightings of tapirs in 2008, noticing that they had become more common in the communal lands of Calakmul. The corresponding database includes the name of the person who reported the tapir (local inhabitants, researchers, rangers, police or tourists), the date, location and distance to the nearest human settlement of the sighting, and the age class, sex and health status of the individual observed. To determine health status, we scored the body condition using the technique developed by Pérez-Flores et al. [45] for Baird's tapir. This technique is based on a visual assessment of the appearance of the fat and muscles of six anatomical regions (head, neck, shoulders, ribs, spine and pelvic bones). A score (1 to 5 points) is assigned to each region, and their sum provides the body condition score (range = 6 to 30 points) of a given individual. After scoring all individuals, we classified them into two groups: healthy tapirs (body score condition ranging from 19 to 30 points) and unhealthy tapirs (body score condition 18 points or less) (see in detail [45,49]).

2.3. How Do We Recognize a Jaguar's Attack on a Tapir?

Several studies have documented that species of the genus *Panthera* (i.e., lion *Panthera leo*, tiger *Panthera tigris*, leopard *Panthera pardus*, snow leopard *Panthera uncia*, and jaguar *P. onca*) can prey on species heavier and larger than themselves [26,27,51–54]. To the best of our knowledge, however, there is no description in the scientific literature of the pattern of injuries inflicted on this type of prey by these predators. For this reason, we analysed videos

(n = 101) and photographs (n = 285) found on a social networking website (YouTube) and a search engine (Google) to observe how they attack and to establish a pattern of injuries. We found photographic records or videos of lions, tigers and snow leopards attacking large-sized prey, but none of jaguars. In the case of lions, we only analysed the videos and photos where a single lion attacked a prey.

In order to establish a pattern of injuries, we divided prey bodies into eight anatomical regions (head, neck, shoulder, forelegs, spine, ribs, pelvis and hindlegs) and documented which regions these big cats most frequently attack. We repeated the same procedure with 7 injured tapirs out of the 23 recorded from Calakmul to compare their wounds with those inflicted by big cats on other prey. The severity of the lesions of each anatomical region were scored as following: minor (1), moderate (2), serious (3), severe (4), critical (5) and fatal (6).

2.4. Human Shield

To test whether unhealthy tapirs came closer to humans, we grouped the sightings into three categories according to the distance they were recorded from the nearest human settlement: 0 to 0.5 km, human shield (HS); >0.5 km to 5 km, human activity area (HA) where there is a high probability of human presence; and >5 km, low human activity (LHA), where there is a low probability of human presence (Figure 2). To determine the categories, we measured the distance between each of the settlements in the Calakmul region with more than 40 inhabitants using software QGIS version 3.16 Hannover with the analysing tool "Distance Matrix" and used information on the range of subsistence hunting in the region [55]. The average distance between the 79 settlements was 4.77 km (range = 0.275 to 134.5 km, SD = 30.4 km).

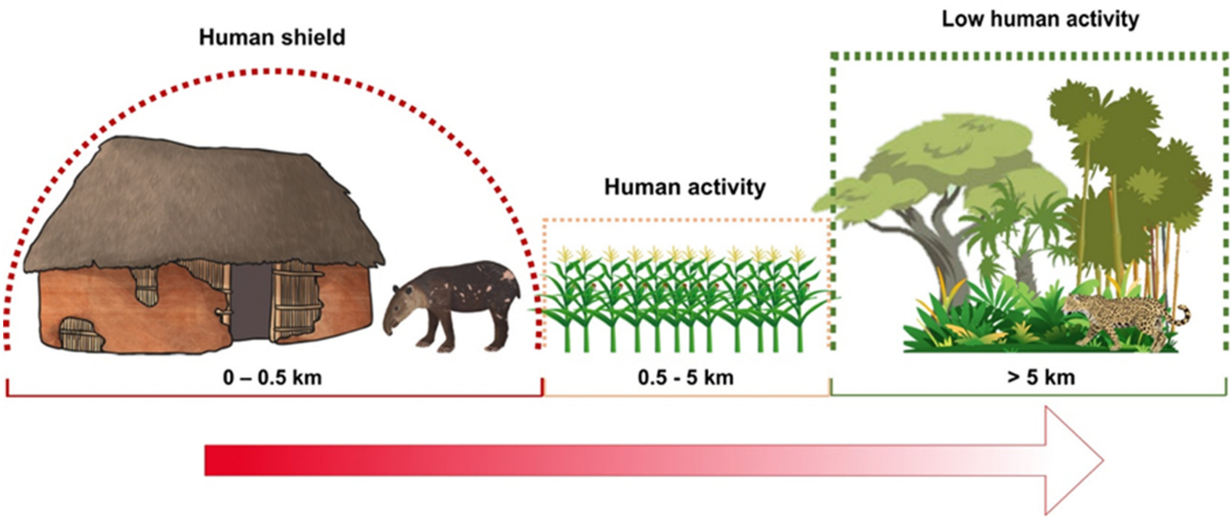

Figure 2. Schematic drawing of the categories of human activities based on their distance to human settlements where healthy and unhealthy tapirs were observed in the region of Calakmul, Campeche, Mexico. Human shield: 0 to 0.5 km; Human activity: >0.5 to 5 km; and Low human activity: >5 km).

2.5. Statistical Analyses

We used a G-test to test for differences in the number of individuals observed between the area with human activity (settlement: Hs and crops, apiaries, etc.: HA) and the forest with low human activity (LHA). The same test was used to determine if the proportion of injured individuals differed from random expectation in each category (HS, HA, LHA). A multidimensional scaling (MDS) analysis, based on a correlation matrix, was used to explore relationships among health status (healthy and unhealthy), injuries (injured and not injured), seasonality (dry and rainy) and sighting distance (HS, HA and LHA). This analysis allows to show the relative positions among variables, hence their relationships, where shorter distances represent higher correlations. All analyses were performed using Statistica 7.0.

3. Results

Of the 23 tapir sightings recorded near or inside 14 settlements in the region of Calakmul, 21 were adults (91.3%) and two were calves (8.7%). Fourteen of these individuals (60.9%) were in poor body condition (dehydrated, emaciated, low alertness and responsiveness). Seven tapirs (30.4%) had wounds (six males and one female), all of which were classified as unhealthy (Figure 3). Eighteen records (78.3%) occurred during the dry season (December to May). The HS areas have the highest number of sightings (n = 10) and the highest proportion of unhealthy tapirs (90%). In the HS areas, 80% of recorded tapirs were males and 20% were females. HA and LHA areas have, respectively, 62% and 40% of unhealthy tapirs (Table 1). The sex of the individuals could not be identified in these two categories of areas. As expected, more individuals were sighted in areas with human activity (HS or HA) than in areas with low human activity (LHA) (G-test 18 vs. 5, $G = 7.79$, $df = 1$, $p = 0.005$). In HS areas, most of the tapirs observed were unhealthy (G-test 9 vs. 1, $G = 7.3$, $df = 1$, $p = 0.006$), whereas in HA and LHA, the numbers of unhealthy and healthy tapirs were similar (HA, G-test 5 vs. 3, $G = 0.5$, $df = 1$, $p = 0.47$; LHA, G-test 2 vs. 3, $G = 0.2$, $df = 1$, $p = 0.65$).

Figure 3. Tapirs injured sighted in settlements of Calakmul, Mexico. Tapirs presented different levels of severity of injuries. (**A**) Female tapir found in the settlement of Nueva Vida in 2017; (**B**) Male tapir found close to the settlement of Alvaro Obregon in 2015; (**C**) Male tapir sighted close to the settlement of 20 de Noviembre in 2020; and (**D**) Male tapir close to the settlement of Once de Mayo in 2019.

Table 1. Classification of tapir sightings according to the distance to the nearest human settlement where they were recorded. HS = human shield, HA = human activity and LHA = low human activity.

Area	Number of Individuals		
	Total	**Unhealthy *n* (%)**	**Healthy *n* (%)**
HS (0 to 0.5 km)	10	9 (90%)	1 (10%)
HA (>0.5 km to 5 km)	8	5 (62%)	48 (3%)
LHA (>5 km)	5	2 (40%)	3 (60%)

We found that the anatomical regions most frequently attacked by lions, tigers and snow leopards are the pelvis, hindlegs, neck, spine, and less frequently, the head and forelegs (Table 2). In the seven tapirs presumably attacked by jaguars in the Calakmul region, the anatomical regions most frequently wounded were the pelvis (100%), hindlegs (100%) and the head (86%) (Table 3; Figure 4), similar to the anatomical regions of prey attacked by other big cats (Figure 5). The severity of the lesions varied largely among tapirs (Table 3; Supplementary Figures S1–S5).

Table 2. Anatomical regions injured in attacks of species of the genus *Panthera* on prey species larger and heavier than them. H = head, N = neck, SH = shoulder, FL = forelegs, SP = spine, R = ribs, P = pelvis and HL = hindlegs. +Sea turtle species.

Predator Species (Body Mass) (kg)	Prey		
	Species	Body Mass (kg)	Injured Anatomical Region
P. leo (110–225)	*Tragelaphus oryx*	350–1000	N, SP, R, P, HL
	Syncerus caffer	500–1000	H, N, SH, SP, R, P, HL
	Giraffa camelopardalis	800–1200	N, P, HL
	Diceros bicornis	800–1400	SP, P, HL
	Hippopotamus amphibious	1300–1500	SP, P, HL
	Ceratotherium simum	1700–2300	P, HL
	Loxodonta africana	3000–6000	H, SP, P, HL
P. tigris (65–300)	*Tapirus indicus*	250–540	–
	Alces alces	270–771	–
	Bos javanicus	590–800	H, N, SH
	Bubalus bubalis	300–1000	N
	Bos gaurus	440–1500	N, SP, P, HL
	Rhinoceros unicornis	1500–2000	P, HL
	Elephas maximus	2000–6000	H
P. pardus (25–80)	*Tapirus indicus*	250–540	–
P. onca (40–60)	+*Eretmochelys imbricata*	35–127	H, N, FL
	+*Chelonia mydas*	150–200	H, N, FL
	Tapirus bairdii	150–300	H, N, SH, FL, SP, R, P, HL
	+*Dermochelys coriacea*	250–900	H, N, FL
P. uncia (22–75)	*Capra ibex sibirica*	30–130	H, FL
	Ovis ammon	60–185	–
	Sus scrofa	66–272	–
	Equus hemionus	200–262	–
	Bos mutus	305–1200	N

Table 3. Description of the cases of Baird's tapirs presumably attacked by jaguars in Calakmul, Mexico. M = male, F = female, U = unhealthy, H = head, N = neck, SH = shoulder, FL = forelegs, SP = spine, R = ribs, P = pelvis and HL = hindlegs. The severity of lesions is given in the same order as the anatomical regions injured, with the following scores: minor (1), moderate (2), serious (3), severe (4), critical (5) and fatal (6).

Individual Identification	Sex	Body Condition	Anatomical Region Injured	Severity of Lesions
20 de Noviembre 1	M	U	H, N, P, HL	3, 1, 2, 2
20 de Noviembre 2	M	U	H, N, SH, R, P, HL	3, 1, 2, 5, 2, 4
20 de Noviembre 3	M	U	H, SH, SP, R, P, HL	2, 2, 5, 3, 5, 5
Alvaro Obregon	M	U	H, SH, SP, R, P, HL	1, 2, 2, 2, 3, 3
Nuevo Becal	M	U	P, HL	2, 2
Nueva Vida	F	U	H, N, SH, FL, R, P, HL	2, 1, 3, 2, 2, 3, 2
Once de Mayo	M	U	H, N, SH, FL, SP, R, P, HL	4, 2, 5, 5, 5, 5, 5, 5

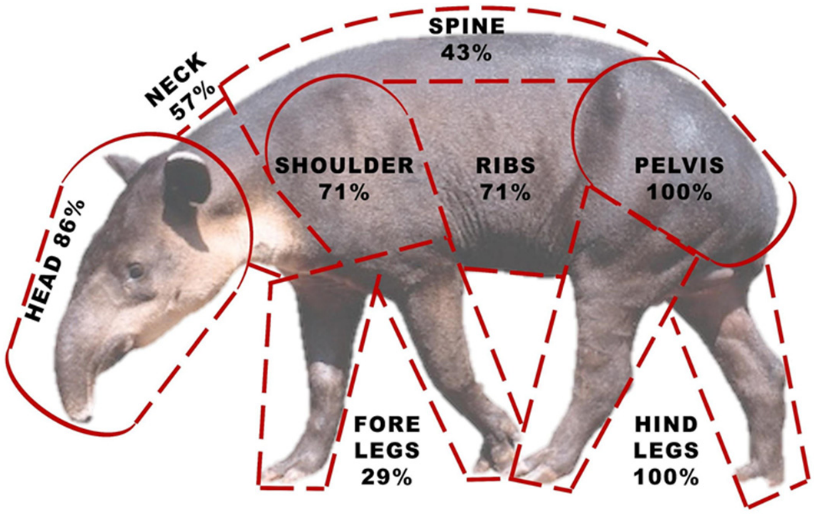

Figure 4. Division of the body into eight anatomical regions to determine the pattern of injuries: head, neck, shoulder, forelegs, spine, ribs, pelvis and hindlegs. It also shows the frequency of injuries observed in tapirs presumably attacked by jaguars in Calakmul, Mexico.

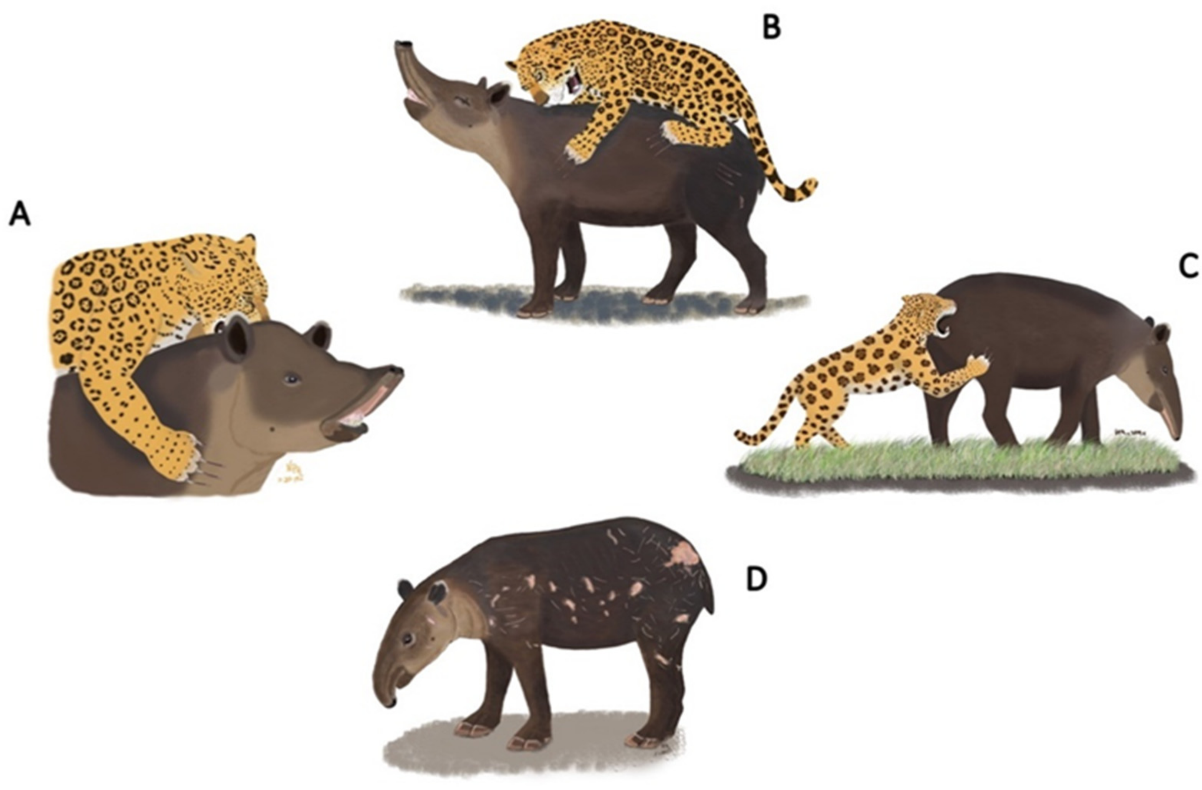

Figure 5. Recreation of an attack of jaguar on Baird's tapir. Jaguars attack different anatomical regions: (**A**) jaguar biting and scratching the head and neck, (**B**) jaguar biting the back and scratching the body, (**C**) jaguar biting and scratching the rump and hindlegs, and (**D**) injured tapir after a jaguar attack.

The MDS analysis clearly indicated an association between unhealthy individuals, dry season, injuries, and HS, while good health was associated with HA and the rainy season, and the lack of injuries was associated with LHA and the rainy season (Figure 6).

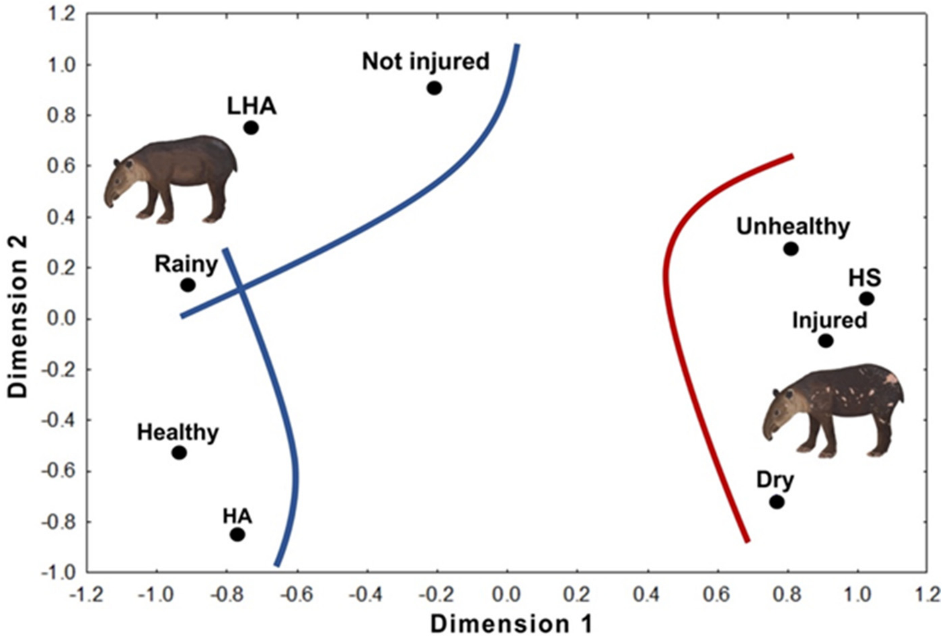

Figure 6. Distribution of the variables (seasonality, health, injuries and categories of areas based on the distance to settlements). The blue curves include variables associated with healthy or uninjured individuals. The red curve congregates variables associated with unhealthy individuals. HS = human shield, HA = human activity and LHA = low human activity.

4. Discussion

We showed that tapirs may use humans as a shield against jaguars by tapirs. This occurred despite healthy tapirs generally avoiding humans, especially in places with high hunting pressure [38]. We found that tapir sightings near human settlements in Calakmul are related to health deterioration, injuries and seasonality. We observed a pattern of injuries in tapirs similar to that caused by big cats on large prey and therefore likely inflicted by jaguars. Our results suggest that unhealthy and injured tapirs approach human settlements in search of protection from jaguars or resources such as water, despite the risk of being hunted.

The hypothesis postulated by Berger [12] in which prey species reduce the risk of predation by increasing the spatio-temporal overlap with people is congruent with the behaviour demonstrated by tapirs in Calakmul. Tapirs seem to adopt the strategy of approaching humans or human infrastructures to evade jaguars and increase their probability of survival, as has been previously reported in other ungulates [3,56,57]. Furthermore, the use of areas with increased human presence seems to be influenced by the vulnerability of tapirs to predation (e.g., when they are young <1 year, senile, sick or in poor physical condition) [34]. These direct and indirect effects of humans on the predator–prey relationships could have important implications for species conservation and management [58].

Several species relate humans to potential sources of food, water, shelter, and protection from predators [13,14,59–61]. Most of the tapirs sighted wandering the villages allowed people to approach to give them food or water. In fact, three-quarters of all sightings occurred during the dry season, when water is very scarce and food is usually of poor quality; more than half were recorded during 2019 alone, one of the years with the lowest rainfall in the last decade (626.6 mm; mean annual precipitation is 1076 mm) [46], following several years of drought caused by a large El Niño event. Most of these tapirs were also unhealthy and injured. This is consistent with the high probability of finding unhealthy tapirs in anthropogenic habitats reported by Pérez-Flores et al. [49], although they did not find a relationship between health status and drought [45,49].

The docility of tapirs wandering within settlements contrasts with the numerous records of attacks on humans by wild and captive tapirs [62–64]. We hypothesise that this lack of aggression may be due to a "trade-off" with the immune system. Aggressive and anti-predator behaviours are energetically expensive [65,66]; therefore, unhealthy animals suppress these behaviours to conserve energy for their immune system. Although tapirs sometimes become aggressive after full recovery (i.e., six to nine months after wounds are healed and when they reach approximatively 200 kg), they remain docile while in poor condition or injured, allowing medical procedures without the use of anaesthetic drugs (JPF and SC personal observations).

Most tapirs recorded in the HS areas were unhealthy males (80%). In animal populations, disease-induced mortality is male-biased [67,68]. In mammals, this difference is linked to a sex steroid immune response: in males, androgens (testosterone) suppress disease defences and regulate reproductive trade-offs [69–71]. Behavioural differences between male and female tapirs may increase their risk of injuries or disease. For instance, male tapirs do not tolerate other males in their territory and expend a great amount of energy in agonistic interactions [72]. Those fights can cause serious injuries inflicted by their well-developed canines and incisors [73].

The highest proportion of unhealthy tapirs (90%) was registered within 5 km of the settlements, in what we considered the "Human Shield area", suggesting that health deterioration is related to decreasing fear of humans, as they become sick and weak and then more vulnerable to jaguar attacks. We have observed (through monitoring with GPS collars) that when these tapirs are returned to the forest before being 100% recovered, they are predated by jaguars within approximately 30 days (SC and JPF personal observations; Wilber Martinez personal communication). This strategy to avoid the risk of predation seems to be quite effective, since jaguars rarely approach human settlements in this region [74].

Our findings reveal that despite being hunted by humans, tapirs choose to find refuge in areas frequented by humans rather than taking the chance of facing a jaguar. Similar behaviours have been documented in elks from Banff National Park, Canada, which are attracted to areas with high human activities to avoid predation by wolves [21,75]. However, the success of the "human shield" may vary according to the negative effects associated with humans (e.g., hunting, poisoning). For tapirs, fearing a jaguar more than a human could be part of the experience and learning in a tapir's life. Encounters between humans and tapirs are usually without consequences (for both) but are sometimes fatal for tapirs, as hunters shoot them in the head at a close range (JPF personal observation). Solitary tapirs may therefore not learn from human dangerousness, which may also explain why they prefer to take refuge with humans than face a jaguar.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/d14121103/s1, Figure S1. Tapirs presenting different levels of severity of injuries in the head. (**A**) Minor lesions, (**B**) moderate lesions, (**C**) serious lesions, and (**D**) severe lesions (notice the lack of the auricular pavilion). Figure S2. Tapirs presenting different levels of severity of injuries in the shoulder. (**A**) Minor lesions, (**B**) moderate lesions, (**C**) serious lesions, and (**D**) critical lesions. Figure S3. Tapirs presenting different levels of severity of injuries in the thorax. (**A**) Minor lesions, (**B**) moderate lesions, (**C**) serious lesions, and (**D**) critical lesions. Figure S4. Tapirs presenting different levels of severity of injuries in the spine. (**A**) Minor lesions, (**B**) moderate lesions, (**C**) serious lesions, and (**D**) critical lesions. Figure S5. Tapirs presenting different levels of severity of injuries in the hindlegs. (**A**) Minor lesions, (**B**) moderate lesions, (**C**) serious lesions, and (**D**) severe lesions.

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Conflicts of Interest: The authors declare no conflict of interest.

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