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Mutualistic relationship between Baird´s tapir *Tapirus bairdii* and brown basilisk *Basiliscus basiliscus* at Corcovado National Park, Costa Rica

Relación mutualista entre el tapir centroamericano *Tapirus bairdii* y el cherepo *Basiliscus basiliscus* en el Parque Nacional Corcovado, Costa Rica

Dionisio Paniagua[1], and José Manuel Mora[2,3]*

[1]Surcos Tours, C. P. 60702, Puerto Jiménez. Puntarenas, Costa Rica. E-mail: nitolaparios@gmail.com (DP).
[2]Carrera de Gestión Ecoturística, Sede Central, Universidad Técnica Nacional (UTN), C. P. 1902-4050. Alajuela, Costa Rica. E-mail: josemora07@gmail.com (JMM).
[3]Department of Biology and Museum of Vertebrate Biology, Portland State University, C. P 97207, Portland. Oregon, U.S.A.
*Corresponding author

Some symbiotic relationships, like mutualism, benefit individuals of the species involved. While there are documented instances of animals feeding on blood-feeding organisms that infest other vertebrates, cases of reptiles feeding on mammals are rare. In this note, we present a case of a brown basilisk, *Basiliscus basiliscus*, feeding on the back of a Baird's tapir, *Tapirus bairdii*, in Costa Rica. Observations were conducted in Corcovado National Park, Costa Rica, where one of the authors (D. Paniagua) leads excursions with tourist groups. During these excursions, brown basilisks have been observed on the backs of tapirs, hunting horseflies (Tabanidae) that land on them to feed on their blood. At least 10 instances of this behavior between brown basilisk and tapirs were recorded. These cases were observed more frequently on hot days and when there was sufficient water in puddles or other sources. When tapirs rested in dry areas, the presence of brown basilisk was not observed. This behavior aims to feed on female horseflies, which constantly harass tapirs by trying to land and feed on their blood. Brown basilisk obtain food and help tapirs by reducing painful horsefly bites and the potential spread of diseases. This mutualistic behavior had not been previously described for either of these 2 species.

Key words: Behavior; horsefly; mammal; reptile; Tabanidae.

Algunas relaciones simbióticas, como el mutualismo, benefician a los individuos de las especies involucradas. Aunque existen registros de animales que se alimentan de organismos hematófagos que infestan a otros vertebrados, los casos de reptiles que se alimentan sobre mamíferos son escasos. Aquí reportamos el caso del cherepo, *Basiliscus basiliscus* alimentándose sobre la danta, *Tapirus bairdii*, en Costa Rica. Las observaciones se llevaron a cabo en el Parque Nacional Corcovado, Costa Rica donde uno de los autores (D. Paniagua) realiza excursiones con grupos de turistas. Durante tales excursiones, se ha observado a basiliscos en la espalda de tapires cazando tábanos (Tabanidae) que aterrizan en ellos para alimentarse de su sangre. Se obtuvieron al menos 10 observaciones de este comportamiento entre basiliscos y tapires. Estos casos se observaron con mayor frecuencia en días calurosos y cuando hay suficiente agua en los charcos u otras fuentes. Cuando los tapires descansan en lugares secos, no se ha observado la presencia de basiliscos. Este comportamiento tiene como objetivo alimentarse de tábanos hembra, que constantemente acosan a los tapires intentando posarse y alimentarse de su sangre. El cherepo obtiene alimento y ayuda a los tapires al reducir las picaduras dolorosas de los tábanos y la propagación potencial de enfermedades. Este comportamiento mutualista no había sido descrito anteriormente para ninguna de estas 2 especies.

Palabras clave: Comportamiento; mamífero; reptil; Tabanidae; tábano.

Some symbiotic relationships are negative for individuals of one of the species involved, such as ectoparasitism or predation, while others are positive (Smith and Smith 2007). Among the latter category, mutualistic relationships benefit both species involved (Begon *et al.* 2006). For example, just in Africa, at least 96 bird species have developed feeding associations with various mammal species, including several ungulates (Dean and McDonald 1981; Rodríguez 2020). As a result, the birds obtain food, and the mammals are relieved of ectoparasites.

Potential advantages for individuals participating in mixed-species associations are very diverse and include: a reduction in parasite load, reduced risk of predation, and increased access to food and other resources (Dickman 1992). In many species, associations among individuals may be favored if they increase the *per capita* feeding success, increase access to favorable habitats, or reduce the *per capita* risk of predation (Pulliam and Caraco 1984).

There are records of animals feeding on and cleaning off hematophagous or parasitic organisms that infest

other vertebrates, forming mutualistic symbiotic relationships (Villalobos-Juárez and García-Padilla 2023). However, most of the documented cases involve birds feeding on mammals (Dean and McDonald 1981), and more rarely on reptiles such as terrestrial turtles and iguanas (Christian 1980). Even rarer are the cases of reptiles feeding on top of mammals (Villalobos-Juárez and García-Padilla 2023).

Baird's tapir, *Tapirus bairdii* (Gill 1865), ranges from México to Colombia, from sea level up to 3,600 m (Medici 2011; Schank *et al.* 2017). In Costa Rica, it can be found throughout the country, from coastal areas to the highest peaks (Mora 2000). Baird's tapir is a large, robust, hoofed mammal with a weight that can reach up to 350 kg, making it the largest terrestrial native mammal in Central America and the Neotropics as a whole (Reid 2009; Medici 2011).

Baird's tapir typically inhabits areas in close proximity to water sources and exhibits a preference for marshy or humid environments. They are highly skilled swimmers and adept divers (Mora 2000; Reid 2009), and often travel along watercourses (Naranjo 2019). Throughout the day, Baird's tapir can be found resting in shaded thickets, as well as in mud wallows or standing water (Reid 2009).

Brown basilisk, *Basiliscus basiliscus* (Linnaeus 1758), known in Costa Rica as cherepo, is distributed along the Pacific slope, spanning from southwestern Nicaragua to northern South America, and on the Atlantic slope of central Panamá, occupying elevations ranging from sea level to 1,200 m (Leenders 2019). Brown basilisk is a sizable lizard characterized by elongated legs and tail, reaching a maximum snout-vent length of 250 mm and a total length of 900 mm in males; females are considerably smaller (Savage 2002). Its coloration is olive-brown, adorned with 2 light stripes running along each side of the body, accompanied by dark crossbands that pattern the body and tail (Savage 2002). Adult males exhibit prominent crests on the head, as well as sail-like crests on the back and tail. These features are less developed or absent in females and smaller juvenile individuals (Leenders 2019). Brown basilisk is commonly encountered along the vegetated edges of streams and rivers in lowland areas, including gallery forests and secondary growth along streams in highly disturbed agricultural areas (Savage 2002). As a defensive strategy, basilisks often retreat into the water to evade predators on land. They even have the ability to run on the surface of water (Leenders 2019). The tendency to limit their time spent in water suggests they may also exercise caution towards potential aquatic predators, including crocodilians (Leenders 2019). The diet of brown basilisk is highly diverse, encompassing insects, scorpions, shrimp, and small vertebrates like lizards, snakes, fish, mammals, and birds (Savage 2002; Solórzano and Hidalgo 2014). Additionally, it supplements its diet with plant material, including flowers, fruits, and buds (Van Devender 1983).

Information about reptiles feeding on top of other vertebrates is still limited (Villalobos-Juárez and García-Padilla 2023). One of the most well-known cases of mutualism is that of the lava lizard (*Microlophus albemarlensis*), which feeds on insects that perch on sea lions or marine iguanas (Stebbins *et al.* 1967; Beebe 1988). Another example involves the mesquite lizard, *Sceloporus grammicus*, which jumps onto the backs and extremities of cattle (*Bos taurus*) when they lay down to prey on stable flies (*Stomoxys calcitrans*), known to alight on cattle to feed on their blood (Villalobos-Juárez and García-Padilla 2023). Here, we present the first documented case of a mutualistic relationship between Baird's tapir and the brown basilisk. The brown basilisk perches on top of Baird's tapir and captures horseflies that feed on the tapir's blood.

The observations were conducted at Corcovado National Park (CNP), located in the Puerto Jiménez county on the southwestern coast of the Osa Peninsula, Costa Rica (Figure 1). This park, established in 1975, encompasses 3,354 marine ha and 42,560 terrestrial ha of lowland tropical rainforest in Southwestern Costa Rica and supports a rich biodiversity (Foerster and Vaughan 2002). The mean annual temperature at CNP ranges between 23 and 26.5 °C depending on elevation (Foerster and Vaughan 2002). This protected area receives 5,500 mm–6,000 mm of precipitation annually, primarily during the rainy season in April through December (Kappelle 2016).

One of the authors (D. Paniagua) routinely leads groups of tourists within CNP, and most of the time, the group observes tapirs during the hikes, frequently near the beach. The size of the tourist group varies from just a couple to up to 10 people. At specific and well-known locations, the group diverts from the main trail to actively search for tapirs. Quite often, the group has spotted tapirs relaxing in mud wallows or shallow standing water near side trails. Although the group typically needs to continue the tour, D. Paniagua has briefly paused to conduct specific observations. These observations have been conducted using the naked eye, as well as through a small telescope or binoculars. Tourists have the opportunity to take pictures using smartphones or their own cameras. However, since D. Paniagua is guiding them, he has only been able to record videos while simultaneously explaining the scenario to the tourists as they take photographs.

On at least 10 occasions, basilisks have been observed on the backs of tapirs preying on horseflies (Tabanidae) that land on them to feed on their blood. These instances are most commonly observed when the day is very hot and there is enough water in the puddles or other water sources. When tapirs rest in dry places, no basilisks have been observed.

On June 21, 2023, at 08:30 hr, a young adult tapir was observed resting at a shallow pond along the Naranjos trail (8° 28′ 21″ N, 83° 35′ 25″ W; 33 m; Figures 1, 2). Another video was recorded on August 2, 2013, at 07:01 hr; this video can be viewed on the Costaricaguide/TikTok page (https://www.tiktok.com/@costaricaguide/video/7247323439776730373?is_from_webapp=1&sender_device=pc&web_id=7241231254254994949).

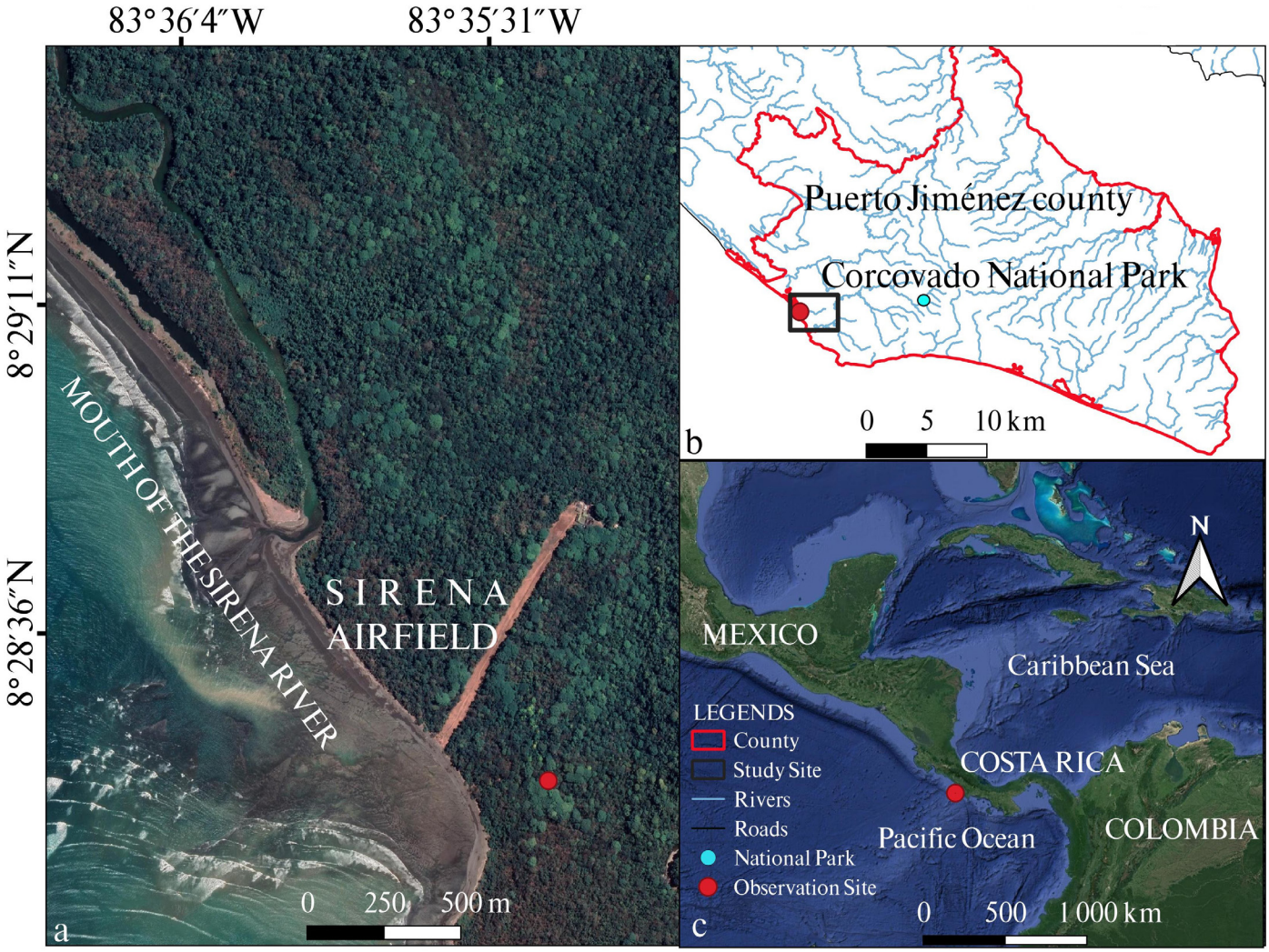

Figure 1. a) The location where a brown basilisk (*Basiliscus basiliscus*) captured horseflies on top of a Baird's tapir (*Tapirus bairdii*) near the Naranjos trail in the Sirena sector; b) the location of Corcovado National Park in the Puerto Jiménez county of c) Costa Rica. Map by G. Chaves.

It was evident that brown basilisk is particularly interested in horseflies. We noticed that basilisks are generally cautious, and when someone approaches, they rapidly scamper away. However, when a horsefly alights on a tapir, the basilisk reapproaches to attempt to catch it. Basilisks remain extremely attentive, and as soon as a fly settles, they swiftly move toward the tapir until they reach the spot where the horsefly has landed. Even if a fly is approaching, should someone come closer to the tapir, the basilisk temporarily retreats, yet as soon as it spots a fly landing, it promptly returns to the tapir and waits for horseflies.

The most significant aspect of our observations is that the basilisk perches on the tapir to capture horseflies that are attracted to it. The basilisk feeds on the horseflies, and perhaps other insects, while the tapir is relieved of the flies that deliver painful bites by slashing the skin with a pair of blades to feed on blood (Hanson and Nishida 2016). Horseflies are typically large and active flies, with females aggressively pursuing blood meals (Gerhardt and Hribar 2019). These flies rely on visual cues, such as the shape, size, and color of their potential hosts, and the movement of these hosts is also crucial (Mullens 2019). Shades of blue, black, or red are particularly attractive to tabanids (Mullens 2019). Baird's tapir is dark brown to dark gray in color (Mora 2000), which may make them more appealing to horseflies.

While tabanids can biologically transmit some pathogens and parasites, they more commonly transmit pathogens mechanically via contaminated blood on their mouthparts (Mullens 2019). They are among the most effective potential mechanical vectors of disease agents. When disturbed or dislodged, they will quickly return to the same host or one nearby within seconds (Mullens 2019). Tabanids serve as vectors for various disease agents in animals, including viruses, bacteria, protozoans, and nematodes. Some examples of disease agents mechanically transmitted by horseflies include the viruses that cause equine infectious anemia, *Anaplasma marginale*, the causative agent of anaplasmosis, and *Trypanosoma vivax* (Desquesnes *et al.* 2013; Mullens 2019). During periods of intense tabanid attacks, animals can experience a daily blood loss of up to 200 mL per individual (Mullens 2019), rendering them more susceptible to other diseases.

Some forms of apparently cooperative behavior are classified as by-product mutualisms, where an individual's behavior maximizes its own immediate fitness, and any positive effects on the fitness of other individuals are coincidental and do not contribute to the selection pressures maintaining the behavior (Bednekoff 1997). As a result, commensal and mutualistic associations among terrestrial vertebrates are clearly dynamic and can form or dissolve under different conditions of predator risk, resource levels, competition, and various other factors (Dickman 1992). Interspecific mutualism can manifest in various forms, with benefits that may be immediate or deferred (Hoeksema and Bruna 2000; Clutton-Brock 2002). The symbiotic relationship between the brown basilisk and Baird's tapir may be localized due to the habitat preferences of both species and the specific conditions in CNP. Both species are associated with habitats characterized by the presence of permanent water sources. Interestingly, horseflies prefer humid habitats where females typically lay eggs, often on plants or other objects overlying shallow water or wet soil, and some lay eggs directly over floating vegetation (Hanson and Nishida 2016). Additionally, the brown basilisk is active during the day, aligning with the diurnal biting habits of horseflies (Mullens 2019).

Figure 2. A brown basilisk, *Basiliscus basiliscus* perching on top of a Baird´s tapir, *Tapirus bairdii* to feed on horseflies close to Naranjos trail, Sirena sector, Corcovado National Park, Costa Rica. Photo from video by D. Paniagua.

There are few documented cases of mutualistic relationships among vertebrates in Costa Rica. Rodríguez (2020) observed and recorded 60 events of interactions between white-tailed deer (*Odocoileus virginianus*) and 4 bird species. Some of these interactions were classified as mutual cooperation, as the bird species directly removed ticks and other ectoparasites from the deer's skin, benefiting both species (Rodríguez 2020). The removal of ticks and ectoparasites is advantageous for white-tailed deer as it prevents blood loss, discomfort, and reduces the risk of disease transmission from these parasites (Rodríguez 2020). Another case of mutualism involving Baird´s tapirs has also been described in Corcovado National Park. In this case, it is a cleaning relationship where the yellow-headed caracara (*Milvago chimachima*) cleans ticks from the tapir (Coulson *et al.* 2018). The tapir clearly benefits by having the caracara free it from ticks and perhaps other parasites.

In a cleaning symbiosis, one species, the cleaner, removes and consumes ectoparasites, necrotic tissue, or mucus from another species, the client or host (Coulson *et al.* 2018). Consequently, the mutualistic relationship between brown basilisks and Baird's tapirs is another example of a cleaning symbiosis. The lizards capture flies for food, preventing them from biting the tapirs and potentially transmitting diseases. The tapir, as an attractive feeding perch, draws flies seeking blood as their food source. Additionally, few predators would approach a tapir, providing some protection for the basilisk while it feeds. Basilisks are cautious and rapidly scamper away if there is danger for them. However, they remain alert and come back when horseflies settle on the tapirs. As mentioned earlier, basilisks possess the ability to run on the water's surface (Leenders 2019), which might explain their method of jumping onto the tapir's back.

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