Manilkara zapota: A New Record of a Species Dispersed by Tapirs

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Abstract

Baird's tapir is the largest terrestrial Neotropical mammal in Central and South America. Tapirs are strict herbivores and they have been described as important seed dispersers and predators. However, it remains unclear to what extent the Baird's tapir can be consistently classified as a seed predator or disperser for a given tree species. *Manilkara zapota* (zapote) seeds were previously reported to be predated by tapirs because the seeds were thought to be too weak to withstand the tapir's molar mill. Here, we describe recent observations from the Greater Calakmul Region (Mexico) that show intact seeds and seedlings of zapote in tapir dung. The implications of these observations for zapote recruitment and distribution are the focus of ongoing research.

Introduction

The Baird's tapir (*Tapirus bairdii*) is the largest terrestrial Neotropical mammal in Central and South America to have escaped the Late Pleistocene extinctions between 22,000 to 10,000 years ago (Janzen, 1982; Brooks et al., 1997; Tobler, 2002). Populations of this species were formerly found from Veracruz in southeastern Mexico to the western cordillera of the Andes in Ecuador (Tobler, 2002). It is now considered extinct in El Salvador and endangered in all other parts of its range (Foerster and Vaughan, 2002; Norton and Ashley, 2004). It is probable that one of the biggest populations (between 1,000-4,800 individuals) is located in Mexico in the Lacandon Forest of Chiapas and in the Calakmul region in Campeche (Naranjo and Bodmer, 2002), however there are no proper population estimates (Brooks et al., 1997, Naranjo and Bodmer, 2002).

Tapirs are strict herbivores (Padilla and Dowler, 1994; Brooks et al., 1997; Olmos, 1997; Foerster and Vaughan, 2002; Lira-Torres et al., 2004). They have been described as important seed dispersers and seed predators (Naranjo and Cruz, 1998; Foerster and Vaughan, 2002; Tobler, 2002; Fragoso et al., 2003). Seed predation is caused either by chewing or seed digestion (Brooks et al., 1997; Olmos, 1997); additional disperser induced mortality may occur by the deposition of seeds in unsuitable places (e.g. in water, Salas 1996). The vulnerability of the seeds ingested depends on the hardness and thickness of their coat, their size, and the time spent in the digestive tract (Brooks et al., 1997).

Tapirs have been defined as Pleistocene relicts and are obvious candidates for the dispersal of large seeds once dispersed by the mega fauna now extinct (Janzen, 1982). Janzen and Martin (1982) suggested that, during the Pleistocene, extant mega fauna of Central America maintained unique biological relationships with the plants they ingested. This unique ecological relationship between large mammals and plants has been supported by field observations in Africa and Asia (Chapman et al., 1992; Dinerstein and Wemmer, 1988). However, the general validity of this observation appears controversial for some species such as the Baird's tapir, and it remains unclear to what extent this species can be consistently classified as a seed predator or disperser for any given tree species. For example, Janzen (1981) reported that 100% of carao seeds (*Cassia emarginata*) were killed during the ingestion/digestion process despite the hardness of their coats, whereas Williams (1984) found live carao seeds in dung piles.

The zapote, chicle, chicozapote, or zapotillo, as *Manilkara zapota* (L.) Royen (Sapotaceae) is commonly known (Morton, 1987), is an important component of the tropical and subtropical vegetation of Mexico (Cruz-Rodriguez and Lopez-Mata, 2004). It is found in the Pacific and gulf coasts of Mexico and especially in the Yucatan Peninsula, as well as in Guatemala, Northern Belize and the Atlantic coastal forest of Nicaragua (Monton, 1987). The large, sweet, indehis-

cent fruits of *Manilkara zapota* seem to have evolved to enhance seed dispersal by large mammals. However, precise field observations in Costa Rica suggest that zapote seeds are too large and weak to withstand the molar mill of a tapir (Janzen, 1982; Williams, 1984). Naranjo and Cruz (1998) found evidence from faecal analysis of species from the same genus in the diet of Baird's tapir, but it is not known whether this observation referred to intact and viable seeds. Here we report the results of recent observations of intact seeds and seedlings of *Manilkara zapota* in the dung of Baird's tapir.

Study Site and Species

Our work was carried out in the Greater Calakmul Region (19°15' to 17°50'N and 90°20' to 89°00'W) that includes the Municipality of Calakmul in the southern state of Campeche, the Calakmul Biosphere Reserve and the buffer and corridor areas around it (Galindo-Leal et al., 2000). The Calakmul Reserve is the second largest protected area, and the largest protected tropical forest in Mexico (CONABIO, 1998).

The region is a mosaic of different kinds of tropical forests, from low-deciduous forest in the north, to tall-evergreen forest in the southeastern part (Martínez et al., 2002). More than 1,600 plant species have been found in Calakmul, and this region contains more than 80% of the plant species in the Yucatan Peninsula (SEMARNAP, 2000).

Manilkara zapota is a slow-growing, large tropical tree that can reach 45 m in height. Its fruits vary from 5-10 cm in width and, when mature, are soft and juicy. Although some fruits are seedless, normally there are from 3 to 12 seeds per drupe (Morton, 1987; Heaton et al., 1999). The seeds are brown or black, hard, glossy, long–oval, flat, usually with a curved hook on one margin and an elongate white scar (Morton, 1987; Heaton, et al., 1999). Seeds range from 16-23 mm long, 8-16 mm wide and of 0.3 g wet mass (Morton, 1987; Cruz-Rodriguez and Lopez-Mata, 2004).

There are 94 species of mammals reported in this reserve that includes the last remaining natural areas for several species with large habitat requirements such as tapir (*Tapirus bairdii*), white-lipped peccary (*Tayassu peccari*), jaguar (*Panthera onca*) and king vulture (*Sarcoramphus papa*), among others (SEMARNAT, 2000).

Tapir populations are declining due to habitat destruction and hunting (Brooks et al., 1997). The fragmentation and isolation of tapir populations increases their risk of extinction due to demographic, genetic, and environmental stochasticity (Norton and Ashley, 2004). Baird's tapir have been observed to move over 20 km a day in Costa Rica where food and water availability are important factors in habitat selection (Brooks et al., 1997, Foerster and Vaughan, 2002, Naranjo and Bodmer, 2002). This species is catalogued as "vulnerable" in CITES Appendix I (Tobler, 2002) and are listed as endangered by Mexican law (Naranjo, 1995, SEMARNAP, 2000). Very little is known on the tapir populations in the Greater Calakmul Region and there are no formal previous studies in this region.

Methods

In July 2005, we visited several waterholes (locally known as *aguadas*) outside and inside the Calakmul Biosphere Reserve. Dry waterholes and non-flooding areas were also visited. The sites outside of the reserve were located within the communal lands of Nuevo Becal and Narciso Mendoza. We were accompanied by local guides who are both skilled subsistence hunters and *chicle* gum harvesters (*chicle* gum is the latex of *Manilkara zapota*). Our guides were thus knowledgeable about local *aguadas*, as they hunt and camp nearby during *chicle* extraction.

Tapir dung samples were collected near waterholes. We focused on these areas as latrines were found around flooded or potentially flooded areas in other studies (Naranjo, 1995; Naranjo and Cruz, 1998; Lira-Torres, 2004). Any sample found while searching for the waterholes was also collected. A sample consisted of all the boluses found within a single dung pile. Care was taken to avoid any soil and litter material while collecting the sample.

Figure 1. Germinated zapote seeds in a tapir dung bolus.

Each sample was sorted and complete zapote seeds and seedlings were collected and counted. Zapote seeds were previously identified directly from trees and most seedlings where found still attached to the seed coat (Figure 1). Field notes and photographs were used to document seedlings that germinated directly from seeds within the faeces.

Results

Tapir latrines were found around waterholes, some of which were dry because the field work was carried out at the very beginning of the rainy season. However, some samples were found in areas that are known by local people to be non-inundated (elevated) areas.

During our field study we collected 85 samples (dung piles). Table 1 summarizes relative frequency of viable zapote seeds and seedlings in these samples. All ungerminated seeds were found intact.

Table 1. Frequency and percentages of samples with seeds and seedlings.

	FREQUENCY	PERCENTAGE
Total number of samples	85	
Samples with intact seeds and seedlings	31	36.5%
Samples with seeds and seedling in the same dung pile	9	10.6%
Samples with seeds (only three samples presented more than one seed per dung pile)	25	29.4%
Samples with seedlings (seven samples presented more than one seedling)	15	17.6%

Discussion

Previous studies with Baird's tapir in Mexico (Chiapas) and Costa Rica included aspects of their diet, abundance and distribution, and human impacts (Terwilliger, 1978; Naranjo, 1995; Naranjo and Cruz, 1998; Foerster and Vaughan, 2002; Tobler, 2002; Lira-Torres et al., 2004). There are no previous studies in the Yucatan Peninsula, and specifically on species dispersed by tapirs. Naranjo and Cruz (1998) reported a species of the genus *Manilkara* (described up to genus) as being consumed by tapirs in The Sepultura Biosphere Reserve in Chiapas, Mexico. However these authors do not mention the viability of these seeds or of any zapote seedlings found in tapir dung. There is no other record of *Manilkara zapota* either as part of the tapir's diet or as a seed dispersed by tapirs.

Almost 40% of the dung samples contained seeds or seedlings. The results of this preliminary study contradict previous conjecture that *Manilkara zapota* should be predated by tapirs (Janzen, 1982; Williams, 1984). We provide evidence that tapirs are moving intact zapote seeds from one place to another, and that these seeds are viable and can germinate; future experiments will determine whether germination is indeed facilitated by the dung. Alone these data suggest that *Manilkara zapota* can now be added to the list of species already reported as being dispersed by Baird's tapir (Naranjo, 1995; Williams, 1984). Whether dispersal of viable seeds and subsequent germination by the tapir has a significant impact on the spatial distribution of zapote depends greatly upon whether the dung is left in habitat suitable for subsequent seedling growth and survival. The majority of dung samples were found around *aguadas* where adult zapote trees are often found, suggesting that these dung deposition sites are not unsuitable for zapote growth. Current seed germination experiments are addressing this important issue directly.

The functional role of the Baird's tapir as a seed disperser in this and other regions remains poorly understood and further study is clearly necessary. Its status as the largest extant forest-dwelling mammal in Central America (Olmos, 1997) suggests a unique functional role as the disperser of certain abundant large seeded tree species (Fragoso and Huffman, 2000). Whether this endangered species is a significant determinant of the structure of tropical forests (Fragoso, 1997) throughout its range is a question of considerable pure and applied relevance.

Conclusion

Although previous observations in Costa Rica suggested that *Manilkara zapota* seeds where too weak to withstand the molar mill of tapirs (Janzen, 1982), this paper presents field observations and the first record on *Manilkara zapota* seed dispersal by Baird's tapir in the Greater Calakmul Region in Mexico. Intact seeds and seedlings of *Manilkara zapota* were observed in tapir dung. However, further work on seedling establishment success is required to ascertain the importance of the Baird's tapir as a major determinant of *Manilkara zapota* abundance and distribution.

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***Manilkara zapota*: The large sweet fruits attract large herbivores.**