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Peccaries in Mexico

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Peccaries are restricted to the New World. Of the three recognized species, two, the white-lipped peccary (*Tayassu pecari*) and the collared peccary (*Pecari tajacu*), occur in Mexico. The white-lipped peccary occurs from northern Argentina through southeastern Mexico, and the collared peccary occurs from northern Argentina to the southwestern US. The third species, the Chacoan peccary (*Catagonus wagneri*), known only from fossil specimens until the 1970s, was documented as an extant species in the dry forest of the Chaco region in Paraguay, Argentina, and Bolivia (Wetzel et al. 1975). A fourth species, the giant peccary (*Pecari maximus*), from the Amazon region, was proposed by Van Roosmalen et al. (2007); however, it is still undetermined whether it is a subspecies of collared peccary (Gongora et al. 2007).

Peccaries perform several ecological functions: they are seed predators, seed dispersers, and prey of large predators, and they can alter the structure and composition of plant communities. In addition, they are among the preferred prey species of subsistence and sport hunters throughout their distributional range (Sowls 1997). For many indigenous communities, peccaries are the most important source of animal protein (Donkin 1985, Stearman 1992, Sowls 1997). In addition, peccaries have the potential to provide a significant source of income; some communities in the northern Amazon Basin that practice sustainable population management are becoming nationally and internationally certified to commercialize peccary skins (Fang et al. 2008).

Historical Perspective

Peccaries were important in the diets and cultures of pre-Columbian peoples; early explorers mentioned that the Maya, Aztec, and Yaqui, among others, hunted peccaries and kept them captive as a source of food. Díaz del Castillo (2005) in 1632 described the

presence of “abundant wild boar with the belly button on their back.” Presumably, Montezuma also kept peccaries in his amazing zoological park, described by Cortés in the mid-1520s.

Taxonomy

Peccaries are piglike animals classified in the family Tayassuidae; the collared peccary is the only species in the Nearctic, and the other species are restricted to the Neotropics. Of the five subspecies of white-lipped peccary, only the Mexican subspecies (*ringens*), which extends into northern Nicaragua (March 1993), occurs in Mexico. Vernacular names include *pecarí labios blancos*, *jabalí*, *tropero*, *huangana*, *baquiro*, *coche de monte*, and *chancho cariblanco* in Mexico and other Latin American countries; *senso* and *hach kekén* in Chiapas; *jabalí* and *hauilla* in Campeche; and *chancho de monte* on the Yucatán Peninsula.

Hall (1981) recognized 14 subspecies of collared peccaries in North America, of which 3 occur in Mexico: *angulatus* occurs along the Gulf of Mexico in Tamaulipas and South Texas; *sonorensis* occurs in central Sonora and in the US in Arizona and New Mexico; and *yucatanensis* occurs on the Yucatán Peninsula (Hellgren and Bissonette 2003). Genetic studies have revealed two major groups of collared peccaries throughout their distributional range that could merit subspecies status, or perhaps species status (Gongora et al. 2006). Alvaréz-Castañeda et al. (2015) divided collared peccaries from Mexico into two species (*Dicotyles angulatus* and *D. crassus*) based on skull morphometry and color differences. Efforts to classify collared peccaries show that this species is highly diverse and that more research is needed to clearly elucidate its taxonomic status throughout its distributional range. In this chapter, we will consider the collared peccary as a single species (*P. tajacu*).

Distribution

White-lipped

The white-lipped peccary originally occurred from Veracruz through most of southeastern Mexico (Leopold 1959, March 1990); however, its distributional range has been reduced by 84% in the last 50 years (Altrichter et al. 2012). This species has been extirpated from Veracruz and Tabasco, and single populations exist in Oaxaca and Yucatán (Altrichter et al. 2012; Naranjo et al. 2015; C. Alcerreca, personal communication); the only remaining large populations occur in Chiapas, Campeche, and Quintana Roo (fig. 14.1).

Collared

The collared peccary is widely distributed; it extends from the southern states and the Yucatán Peninsula to the north along both coasts and the two cordilleras (western and eastern Sierra Madre) to South and West Texas, southern Arizona, and New Mexico in the US (fig. 14.2). In central Mexico it has been recorded in Morelos, which represents its northernmost

distribution in south-central Mexico (Mason-Romo et al. 2008).

Description

White-lipped

The white-lipped peccary is a small to medium-sized ungulate with relatively long legs and small hooves. The tail is reduced and almost absent; the head is massive and has a round nasal disk that enables foraging in the soil. The jaws are powerful and can break some of the hardest nuts (i.e., seeds of palm trees: *Mauritia flexuosa*, *Astrocaryum* sp., *Jessenia* sp., *Iriartea ventricosa*, and *Socratea exorrhiza*) (Kiltie 1981a). The white-lipped peccary has a pair of lower and upper tusks that are used mainly for defense, and to make a clacking sound that is characteristic of this species when alarmed or irritated. All peccaries have a unique dorsal gland; the substance excreted has a characteristic smell that probably has a communication function (Sowls 1997). Most of the body is black except for a white line around the lips that extends into the cheeks (from which the species gets its common name), and

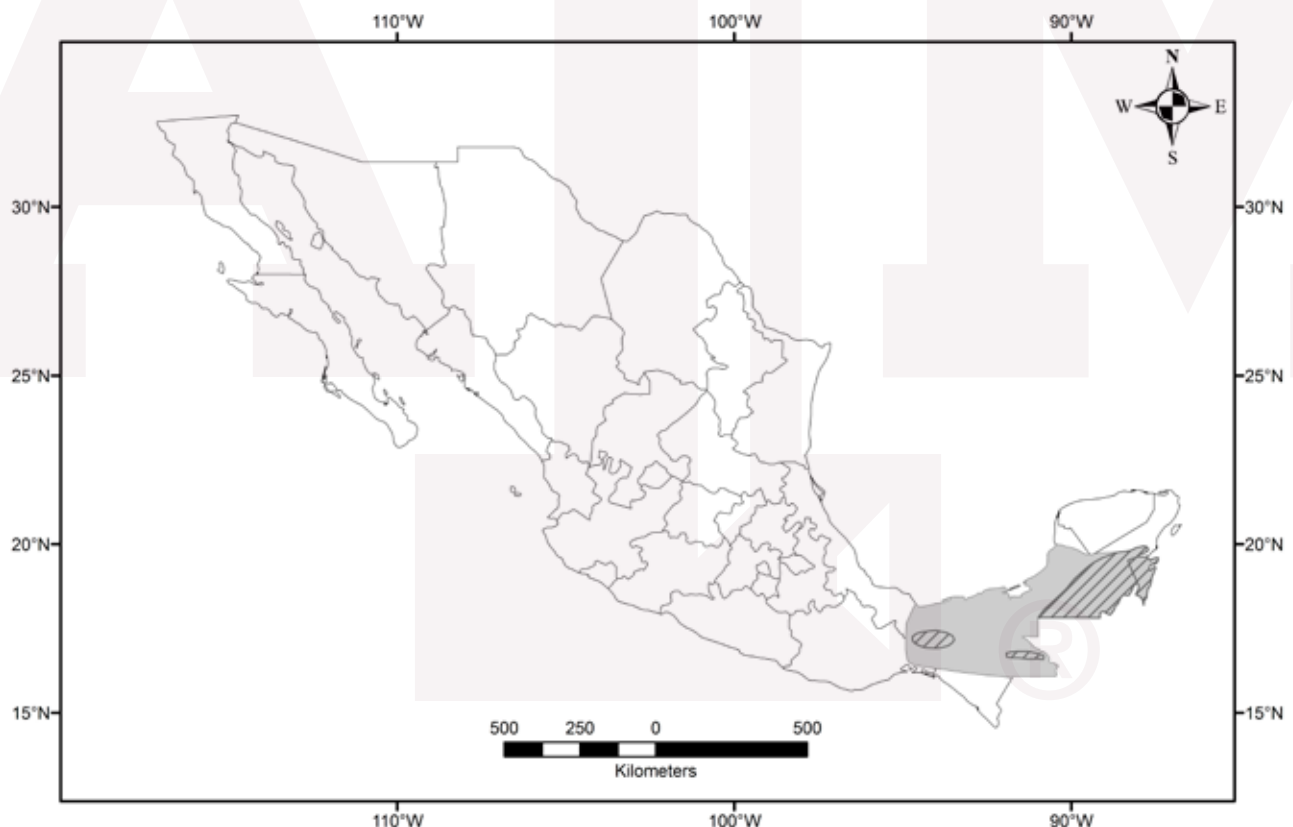


Figure 14.1. Potential (shaded) and current (barred) distribution of the white-lipped peccary in Mexico.

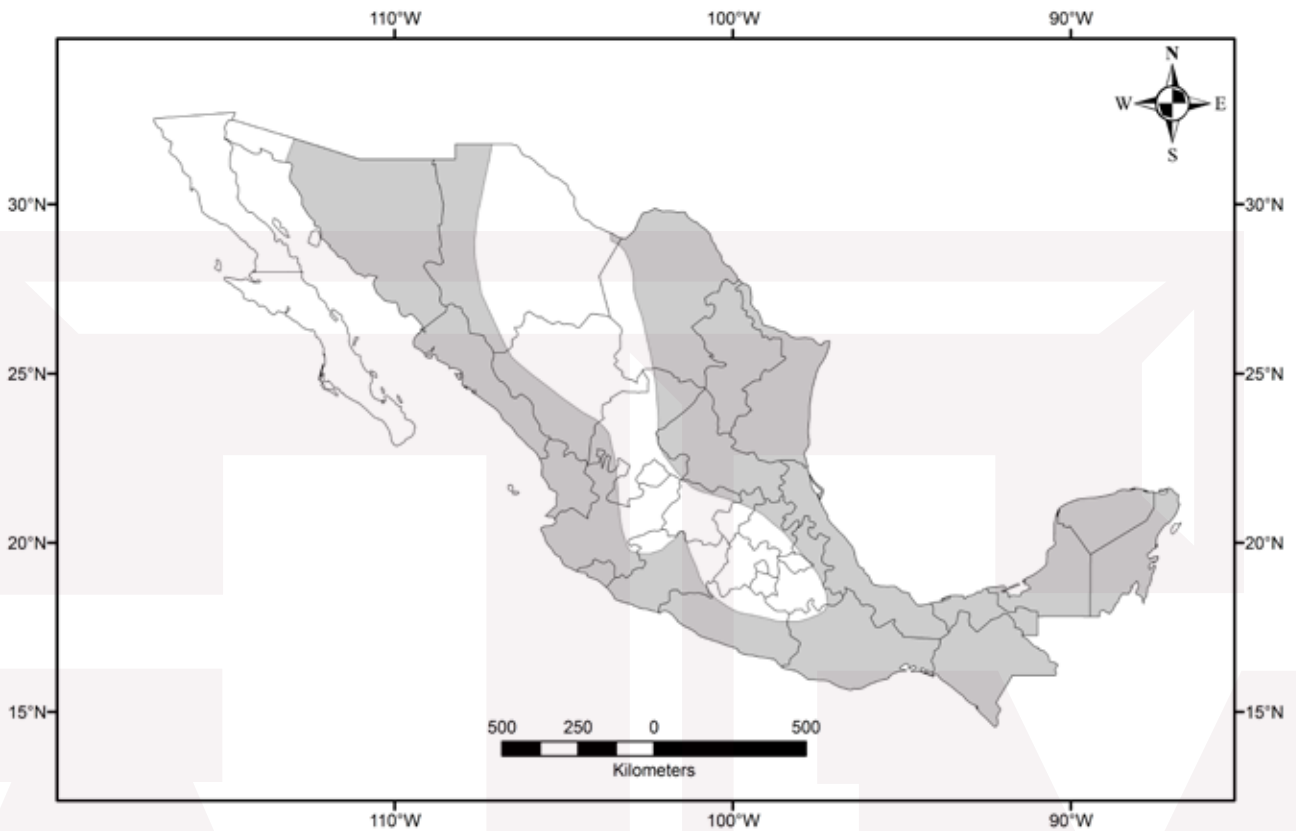


Figure 14.2. Potential distribution of the collared peccary in Mexico.

reddish areas around the neck (fig. 14.3). Neonates are a mixture of red-brown, black, and cream stripes; by the third year of age, the color changes from reddish to black. Adults attain body lengths of between 9.30 and 13 cm (3.66 and 5.11 in). Individuals measured in the Calakmul Biosphere Reserve (CBR) in Campeche ranged from 10.40 to 12.40 cm (4.09 to 4.88 in) in length. Body masses of individuals from throughout their range vary from 25 to 42 kg (55 to 93 lb). Fifteen individuals from Calakmul weighed between 25 and 38 kg (55 to 84 lb), with a mean of 30 kg (66 lb) (E. Rojas-Flores, personal communication). The sexes are not distinct anatomically.

Collared

The collared peccary, the smallest tayassuid, ranges in total length between 9.32 and 10.36 cm (3.66 and 4.07 in), and body weights of adults range from 15 to 28 kg (33 to 62 lb) (Sowls 1997). The head is larger in relationship to the body than it is in the white-lipped peccary; the legs are shorter, and they have a rounder appearance than those of white-lipped peccaries. The hair is a mix of black, white, and

yellow, which gives the species a grayish appearance, highlighting a dark line of hair along the back, while white hairs form a collar around the neck, from which the common name is derived (fig. 14.4). The difference in jaw force and access to certain fruits has been proposed as a niche separation between the two species; only white-lipped peccaries can break very hard nuts (Kiltie 1981b). Collared peccaries also have a pair of long tusks that are used to dig wallows, defend against predators, and create an alarm sound (clacking) when stressed (Sowls 1997). Newborns are reddish, but after the age of three months, the body color is similar to that of adults (March 2005).

Life History

Diet

White-lipped

The white-lipped peccary is omnivorous but prefers a greater percentage of fruits and seeds than vegetative parts or animal material. Kiltie (1981a) analyzed the contents of 34 stomachs; reproductive plant parts (flowers, seeds, and fruits) constituted 61% of the

Figure 14.3. White-lipped peccary in Calakmul Biosphere Reserve in Campeche, Mexico. Photo by Rafael Reyna.



Figure 14.4. Collared peccaries in Calakmul Biosphere Reserve in Campeche, Mexico. Photo by Rafael Reyna.



contents, while 39% consisted of vegetative parts (leaves, stems, and roots). The stomach contents of nine white-lipped peccaries from the CBR consisted of 81% fruit, while the rest comprised leaves, fibrous material, and animal matter (Pérez-Cortéz and Reyna-Hurtado 2008). It is possible that animal material has been underestimated in the diet of this species. Bodmer (1991) found 11% animal material in 46 samples, and R. Reyna-Hurtado (personal observation) documented groups of white-lipped peccaries in the CBR that spent long periods, even

days, foraging in flooded forest during a season when earthworms and other larvae were abundant and fruit was not available. Herds also spent long periods foraging around pond edges capturing eels (*Ophiosternum aenigmaticum*) (fig. 14.5) (Pérez-Cortéz and Reyna-Hurtado, 2008).

Collared

Collared peccaries are omnivorous as well but have a more diversified diet than white-lipped peccaries. They can survive eating cactus (*Opuntia* spp.) and

Figure 14.5. White-lipped peccaries searching for eels in a pond in Calakmul Biosphere Reserve in Campeche, Mexico. Photo by Rafael Reyna.



roots in xeric habitats of Sonora, Arizona, and Texas, while a preference for fruits is evident in tropical forests (Sowls 1997). In the deciduous tropical forest of Jalisco, diets consisted of between 46% and 50% roots, between 39% and 43% leaves, and only 10% to 11% fruits (Martínez Romero and Mandujano 1995). In the Calakmul region, Pérez-Cortéz and Reyna-Hurtado (2008) found that stomach contents of collared peccary consisted of 56% fruits, 33% leaves, 8.5% fibrous material (probably from roots), and only 0.5% animal matter. The diverse food items in the diets of collared peccaries and the ability to switch from one food item to another probably explain the persistence of this species in highly disturbed areas (Leopold 1959, Sowls 1997).

Reproduction

March (1993) reported that white-lipped peccaries can reproduce year-round, but a marked breeding season probably occurs between April and June. In the CBR and surrounding areas, Reyna-Hurtado (2009) reported that 18 of 19 births recorded occurred from late December through March. The gestation period lasted between 156 and 172 days, and the average litter size was two, with a range of

one to three. Naranjo and Bodmer (2007) reported that sex ratios in both species conformed to the expected 1:1 ratio in the Lacandon Forest in Chiapas, although there was a slightly higher percentage of males than females in both species. The maximum longevity reported for the collared peccary in captivity is 13 years (Mayer and Wetzel 1987). The longevity of white-lipped peccaries is unknown, but animals older than six years have been recorded in the Peruvian Amazon (Fang et al. 2008).

The gestation period of collared peccaries is between 141 and 151 days; females usually produce two litters and give birth any time of year (March 2005). Naranjo and Bodmer (2007) reported a sex ratio of about 1:1 for animals hunted in communities of the Lacandon Forest in Chiapas. The maximum longevity is 24 years and 8 months in captivity (Crandall 1964, March and Mandujano 2005); in the wild, average longevity is 7 years (Sowls 1997). However, a female recorded in the wild in Arizona was estimated to be 15 years old based on dental annuli (Day 1985).

Growth

Newborn white-lipped peccaries weigh 1.1–1.35 kg (2.4–2.9 lb) and reach maturity at two years of

age. Collared peccary newborns weigh around 0.5 kg (1.1 lb) and reach sexual maturity at the age of 11 months; females are probably receptive shortly thereafter (March 2005).

Energy requirements

White-lipped

White-lipped peccaries feed on high-energy food items, such as fruits and large seeds. These are usually dispersed in tropical forests, but their spatial and temporal availability are unpredictable (Reyna-Hurtado et al. 2012). Thus the white-lipped peccary is a mobile species that continually searches for resources over large areas (Reyna-Hurtado et al. 2009). In addition, they live in large and cohesive groups that require large quantities of food to fulfill their energy requirements. The movements of white-lipped peccary herds have been documented on Maracá Island, Brazil (Fragoso 1998); in Corcovado National Park, Costa Rica (Carrillo et al. 2002); in the Atlantic Forest (Keuroghlian et al. 2004) and Cerrado areas of Brazil (Almeida-Jácomo 2004); and in Mexico in the CBR, where herds traveled up to 17 km (10.5 mi) (Reyna-Hurtado et al. 2009).

Collared

Collared peccaries have a different strategy to cope with their daily energy requirements. They feed on less-energetic food items like roots, herbs, and cactus, but they also live in smaller groups than white-lipped peccaries and frequently split into subgroups. This species is considerably less mobile than the white-lipped peccary, presumably because it requires less energy (Sowls 1997).

Water requirements and thermal relationships

White-lipped

White-lipped peccaries require drinking water frequently. Because they lack sweat glands, they wallow at the edges of ponds and in drying streams and rivers, and they take mud baths to avoid overheating when temperatures are high, and to help shield their bodies from external parasites. White-lipped peccaries also drink water almost daily. Movements of more than 17 km (10.5 mi) to reach watering sites were documented during the dry season in both Calakmul (Reyna-Hurtado 2007) and Montes Azules (Naranjo

2002) Biosphere Reserves; these sites became centers of foraging movements (Reyna-Hurtado et al. 2009). This behavior is very well known among subsistence and sport hunters, who hunt this species around ponds and streams (Naranjo 2002, Reyna-Hurtado et al. 2010).

Collared

Collared peccaries use several strategies to cope with the drier habitats they inhabit (Zervanos 1975, Zervanos and Hadley 1973, Zervanos and Day 1977, Sowls 1997). In Chamela, Jalisco, collared peccaries feed on water-rich fruits of *Spondias* trees that fall to the ground after being shaken loose by chachalacas (*Ortalis poliocephala*) (Mandujano and Martínez Romero 1997). In the southwestern US, collared peccaries live in desert habitats without standing water. They fulfill their water requirements by eating succulent cactus (*Opuntia* spp.) and roots, and by spending long periods in the shade or in caves (Day 1985, Sowls 1997).

Behavior

White-lipped

White-lipped peccaries are a social species that forms larger herds than any other ungulate in dense tropical forests (Kiltie and Terborgh 1983). They form herds of 10 to 300 animals, although there are confirmed reports of herds of 400 and 700 in the Amazon Basin (J. Fragoso and R. Bodmer, personal communication), and there are historical reports of groups of 1,000 animals (Mayer and Wetzel 1987). In Mexico, group size varies from 5 to 80 in the Lacandon Forest (Naranjo 2002; I. March, personal observation), and from 11 to 44 in the CBR (fig. 14.6) (Reyna-Hurtado et al. 2009; R. Reyna-Hurtado, personal observation). In the Petén Forest of northern Guatemala, groups of 10 to 60 were observed (Moreira 2009). Herds are usually cohesive (Fragoso 1998, Reyna-Hurtado et al. 2009), but groups may split into subgroups temporarily (Carrillo et al. 2002, Keuroghlian et al. 2004). In the CBR, Reyna-Hurtado et al. (2009) followed radio-marked animals and found high group fidelity despite several occasions when different groups remained close and even traveled together for several days without forming a single herd.



Figure 14.6. White-lipped peccaries wallowing in mud in a pond in Calakmul Biosphere Reserve in Campeche, Mexico. Photo by Rafael Reyna.

Collared

Collared peccaries form smaller groups than white-lipped peccaries, numbering up to 50 animals in desert areas of the US, and even smaller groups (< 20) in tropical forests (Robinson and Eisenberg 1985, March 2005). In the deciduous tropical forests of Chamela, groups of up to 12 peccaries were observed, although the most frequent group size was 1 to 4 (Mandujano 1999). In El Eden, a semideciduous forest of the Yucatán Peninsula, González-Marín et al. (2008) observed herds of 2 to 15. In the Calakmul region, the largest group observed consisted of 9 individuals (R. Reyna-Hurtado, personal observation), while in the Lacandon Forest, there were groups of 1 to 15, with a mean of 2.3 per group (Naranjo 2002).

Movements

White-lipped

White-lipped peccaries are very mobile and can travel as far as 17 km (10.5 mi) in a single day (Reyna-Hurtado et al. 2012). The presence of this species in a certain area is unpredictable, and its movements have been described as migratory, nomadic, and episodic (Sowls 1997, Fragoso 1999, Altrichter et al.

2001). Groups can appear and remain in one area for months or even years, and then disappear for several years (Fragoso 1994, Reyna-Hurtado et al. 2009). Several indigenous groups persistently hunt white-lipped peccaries when they are in a localized area (Donkin 1985, Stearman 1992, Reyna-Hurtado 2007). In the CBR, four groups that were followed for 7–18 months traveled long distances (7–17 km, 4.3–10.5 mi) in an irregular pattern, except for one group that stayed in the same area during the dry season and moved to another area during the rainy season. The other three groups moved unpredictably, but movements could have been related to watering sources (Reyna-Hurtado et al. 2009, 2012).

Collared

The movements of collared peccary have been described primarily for arid habitats of the southwestern US, where visibility is higher than in dense tropical forests. Collared peccary groups moved mainly at dawn and dusk, with individual herd members spreading over 100 m (328 ft) (Sowls 1997); this contrasted with white-lipped peccaries, which moved in tight groups usually within visual and auditory distance of each other (Fragoso 1998, Reyna-Hurtado

et al. 2009). Collared peccaries have been found as far as 8 km (4.9 mi) from where they were marked; however, these could be dispersal movements, because this species usually restricts its movements within 5 km² (1.9 mi²) (Ellisor and Harwell 1969, Schweinsburg 1971).

Communication

White-lipped

Both peccary species maintain communication through physical, olfactory, and acoustic signals. Usually they greet each other by rubbing their nose against the dorsal gland of a mate to acquire a group odor identifiable to all herd members (Sowls 1997). The white-lipped peccary also has a broad vocal repertoire, and herd members are usually in contact acoustically, which is especially important when traveling through dense vegetation (March 1993). The contact call is a low growl or moan, but white-lipped peccaries also clatter their teeth and bark sharply during conflict, and they will use a deep bark as an alarm call. Adults and juveniles also make a raspy bleat (Mayer and Wetzell 1987). White-lipped peccaries frequently clack their tusks, usually during stressful periods, accompanied by barking at different intensities. When they detect a potential danger such as human or jaguar odor, they respond with loud, explosive clacking of their tusks as they flee. This explosion of sound and movement ends in seconds, and then they usually stop and remain quiet, a strategy believed to enable them to listen and smell to better detect the origin of the threat. If the danger continues, they again initiate clacking, barking, and running. On some occasions, the running/clacking and stopping is repeated more than five times as the group flees (R. Reyna-Hurtado, personal observation).

Collared

Collared peccaries also depend on odor as well as auditory communication. Sowls (1997) categorized vocalizations into nine types used to maintain group cohesion, locate other members, establish dominance, warn others, and react to a threatening situation. Collared peccaries also rub each other's backs, which spreads the product of the dorsal gland for within-group identification (Sowls 1997).

Home Range

White-lipped

White-lipped peccaries have home ranges several times larger than those of any other tropical forest ungulate. In the only estimate of white-lipped peccary home ranges in Mexico, which were recorded in the CBR, home ranges measured from 77.2 to 121.8 km² (29.8 to 47 mi²) (determined using the Minimum Convex Polygon method for two groups of 25 and 18 individuals) (Reyna-Hurtado et al. 2009). In other countries, similar or larger home ranges were recorded for groups on Maracá Island, Roraima, Brazil: 109 and 200 km² (42 and 77 mi²) for groups of 124–134, and more than 200 individuals, respectively (Fragoso 1998, 2004); and for groups living in a mosaic of open and closed habitats in the Cerrado ecosystem in Goiás State, Brazil: 288, 137, and 114 km² (111, 52, and 44 mi²) for groups of 65, 75, and 45 individuals, respectively (Almeida-Jácomo 2004). Home range estimates for white-lipped peccaries from closed habitats in other countries are smaller than those from Mexico: 21.8 km² (8.4 mi²) for a 39-member herd on Maracá Island (Fragoso 1998); 37.2 km² (14.3 mi²) for a 40–70-member herd in Corcovado National Park, Costa Rica (Carrillo et al. 2002); 18.71 km² (7.22 mi²) for a 42-member herd in the Atlantic Forest region of Brazil (Keuroghlian et al. 2004); and 14.3–84.8 km² (5.5–32.7 mi²) for other herds ranging from 15 to 130 animals in the Cerrado ecosystem of Goiás, Brazil (Almeida-Jácomo 2004).

Collared

The only estimate of collared peccary home range in Mexico was 7.3 km² (2.8 mi²) for a herd in the Lacandon Forest, Chiapas (Naranjo 2002). Annual home ranges of collared peccaries in Arizona varied from 0.5 to 3.1 km² (0.2 to 1.2 mi²) (Gabor and Hellgren 2000). In fragments of the Brazilian Atlantic Forest, home ranges consisted of 123 and 305 ha (303 and 753 ac) (Keuroghlian et al. 2004). Fragoso (1999) reported home ranges of 10.5 to 11.7 km² (4 to 4.5 mi²) on Maracá Island, Brazil. In a tropical forest in French Guiana, home ranges varied from 157 to 243 ha (387 to 600 ac) for herds of 5 to 11 animals (Judas and Henry 1999).

Density

White-lipped

White-lipped peccary densities are variable. Naranjo and Bodmer (2007) reported densities of 7.93 and 1.08 ind/km² (20.86 and 2.84 ind/mi²) in slightly hunted and persistently hunted sites, respectively, in the Lacandon rainforest, while Reyna-Hurtado et al. (2010) recorded a density of 0.43 ind/km² (1.13 ind/mi²) in the semidry forests of the CBR. In the Petén Forest of northern Guatemala, which forms a continuous forest with Calakmul, Novack et al. (2005) reported a density of 9.6 ind/km² (25.2 ind/mi²) in a nonhunted site using the line transect method. These differences, however, could be influenced by the method used, or the higher-quality habitat in the Petén Forest compared to the drier forest in Calakmul (Reyna-Hurtado et al. 2009).

Keuroghlian et al. (2004) and Cullen et al. (2000), both working in southern Brazil, reported densities between 3.9 and 10.2 ind/km² (10.2 and 26.8 ind/mi²) in fragments of the Atlantic Forest. Fragoso (1994, 2004) reported densities of 139–542 ind/km² (365–1,426 ind/mi²) in 1988, which declined to 1.4–8.3 ind/km² (3.6–21.8 ind/mi²) in 1992 after an apparent disease-driven population crash on Maracá Island, Brazil. Desbiez (2007) found densities of 13.7 and 3.0 ind/km² (36 and 7.9 ind/mi²) in forested and open Cerrado habitat of the Brazilian Pantanal, respectively. Altrichter (2005) estimated 0.33 ind/km² (0.86 ind/mi²) in hunted sites, and 1.04 ind/km² (2.73 ind/mi²) in nonhunted sites of the dry forest in the Argentine Gran Chaco.

Collared

Population density of collared peccary in Mexico in Chamela dry forest in Jalisco was 4.9 ind/km² (12.8 ind/mi²) (Martínez Romero and Mandujano 1995) and 7.5 ind/km² (19.7 ind/mi²) (Mandujano 2007). Naranjo and Bodmer (2007) estimated 1.53 and 1.15 ind/km² (4.02 and 3.02 ind/mi²) in slightly hunted and persistently hunted sites of the Lacandon Forest, respectively. On the Yucatán Peninsula, a density of 1.9 ind/km² (5 ind/mi²) was reported in El Eden, a small, protected, semidry tropical forest (González-Marín et al. 2008). In other areas of the distributional range, collared peccaries have been estimated to have the following densities: Peres (1996) found densities ranging from 0.4 to 11.6 ind/km² (1.1 to

30.5 ind/mi²) in Amazon forest sites subjected to different degrees of hunting pressure. In Atlantic Forest fragments, Keuroghlian et al. (2004) found 5.9 ind/km² (15.5 ind/mi²), with a range between 2.8 and 8.9 ind/km² (7.3 and 23.4 ind/mi²), while Cullen et al. (2000) reported a similar density in the same area of 6.4 ind/km² (16.8 ind/mi²), with a range of 3.7 to 11.2 ind/km² (9.7 to 29.4 ind/mi²). Altrichter (2005) found a very low density of this species in the hot and dry environment of the Chaco region in Argentina, with 0.62 ind/km² (1.63 ind/mi²) in hunted areas, and 0.91 ind/km² (2.39 ind/mi²) in nonhunted areas. In two national parks in eastern Colombia, Gómez and Montenegro (2012) estimated a density between 0.05 and 0.24 ind/km² (0.13 and 0.63 ind/mi²). Sows (1997) summarized several density estimations for the collared peccary as follows: south-central Arizona, 3.0–4.7 ind/km² (7.9–12.3 ind/mi²) (Schweinsburg 1971) and 2.1–4.5 ind/km² (5.5–11.8 ind/mi²) (Supple 1983); southern Arizona, 4.5–11.5 ind/km² (11.8–30.2 ind/mi²) (Day 1985); West Texas, 1.2–2.5 (3.1–6.5) and 3.3–11.0 ind/km² (8.6–29 ind/mi²) (Bissonette 1982); South Texas, 3.8–8.8 ind/km² (10–23.1 ind/mi²) (Low 1970); Barro Colorado, Panama, 16.0 ind/km² (42.1 ind/mi²) (Eisenberg 1989) and 9.3 ind/km² (24.4 ind/mi²) (Glanz 1982); southern Peru, 5.6 ind/km² (14.7 ind/mi²) (Emmons 1987); Masaguaral, Venezuela, 8.5 ind/km² (22.3 ind/mi²) (Eisenberg et al. 1979); Guatopo National Park, Venezuela, 1.9 ind/km² (5 ind/mi²) (Schaller 1983); Peruvian Amazon, 3.3 ind/km² (8.6 ind/mi²) (Bodmer 1989); and the Neotropics in general, 12.0 ind/km² (31.5 ind/mi²) (Robinson and Redford 1986).

Productivity and recruitment

The high productivity of both peccary species—females can produce one to three young per litter from two to ten years of age—qualifies them as candidates for sustainable harvest programs (Robinson and Redford 1986, Bodmer et al. 1997, Fang et al. 2008). Both species represent an important source of income for subsistence hunters, and a commercial hunting program is being planned in the Peruvian Amazon (Fang et al. 2008). However, sustainable rates of extraction observed in the Amazon rainforest cannot be attained in other areas of the Americas, particularly in Mexico and Central America, where forested areas are considerably smaller.

Survival and mortality factors

Both peccary species are significant prey of jaguars and pumas, occasionally of ocelots, and probably of crocodiles. There are several reports of jaguar predation of both peccary species in Mexico, including historical reports by Leopold (1959) and Alvarez del Toro (1991), among others. Aranda (1990) reported the presence of peccary hairs in 45% of jaguar feces examined in the CBR. In this same area, Amín (2004) reported that both peccary species are important components of jaguar diets, and R. Reyna-Hurtado (personal observation) witnessed three incidents in which jaguars killed and ate white-lipped peccaries in 2005 and 2006.

Human-caused mortality by hunting is probably the biggest threat to peccary populations in Mexico. However, the population responses of the two species can differ: the collared peccary can resist relatively high rates of extraction and still remain abundant in some areas, while the white-lipped peccary can be extirpated under intense hunting, especially when combined with forest loss or fragmentation (Weber 2000, Naranjo and Bodmer 2007, Reyna-Hurtado and Tanner 2007, Altrichter et al. 2012). Part of this difference can be explained by their social behavior. White-lipped peccaries remain in cohesive herds when confronted by hunters, making them easy prey, while collared peccary herds immediately flee from hunters and split into subgroups. However, collared peccaries can also be easy prey for hunters because they tend to seek shelter in caves or logs where they can be cornered, especially when hunted with dogs. Once cornered, they can be approached and killed, even with a pointed stick (R. Reyna-Hurtado, personal observation).

Another difference is their ranging behavior and feeding habits. White-lipped peccaries require larger areas of forest than collared peccaries, because white-lipped peccaries feed in larger groups and focus on energy-rich foods such as fruits that usually have a patchy distribution (Kiltie and Terborgh 1983, Reyna-Hurtado et al. 2012). In contrast, collared peccary herds frequently split into subgroups and feed on a wider array of resources (fruits, herbs, roots, and animal matter) occurring in smaller patches (Sowls 1997). White-lipped peccaries are more vulnerable to habitat loss and fragmentation because they require larger forested areas. Also, their depen-

dence on aquatic habitats makes them vulnerable during the dry season, because they usually require a daily watering source (Sowls 1997, Reyna-Hurtado 2007). Finally, although we lack long-term data in Mexico, populations of white-lipped peccaries could be subject to fluctuations similar to those recorded in the northern Amazon, where cycles of around 15 years have been observed during which populations attain high densities and then crash to lower densities, apparently as a result of disease or depleted resources (Fragoso 1997, 2004).

Emigration and Immigration

In Arizona, five collared peccaries were observed joining different groups (Sowls 1997). Fragoso (1994) also observed emigration of white-lipped peccaries from one group to another. In the Brazilian Atlantic Forest and in Corcovado National Park in Costa Rica, Keuroghlian et al. (2004) and Carrillo et al. (2002), respectively, reported that groups of white-lipped peccaries often share members and exchange individuals. In the only specific study on white-lipped peccaries in Mexico, Reyna-Hurtado et al. (2009) did not find evidence of movements between groups; individuals remained within a single herd during the 18 months of the study, even when herds came within 5 m (16.4 ft) of each other.

Population Trends and Current Status

In Mexico, both peccary species are subject to heavy hunting pressure. In an area surrounding the CBR, collared peccaries were the most frequently hunted species in one community forest (ejido) (Weber 2000), and both species were among the top five prey species in three other ejidos (Escamilla et al. 2000). The white-lipped peccary has disappeared from most ejidos because of hunting pressure and increasing forest fragmentation. In areas where white-lipped peccaries still survive, they are pursued intensively, especially during the dry season when they are most vulnerable; Reyna-Hurtado et al. (2010) documented the extirpation of an entire herd by hunters during one dry season.

White-lipped

The distributional range of white-lipped peccaries has been reduced by overhunting and forest fragmentation (Altrichter et al. 2012). The species is listed in Appendix II of CITES, but its status is poorly

known. The IUCN Red List raised its status from Lower Risk/Least Concern to Near Threatened in 2008 because of its rapid decline (Reyna-Hurtado et al. 2008), and to Vulnerable in 2013 (Keuroghlian et al. 2013). Sixty years ago, Leopold (1959) observed a decrease in its numbers and distribution in Mexico because of habitat loss and excessive hunting. Since then, white-lipped peccaries have disappeared from almost all of Veracruz and Tabasco, with isolated populations remaining in Oaxaca and Yucatán, and relatively large and stable populations occurring only in Chiapas, Quintana Roo, and Campeche (March 1993, 2005). However, the white-lipped peccary was only recently listed as an endangered species in Mexico (SEMARNAT 2010), and sport hunting was permitted in Campeche and Quintana Roo until 2012. Its current status is even more precarious, because subsistence hunting and forest fragmentation continue outside protected areas, and a conservation plan at a regional or national scale has yet to be developed (Reyna-Hurtado et al. 2009).

Collared

The collared peccary is listed as a species of Least Concern by the IUCN (Gongora et al. 2011) but is not included on the endangered species list of Mexico (SEMARNAT 2010). It is still relatively common in large forested areas, and where large forest fragments are interspersed with croplands. However, it is one of the principal prey species of rural subsistence hunters and is subjected to heavy hunting pressure, especially in large protected areas such as Calakmul, El Triunfo, La Sepultura, Montes Azules, and Sian Ka'an Biosphere Reserves (Weber 2000, Naranjo 2002, March and Mandujano 2005, Ramírez-Barajas and Naranjo 2007). The killing of up to six collared peccaries in a single day by organized groups of subsistence hunters with trained dogs was observed in the Calakmul region (R. Reyna-Hurtado, personal observation), and recent evidence shows a decline in their relative abundance in some hunted areas (M. Briceño, unpublished data). The status of the collared peccary is unknown in several areas of Mexico, especially along the Pacific and Gulf coasts.

Population management

White-lipped

White-lipped peccaries require specific management attention because of their complex social behavior, space requirements, susceptibility to disease, and vulnerability to human impacts resulting from forest fragmentation and hunting pressure. The formulation of management plans requires knowledge of population densities, group sizes, herd home ranges, areas shared by groups, age structure, breeding season, and sex ratios. White-lipped peccaries require an area up to 10 times larger than that needed by other tropical ungulates (Reyna-Hurtado et al. 2009); they live in groups of variable size, and they share space with other groups. This species has special habitat requirements because of its need for watering sources and intact tropical forests. Density estimation is challenging because the animals are difficult to observe when conducting transects, which is perhaps the most common method of density estimation for large tropical mammals (R. Reyna-Hurtado, personal observation).

Another factor to consider when determining hunting quotas for white-lipped peccaries is their social behavior and herd composition. No more than 5–10% of any single group should be allowed to be hunted. For example, in an area with a mean group size of 20, no more than 2 individuals per season should be hunted from any given group to maintain a sustainable population (Reyna-Hurtado et al. 2010).

Collared

Collared peccaries have the potential to be sustainably hunted given their relatively high productivity, rapid sexual maturation, and ability to survive in disturbed areas. In two studies comparing hunted and nonhunted or slightly hunted populations in Calakmul and the Lacandon Forest in Mexico, collared peccary densities did not vary between sites, and they were among the most abundant ungulates in disturbed areas; their harvest rate appeared to be sustainable in a few communities (Naranjo and Bodmer 2007, Reyna-Hurtado and Tanner 2007). Indeed, in some areas, subsistence hunting of collared peccaries at reasonable levels could be recommended as a way to limit damage to field crops. In Peru, both peccary species are extracted at a rate of 56,000 pelts/year by subsistence hunters who hunt over a vast area

of the Amazon forest (Fang et al. 2008). However, recent studies (M. Briceño, unpublished data) have found decreasing populations of collared peccaries in some community forests of the Calakmul region in southern Mexico, where this species has been hunted intensively for many years.

Habitat Requirements

White-lipped

White-lipped peccaries occur principally in humid tropical forests; however, they can live in dry or semidry forests, depending on water availability. In the CBR, water was the most important landscape component (Reyna-Hurtado et al. 2012). The movements of four groups were influenced by the availability and distribution of watering sites (*aguadas*). During the dry season, white-lipped peccaries also depended on temporary watering sources, such as water that collected in depressions in rocks (*sartenejas*), where water can persist after large ponds dry up. These were an important source of water for peccary groups, which sometimes traveled 2–4 km (1.2–2.4 mi) in a straight line to reach them (Reyna-Hurtado et al. 2012). An analogous situation occurs at Montes Azules Biosphere Reserve in Chiapas, where peccary herds remain close to watering sources (rivers, streams, and lagoons) during the driest months, February through May (Naranjo 2002). White-lipped peccaries depended heavily on two types of forest in the CBR: medium-height semiperennial forests, and flooded forests. They fed on fruits, especially ramon (*Brosimum alicastrum*) and zapote (*Manilkara zapota*) in the medium-height semiperennial forest, and they visited the flooded forest in the rainy season to feed on invertebrates such as earthworms and larvae, which were especially available at that time (Reyna-Hurtado et al. 2009). In the Lacandon Forest, white-lipped peccaries also used flooded areas frequently and relied heavily on fruits of the same species, as well as those of *Licania platypus*, *Pouteria sapota*, *Attalea butyracea*, and especially *Bactris balanoidea*. In general, across the entire distributional range, the largest populations of white-lipped peccaries occur in undisturbed tall humid tropical forests where water, fruits, and nuts are abundant. In these types of forests, white-lipped peccaries can represent a significant proportion of the mammalian biomass (Peres 1996, Kiltie and Terborgh 1983).

Collared

In contrast, collared peccaries are adapted to live in diverse environments from xeric subtropical areas such as deserts in southern Arizona, Texas, and Sonora, to humid tropical perennial forest (Sowls 1997). In tropical areas, collared peccaries do well in disturbed habitats, such as secondary forest near farm fields in tropical regions (Reyna-Hurtado and Tanner 2005), and they can be a nuisance to agricultural producers, because they can consume large quantities of corn, squash, manioc, and other crops (N. Arias, Nuevo Becal ejido, personal communication). Collared peccaries can occur in landscapes consisting of interspersed primary forest, disturbed native habitats, and croplands—places where white-lipped peccaries would be extirpated.

Habitat Management

Direct habitat improvement

To conserve the white-lipped peccary, it is necessary to preserve extensive areas of primary tropical forest with permanent water sources in Mexico. In particular, communal forests around large protected areas (i.e., Calakmul, Montes Azules, and Sian Ka'an Biosphere Reserves) should be retained to improve connectivity among peccary populations threatened with habitat fragmentation. Evergreen, subdeciduous, and flooded forest patches are especially important in southern Mexico, because they usually contain key water sources for both wildlife and people during the dry season. Land managers need to ensure that peccaries and other wildlife have access to standing water year-round. Sport and subsistence hunters frequently take advantage of the dry season to hunt white-lipped peccaries near water bodies. This is when this species is more vulnerable to hunters and wild predators.

Collared peccary populations can benefit by the presence of small cultivated clearings. Many hunters in some ejidos around the CBR used to allocate half a field for their own consumption and leave the other half to attract brocket deer, white-tailed deer, and collared peccaries (R. Reyna-Hurtado, personal observation). Artificial water and food sources could benefit peccary populations in some instances.

Retaining patches of fruiting trees and conserving undisturbed patches of tropical forest will benefit both collared and white-lipped peccary populations.

For both species, the protection of core habitat areas where hunting is prohibited is essential for the long-term survival of local populations.

Coordination with livestock management

Extensive cattle ranches and white-lipped peccary populations are incompatible. Conventional cattle ranching in the Neotropics requires extensive areas cleared of native vegetation and replanted with exotic grasses. White-lipped peccaries need extensive areas of mature forest with minimal fragmentation. Disease transmission is another potential problem that could have disastrous consequences for white-lipped peccary populations if they come in close contact with livestock, pigs, or other domestic animals (Fragoso 1997, Reyna-Hurtado et al. 2014).

Coordination with timber management

White-lipped peccary and collared peccary management can be compatible with logging if the area is large enough to allow rotation of cut and uncut plots in cycles of several years. White-lipped peccaries usually avoid human-disturbed areas, although in some ejidos in both the Calakmul and Lacandon regions, this species occurs in spite of moderate and seasonal timber extraction. Another problem is that loggers and other workers, when living in isolated forests, tend to engage in excessive hunting and can cause significant harm to wildlife populations, even resulting in local extirpations.

Collared peccary populations can tolerate timber extraction activities better than white-lipped peccaries because they are more resilient and take advantage of small forest clearings for foraging. However, under unrestricted hunting pressure, collared peccary populations can be extirpated (M. Briceño, unpublished data).

Coordination with other uses

For both peccaries, population management can be compatible with minimal environmental disturbances, such as ecotourism, wildlife photography, or low-impact extractive practices such the harvest of *xate* palms, chicle gum, mahogany seeds, or wild honey, which are common in southern Mexico's tropical forests. Sustainable hunting can be practiced in coordination with community-based conservation programs in areas where large tracts of disturbed and undisturbed habitat mosaics remain. Peccary popula-

tion size, herd movement patterns, group size, and availability of water and food resources must be taken into consideration when developing a management plan. Because collared peccary populations still occur in human-disturbed landscapes, this species is an ideal candidate for implementing pilot sustainable harvest programs where hunting is restricted and population parameters are closely monitored (Fang et al. 2008).

Management Challenges in Mexico

Managing white-lipped peccaries in Mexico is a major challenge, considering that their distributional range has been reduced by 84% (Altrichter et al. 2012), and only a few potentially viable populations remain. Efforts to conserve populations (or subpopulations) of this species, particularly outside extant protected areas, such as Calakmul, Montes Azules, Chimalapas, and Sian Ka'an Biosphere Reserves, are urgently needed. These subpopulations will ensure connectivity and dispersal between protected areas and will preclude the isolation of populations within protected areas. Subsistence and sport hunting are urgent issues, because even populations inhabiting high-quality habitats could be extirpated. Because of their precarious status and the lack of ecological data, sport hunting of white-lipped peccaries should be prohibited. This species has the potential to be a game animal, but not until communities develop sustainable management programs that include solid monitoring protocols (Reyna-Hurtado et al. 2010).

Because of its wide distribution and presence in several climatic zones and ecoregions, and its high tolerance of human disturbance as well as its potential economic worth, the collared peccary is an excellent candidate for pilot management programs in rural communities (Fang et al. 2008). Rural communities in southern Mexico currently lack the wildlife management expertise of private landowners in northern areas, but the adaptability of the collared peccary lends itself to adaptive management schemes (Weber et al. 2006). Rural communities are having the greatest negative impacts on peccary populations; it is urgent that these communities adopt sustainable wildlife management programs.

The destruction and fragmentation of tropical forests is the major issue confronting wildlife management in the tropics. The sustainable management of native plant communities and ecosystems is es-

essential to the survival of wildlife populations. Native mature forests serve as a reservoir of animal and plant populations, but they can also be incorporated into community protected areas that link existing wildlife reserves with movement and dispersal corridors. These areas are ideal for low-impact activities that can provide economic incentives for rural communities to practice sustainable management of natural resources. The continued existence of peccaries will depend on the successful implementation of wildlife conservation and management programs that will benefit both wildlife and human communities.

Literature Cited

- Almeida-Jácomo, A. T. 2004. Ecología manejo e conservação do Queixada *Tayassu pecari* in Parque Nacional das Emas e em propriedades rurais de seu entorno. Dissertation, University of Brasília, Brazil.
- Altrichter, M. 2005. The sustainability of subsistence hunting of peccaries in the Argentine Chaco. *Biological Conservation* 126:351–362.
- Altrichter, M., E. Carrillo, J. Saenz, and T. K. Fuller. 2001. White-lipped peccary (*Tayassu pecari*, Artiodactyla: Tayassuidae) diet and fruit availability in a Costa Rican rain forest. *Revista de Biología Tropical* 49:1183–1192.
- Altrichter, M., A. Taber, H. Beck, R. Reyna-Hurtado, and A. Keuroghlian. 2012. Range-wide declines of a key Neotropical ecosystem architect, the Near Threatened white-lipped peccary *Tayassu pecari*. *Oryx* 46:87–98.
- Álvarez-Castañeda, S. T., T. Álvarez, and N. González-Ruiz. 2015. Keys for identifying Mexican mammals in the field and in the laboratory. CIBNOR and UAM, La Paz, Baja California, México.
- Alvarez del Toro, M. 1991. Los mamíferos de Chiapas. Second edition. Gobierno del Estado, Tuxtla Gutiérrez, Chiapas, México.
- Amín, M. 2004. Patrones de alimentación y disponibilidad de presas del jaguar (*Panthera onca*) y del puma (*Puma concolor*) en la Reserva de la Biosfera Calakmul, Campeche, México. Dissertation, Instituto de Ecología, UNAM, México, D. F., México.
- Aranda, M. 1990. El jaguar (*Panthera onca*) en la reserva de la Biosfera de Calakmul: morfometría, hábitos alimentarios y densidad de población. Thesis, Universidad Nacional de Costa Rica, Heredia, Costa Rica.
- Bissonette, J. A. 1982. Ecology and social behavior of the collared peccary in Big Bend National Park, Texas. US Department of the Interior, National Park Service, Scientific Monograph Series No. 16. 85 pp.
- Bodmer, R. 1989. Frugivory in Amazonian Artiodactyla: evidence for the evolution of the ruminant stomach. *Journal of Zoology* 219:457–467.
- Bodmer, R. 1991. Influence of digestive morphology on resource partitioning in Amazonian ungulates. *Oecologia* 85:361–365.
- Bodmer, R., J. F. Eisenberg, and K. H. Redford. 1997. Hunting and the likelihood of extinction of Amazonian mammals. *Conservation Biology* 2:460–466.
- Carrillo, E., J. C. Saenz, and T. K. Fuller. 2002. Movements and activities of white-lipped peccaries in Corcovado National Park, Costa Rica. *Biological Conservation* 108:317–324.
- Crandall, L. S. 1964. The management of wild animals in captivity. University of Chicago Press, Illinois, USA.
- Cullen, L., Jr., R. E. Bodmer, and C. Valladares-Padua. 2000. Effects of hunting in habitat fragments of the Atlantic forests, Brazil. *Biological Conservation* 95:49–56.
- Day, G. I. 1985. Javelina research and management in Arizona. Arizona Game and Fish Department, Phoenix, USA.
- Desbiez, A. L. J. 2007. Wildlife conservation in the Pantanal: habitat alteration, invasive species and bushmeat hunting. Dissertation, University of Kent, Canterbury, United Kingdom.
- Díaz del Castillo, B. 2005. *Historia verdadera de la conquista de la Nueva España*. Mexicanos Unidos, México, D. F., México.
- Donkin, R. A. 1985. The peccary—with observations on the introduction of pigs to the New World. American Philosophical Society, Philadelphia, Pennsylvania, USA.
- Eisenberg, J. F. 1989. Mammals of the Neotropics: the northern Neotropics. University of Chicago Press, Illinois, USA.
- Eisenberg, J. F., M. A. O'Connell, and P. V. August. 1979. Density, productivity and distribution of mammals in two Venezuelan habitats. Pages 187–207 in J. F. Eisenberg, editor. *Vertebrate ecology in the northern Neotropics*. Smithsonian Institution Press, Washington, DC, USA.

- Ellisor, J. E., and W. F. Harwell. 1969. Mobility and home range of collared peccary in southern Texas. *Journal of Wildlife Management* 33:425–427.
- Emmons, L. H. 1987. Comparative feeding ecology of felids in a Neotropical rainforest. *Behavioral Ecology and Sociobiology* 20:271–283.
- Escamilla, A., M. Sanvicente, M. Sosa, and C. Galindo-Leal. 2000. Habitat mosaic, wildlife availability, and hunting in the tropical forest of Calakmul, Mexico. *Conservation Biology* 14:1592–1601.
- Fang, T. R., E. Bodmer, P. E. Puertas, P. Mayor-Aparicio, P. Pérez-Peña, R. Acero-Villanes, and D. T. S. Hayman. 2008. Certificación de pieles de pecaríes en la Amazonia Peruana. Wust Editions, Lima, Peru.
- Fragoso, J. M. V. 1994. Large mammals and the community dynamics of an Amazonian rain forest. Dissertation, University of Florida, Gainesville, USA.
- Fragoso, J. M. V. 1997. Desapariciones locales del baquiro labiado (*Tayassu pecari*) en la Amazonía: migración, sobre-cosecha o epidemia? Pages 309–312 in T. G. Fang, R. Bodmer, R. Aquino, and M. Valqui, editors. *Manejo de fauna silvestre en la Amazonía*. Universidad Nacional de la Amazonía Peruana, University of Florida, UNDP/GEF, and Instituto de Ecología, La Paz, Bolivia.
- Fragoso, J. M. V. 1998. Home range and movement patterns of white-lipped peccary (*Tayassu pecari*) herds in the northern Brazilian Amazon. *Biotropica* 30:458–469.
- Fragoso, J. M. V. 1999. Perception of scale and resource partitioning by peccaries: behavioral causes and ecological implications. *Journal of Mammalogy* 80:993–1003.
- Fragoso, J. M. V. 2004. A long-term study of white-lipped peccary (*Tayassu pecari*) population fluctuation in northern Amazonia. Pages 286–296 in K. Silvius, R. E. Bodmer, and J. M. V. Fragoso, editors. *People in nature: wildlife conservation in South and Central America*. Columbia University Press, New York, New York, USA.
- Gabor, T. M., and E. C. Hellgren. 2000. Variation in peccary populations: landscape composition or competition by an invader? *Ecology* 81:2509–2524.
- Glanz, W. E. 1982. The terrestrial mammal fauna of Barro Colorado Island: censuses and long-term changes. Pages 455–468 in E. G. Leigh Jr., A. S. Rand, and D. M. Windsor, editors. *The ecology of a tropical forest: seasonal rhythms and long-term changes*. Smithsonian Institution Press, Washington, DC, USA.
- Gómez, B., and O. Montenegro. 2012. Abundancia del pecarí de collar (*Pecari tajacu*) en dos áreas protegidas de la Guayana colombiana. *Mastozoología Neotropical* 19:163–178.
- Gongora, J., S. Morales, J. E. Bernal, and C. Moran. 2006. Phylogenetic divisions among collared peccaries (*Pecari tajacu*) detected using mitochondrial and nuclear sequences. *Molecular Phylogenetics and Evolution* 41:1–11.
- Gongora, J., R. Reyna-Hurtado, H. Beck, A. Taber, M. Altrichter, and A. Keuroghlian. 2011. *Pecari tajacu*. IUCN Red List of Threatened Species 2011:e.T41777A10562361. <http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T41777A10562361>. Accessed 23 Nov 2015.
- Gongora, J., A. Taber, A. Keuroghlian, M. Altrichter, R. E. Bodmer, P. Mayor, C. Moran, C. S. Damayanti, and S. González. 2007. Re-examining the evidence for a “new” peccary species, “*Pecari maximus*,” from the Brazilian Amazon. *PPHSG Newsletter* 7:19–26.
- González-Marín, R. M., S. Gallina, S. Mandujano, and M. Weber. 2008. Densidad y distribución de ungulados silvestres en la Reserva Ecológica El Edén, Quintana Roo, México. *Acta Zoológica Mexicana* 24:73–93.
- Hall, E. R. 1981. *The mammals of North America*. Second edition. Volume 2. John Wiley and Sons, New York, New York, USA.
- Hellgren, E. C., and J. A. Bissonette. 2003. Collared peccary. Pages 867–876 in G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, editors. *Wild mammals of North America: biology, management and conservation*. Second edition. Johns Hopkins University Press, Baltimore, Maryland, USA.
- Judas, J., and O. Henry. 1999. Seasonal variation of home range of collared peccary in tropical rain forest of French Guiana. *Journal of Wildlife Management* 63:546–552.
- Keuroghlian, A., A. Desbiez, R. Reyna Hurtado, M. Altrichter, H. Beck, A. Taber, and J. M. V. Fragoso. 2013. *Tayassu pecari*. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Accessed 4 Sep 2015.
- Keuroghlian, A., D. P. Eaton, and W. S. Longland. 2004. Area use by white-lipped and collared peccaries (*Tayassu pecari* and *Tayassu tajacu*) in a

- tropical forest fragment. *Biological Conservation* 120:411–425.
- Kiltie, R. A. 1981a. Stomach content of rain forest peccaries (*Tayassu tajacu* and *T. pecari*). *Biotropica* 13:234–236.
- Kiltie, R. A. 1981b. The significance of interlocking canines in the forest peccaries (Tayassuidae). *Journal of Mammalogy* 62:459–469.
- Kiltie, R. A., and J. Terborgh. 1983. Observations on the behavior of rain forest peccaries in Peru: why do white-lipped peccaries form herds? *Zeitschrift für Tierpsychologie* 62:241–255.
- Leopold, A. S. 1959. *Wildlife of Mexico: the game birds and mammals*. University of California Press, Berkeley, USA.
- Low, W. A. 1970. The influence of aridity on reproduction of the collared peccary (*Dicotyles tajacu* Linn.) in Texas. Dissertation, University of British Columbia, Vancouver, Canada.
- Mandujano, S. 1999. Variation in herd size of collared peccaries in a Mexican tropical forest. *Southwestern Naturalist* 44:199–204.
- Mandujano, S. 2007. Carrying capacity and potential production of ungulates for human use in a Mexican tropical dry forest. *Biotropica* 39:519–524.
- Mandujano, S., and L. E. Martínez Romero. 1997. Fruit fall caused by chachalacas (*Ortalis poliocephala*) on red mombin trees (*Spondias purpurea*): impact on terrestrial fruit consumers, especially the white-tailed deer (*Odocoileus virginianus*). *Studies on Neotropical Fauna and Environment* 32:1–3.
- March, I. J. 1990. Evaluación de hábitat y situación actual del pecarí de labios blancos *Tayassu pecari* en México. Thesis, Universidad Nacional de Costa Rica, Heredia, Costa Rica.
- March, I. J. 1993. The white-lipped peccary (*Tayassu pecari*). Pages 13–22 in W. L. R. Oliver, editor. *Pigs, peccaries and hippos*. IUCN, Gland, Switzerland.
- March, I. 2005. Pecarí de labios blancos. Pages 522–524 in G. Ceballos and G. Oliva, editors. *Los mamíferos silvestres de México*. CONABIO and Fondo de Cultura Económica, México, D. F., México.
- March, I., and S. Mandujano. 2005. Pecarí de collar. Pages 524–527 in G. Ceballos and G. Oliva, editors. *Los mamíferos silvestres de México*. CONABIO and Fondo de Cultura Económica, México, D. F., México.
- Martínez Romero, L. E., and S. Mandujano. 1995. Hábitos alimentarios del pecarí de collar (*Pecari tajacu*) en un bosque tropical caducifolio de Jalisco, México. *Acta Zoológica Mexicana* 64:1–20.
- Mason-Romo, E. D., E. P. Villa-Mendoza, G. Rendon-Alquicira, and D. Valenzuela-Galván. 2008. Primer registro del pecarí de collar (*Pecari tajacu*) en el estado de Morelos. *Revista Mexicana de Mastozoología* 12:170–175.
- Mayer, J. J., and R. M. Wetzel. 1987. *Tayassu pecari*. *Mammalian Species* 293:1–7.
- Moreira, J. 2009. Patrones diarios de actividad, tamaño y abundancia relativa de manadas de jabalí *Tayassu pecari* (Link, 1795), en el Parque Nacional Mirador-Rio Azul, Petén, Guatemala. Thesis, Universidad San Carlos, Guatemala, Guatemala.
- Naranjo, E. J. 2002. Population ecology and conservation of ungulates in the Lacandon Forest, Mexico. Dissertation, University of Florida, Gainesville, USA.
- Naranjo, E. J., S. A. Amador-Alcala, F. A. Falconi-Briones, and R. Reyna-Hurtado. 2015. Distribución, abundancia y amenazas a las poblaciones de tapir centroamericano (*Tapirus bairdii*) y pecarí de labios blancos (*Tayassu pecari*) en México. *Therya* 6:227–249.
- Naranjo, E. J., and R. E. Bodmer. 2007. Source-sink systems and conservation of hunted ungulates in the Lacandon Forest, Mexico. *Biological Conservation* 138:412–420.
- Novack, A., M. Main, M. Sunquist, and R. Labinsky. 2005. Foraging ecology of jaguar (*Panthera onca*) and puma (*Puma concolor*) in hunted and non-hunted sites within the Maya Biosphere Reserve, Guatemala. *Journal of Zoology* 267:167–178.
- Peres, C. A. 1996. Population status of white-lipped *Tayassu pecari* and collared peccaries *T. tajacu* in hunted and unhunted Amazonian forest. *Biological Conservation* 77:115–123.
- Pérez-Cortéz, S., and R. Reyna-Hurtado. 2008. La dieta de los pecaríes (*Pecari tajacu* y *Tayassu pecari*) en la región de Calakmul, Campeche, México. *Revista Mexicana de Mastozoología* 12:17–42.
- Ramírez-Barajas, P. J., and E. J. Naranjo. 2007. La cacería de subsistencia en una comunidad de la zona maya, Quintana Roo, Mexico. *Etnobiología* 5:65–85.
- Reyna-Hurtado, R. 2007. Social ecology of the white-lipped peccary (*Tayassu pecari*) in Calakmul Forest, Campeche, Mexico. Dissertation, University of Florida, Gainesville, USA.

- Reyna-Hurtado, R. 2009. Conservation status of the white-lipped peccary (*Tayassu pecari*) outside the Calakmul Biosphere Reserve in Campeche, Mexico: a synthesis. *Tropical Conservation Science* 2:159–172.
- Reyna-Hurtado, R., C. A. Chapman, S. Calme, and E. Pedersen. 2012. Searching in heterogeneous environments: foraging strategies in the white-lipped peccary (*Tayassu pecari*). *Journal of Mammalogy* 93:124–133.
- Reyna-Hurtado, R., J. Moreira, M. Briceño, M. Sanvicente, R. McNab, R. García, M. Mérida, E. Sandoval, G. Ponce, and D. Hyeroba. 2014. White-lipped peccaries with skin problems in the Maya Forest. *Suiform Soundings* 13:28.
- Reyna-Hurtado, R., E. Naranjo, C. A. Chapman, and G. W. Tanner. 2010. Hunting and the conservation of a social ungulate: the white-lipped peccary *Tayassu pecari* in Calakmul, Mexico. *Oryx* 44:88–96.
- Reyna-Hurtado, R., E. Rojas-Flores, and G. W. Tanner. 2009. Home range and habitat preferences of white-lipped peccary groups (*Tayassu pecari*) in a seasonal tropical forest of the Yucatan Peninsula, Mexico. *Journal of Mammalogy* 90:1199–1209.
- Reyna-Hurtado, R., A. Taber, M. Altrichter, J. Frago, A. Keuroghlian, and H. Beck. 2008. *Tayassu pecari*. 2008 IUCN Red List of Threatened Species. www.iucnredlist.org. Accessed 13 Nov 2012.
- Reyna-Hurtado, R., and G. Tanner. 2005. Habitat preferences of an ungulate community in Calakmul Forest, Campeche, Mexico. *Biotropica* 37:676–685.
- Reyna-Hurtado, R., and G. W. Tanner. 2007. Ungulate relative abundance in hunted and non-hunted sites in Calakmul Forest (southern Mexico). *Biodiversity and Conservation* 16:743–757.
- Robinson, J. G., and J. F. Eisenberg. 1985. Group size and foraging habits of collared peccary (*Tayassu tajacu*). *Journal of Mammalogy* 66:153–155.
- Robinson, J. G., and K. H. Redford. 1986. Body size, diet and population density of Neotropical forest mammals. *American Naturalist* 128:665–680.
- Schaller, G. 1983. Mammals and their biomass on a Brazilian ranch. *Arquivos de Zoologia* 31:1–36.
- Schweinsburg, R. E. 1971. Home range, movements and herd integrity of the collared peccary. *Journal of Wildlife Management* 35:455–460.
- SEMARNAT. 2010. Norma Oficial Mexicana NOM-059-SEMARNAT- 2010, Protección ambiental—Especies nativas de México de flora y fauna silvestres—Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio—Lista de especies en riesgo. Segunda Sección. DOF.
- Sowls, L. K. 1997. Javelinas and the other peccaries: their biology, management and use. Second edition. Texas A&M University Press, College Station, USA.
- Stearman, A. M. 1992. Neotropical hunters and their neighbors: Sirionó, Chimane and Yuquí hunting on the Bolivian frontier. Pages 108–128 in K. Redford and C. Padoch, editors. *Conservation of Neotropical forests (working from traditional use)*. Columbia University Press, New York, New York, USA.
- Supple, V. C. 1983. The dynamics of collared peccary dispersion into available range. Federal Aid in Wildlife Restoration, Project W-78. Arizona Game and Fish Department, Phoenix, USA.
- Van Roosmalen, M. G. M., L. Frenz, P. van Hooft, H. H. de Iong, and H. Leirs. 2007. A new species of living peccary (Mammalia: Tayassuidae) from the Brazilian Amazon. *PPHSG Newsletter* 7:15–19.
- Weber, M. 2000. Effects of hunting on tropical deer populations in southeastern Mexico. Thesis, University of London, United Kingdom.
- Weber, M., G. García-Marmolejo, and R. Reyna-Hurtado. 2006. The tragedy of the commons Mexican style: a critique to the Mexican UMAs concept as applied to wildlife management and use in southeastern Mexico. *Wildlife Society Bulletin* 34:1480–1488.
- Wetzel, R. M., R. E. Dubos, R. L. Martin, and P. Myers. 1975. *Catagonus*, an “extinct” peccary, alive in Paraguay. *Science* 189:379–381.
- Zervanos, S. M. 1975. Seasonal effects of temperature on the respiratory metabolism of the collared peccary (*Tayassu tajacu*). *Comparative Biochemistry and Physiology* 50:365–371.
- Zervanos, S. M., and G. I. Day. 1977. Water and energy requirements of captive and free-living collared peccaries. *Journal of Wildlife Management* 41:527–532.
- Zervanos, S. M., and N. F. Hadley. 1973. Adaptational biology and energy relationships of the collared peccary (*Tayassu tajacu*). *Ecology* 54:759–774.