Short Note

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Mammal use of *Raphia taedigera* palm stands in Costa Rica's Osa Peninsula

Abstract: *Raphia taedigera* is a wetland palm species that occurs in monospecific stands in Central and South America, Africa, and Madagascar. Use of this ecosystem by wildlife is largely unknown. We surveyed *R. taedigera* stands at the Osa Biological Corridor in Costa Rica using 26 camera traps to identify which large (>1 kg) mammal species use this habitat and the distance each species will travel into it from the surrounding habitats. We conclude that *R. taedigera* provides habitat and a connectivity function in the Osa region for coati (*Nasua narica*), raccoon (*Procyon* sp.), collared peccary (*Pecari tajacu*), white-faced capuchin (*Cebus capucinus*), ocelot (*Leopardus pardalis*), northern tamandua (*Tamandua mexicana*), and paca (*Cuniculus paca*). Other species were detected only on the edges of stands or not at all. On the basis of literature review, interviews with farmers, frequent detections of collared peccary, and detection in adjacent habitat, the jaguar (*Panthera onca*) is also expected to traverse *R. taedigera* stands. *Raphia taedigera* stands can be considered an important habitat for maintaining connectivity across the Osa Biological Corridor and potentially provide a similar function in other Neotropical landscapes.

Keywords: camera trap; Costa Rica; mammals; *Raphia taedigera*.

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Raphia taedigera is a riverine palm species that occurs in monospecific stands in South America (Brazil and Columbia), Central America (Costa Rica, Nicaragua, and Panama), Africa, and Madagascar (Henderson et al. 1995). It is the only palm in its genus to occur outside of Africa. This species is found in inundated estuarine habitats in close proximity to mangrove forests and establishes itself further inland along tidal river channels. The palms grow up to 20 m tall and produce 15–20 m long pinnate leaves and scaly, egg-shaped fruits approximately 4×7 cm in size (Jones 1995, Carney and Hiraoka 1997). Although these wetland palm forests are regularly inundated, they are not deep enough to be passable by canoe or boat and are difficult to traverse on foot because of porous alluvial soils and areas of open water. Although *R. taedigera* has numerous human uses in some regions (e.g., cooking oil, pig feed, shrimp and fish traps, medicinal, and household construction in Brazil) (Carney and Hiraoka 1997), very limited information is available on wildlife use of this ecosystem.

As part of a research project investigating habitat use by large mammals at the Osa Biological Corridor in the Osa Peninsula in Costa Rica, we sampled *Raphia taedigera* stands (referred to as *Raphia* hereafter) using 26 automatic camera traps (Reconyx Hyperfire HC 500, Wisconsin, USA). We contrasted the mammal assemblage in *Raphia* sites (n=26) with that in other local habitats, including lowland rainforest sites (n=105), mangrove forests (n=25), and three man-made habitats: pasture or grasslands (n=30), oil palm (*Elaeis guianensis*) (n=26), and grey teak (*Gmelina arborea*) (n=5) stands. In this paper, habitat use was inferred on the basis of presence data from individual trap locations. By combining data from multiple cameras within any habitat type, a general picture of the degree to which that habitat is used by each species was inferred.

A total of 211 sites were sampled across approximately 800 km^2 of the peninsula (Figure 1). From February to June 2013 each site was sampled with one camera for approximately 28 days. The 26 *Raphia* sites were spread across the 40 km^2 of *Raphia* forest in the study area. Cameras were placed inside the *Raphia* sites, 25–1500 m (mean 335 m, median 150 m) away from the edge. Edges were defined as areas where the *Raphia* sites gave way to a different land cover, most often marshy, herbaceous vegetation,

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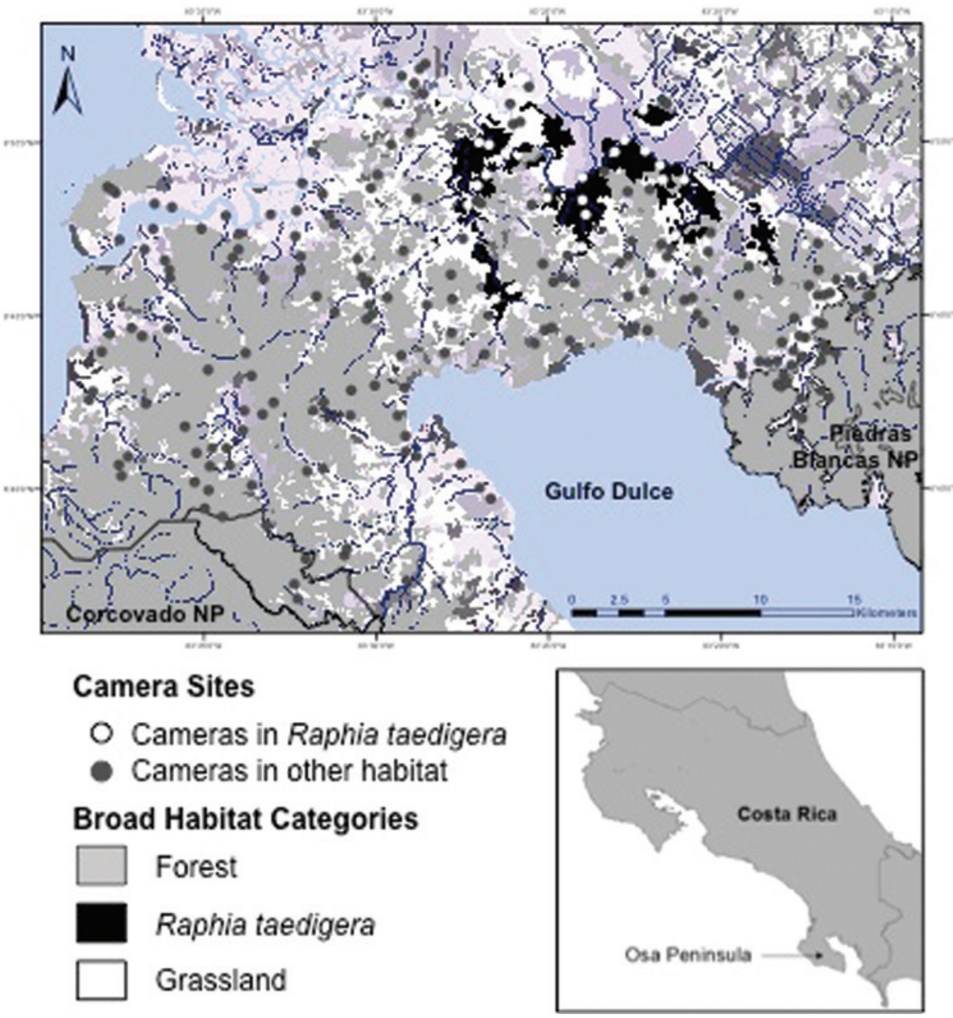

Figure 1 Map of *Raphia taedigera* (black) sample sites (white dots). The dominant grey area is well-drained lowland rainforest and the white areas grasslands. Mangrove forests are light grey, predominantly in the NW coastal area of the map. Grey dots are sample sites in other land covers.

grasslands, or well-drained lowland rainforest (Figure 2). Site selection was based on river and land access and maintaining a 1 km distance between sites. Cameras were baited with a scent lure (Ross Carman, Magna Glan, New Milford, PA, USA).

A total of 12 large mammals (>1 kg) and a number of small mammals (Sciuridae, Muridae, and an opossum) and birds were detected in 753 trap nights of *Raphia* site sampling (Table 1 and Figure 3). No humans were detected. A domesticated dog was detected at one site on eight occasions. This camera was approximately 100 m away from a farm and the dog was likely attracted to the scent lure.

The large mammals detected constituted close to half of the 23 species detected in the overall study. The coati (*Nasua narica*), raccoon (*Procyon* sp.), and collared peccary (*Pecari tajacu*) were the most frequently detected species, followed by the white-faced capuchin (*Cebus capucinus*), ocelot (*Leopardus pardalis*), and northern tamandua (*Tamandua mexicana*). For each of these species a multiple regression analysis was performed to determine the influence on detection frequency of (1) distance from the nearest edge and (2) distance from a well-drained lowland forest. Neither of these variables was statistically significant for any of the species. All six species were occasionally detected at least 1 km into the *Raphia* sites, suggesting that they use these sites as their primary habitat, and do not simply enter the edges while staying close to other preferred habitats (Figure 4).

Interestingly, the coati, tamandua, and capuchin were detected by more cameras in the *Raphia* sites than in any other habitat sampled (for example, 31% of the cameras in *Raphia* detected coati, whereas only 12% of those in mangrove forests detected this species; in other habitats fewer cameras detected this species). For the capuchin and tamandua, this observation could be a result of more time spent on the ground in the *Raphia* sites than in the other

Figure 2 (Top left) View from a pastureland hillside looking down at a large *Raphia taedigera* stand. The edge where pastureland meets the *R. taedigera* is visible, as well as the forested mountains in the background, where the *R. taedigera* stand ends. (Right) Field team walking into a drier stand of *R. taedigera* that lacks a closed canopy. (Bottom left) *Raphia taedigera* growing on both sides of the Sierpe River.

habitats due to a less navigable palm canopy. *Raphia* stands may be a preferred habitat for coati.

Collared peccary were detected at a similar percentage of *Raphia* cameras as forest cameras (42% and 43%, respectively). Capuchins and peccary are known to eat *Raphia* fruit (Janzen and Wilson 1983, Carrillo et al. 2002, Eadie 2012). *Raphia* stands were fruiting at the time of sampling, and the fruiting event likely accounts for the occurrence of capuchins and peccary in this habitat, but no species was photographed eating the fruit. Mangrove was the preferred habitat for raccoons (100%), but *Raphia* (58%) and grey teak (60%) also had a high percentage of cameras detecting the species. Ocelot detections in *Raphia* were similar to those in grasslands and oil palm sites (<20%), whereas grey teak and forest sites had the highest percentage of cameras detecting this species (40% and 30%, respectively).

Agouti (*Dasyprocta punctata*) was detected at only two *Raphia* sites, one located approximately 60 m from a secondary forest and the other 150 m from a pastureland. Agoutis are known to prefer forest habitats, but also use gardens and plantations (Reid 1997). *Raphia* stands are unlikely the preferred habitat of agoutis given that this species was detected at a higher percentage in forest and grey teak sites than in *Raphia* sites (8% in *Raphia* versus 88% in forest and 100% in grey teak sites) and remained near the edges.

Jaguarondis were detected at three sites across the corridor, all no further than 250 m from the edge of the *Raphia* stands. Two sites neighboured the grasslands and forest sites, and the third neighboured hog plum (*Symphonia globulifera*) dominated swamp forest, oil palm, and grassland sites. Although this species is known to use a diverse range of natural and disturbed habitats, possibly preferring dry forests to wetlands (Emmons 1997), forest is the only other habitat in which this species was detected (four sites).

The striped hog-nosed skunk (*Conepatus semistriatus*) was detected at two sites: on two subsequent days at a site located 150 m from the edge of pastureland and once at a site 300 m from a forest edge, 650 m from grassland, and 160 m from a hog plum swamp forest (requiring a 30 m river crossing). Home ranges for this species have been known to extend to 53 ha (Walker 2004), allowing

Table 1 Species detected in *Raphia taedigera* sites.

Common name	Scientific name	Authority	No. of times detected[a]	No. of sites	Detections/ 100 trap nights	% of cameras detecting (n=26)
Large mammals						
White-nosed coati	*Nasua narica*	Linnaeus, 1766	82	21	10.9	0.81
Raccoon	*Procyon* sp.	Storr, 1780	77	15	10.2	0.58
Collared peccary	*Pecari tajacu*	Linnaeus, 1758	30	11	4.0	0.42
White-faced capuchin	*Cebus capucinus*	Linnaeus, 1758	13	8	1.7	0.31
Ocelot	*Leopardus pardalis*	Linnaeus, 1758	14	5	1.9	0.19
Northern tamandua	*Tamandua mexicana*	Saussure, 1860	11	8	1.5	0.31
Central American agouti	*Dasyprocta punctata*	Gray, 1842	7	2	0.9	0.08
Spotted paca	*Cuniculus paca*	Linnaeus, 1766	4	1	0.5	0.04
Jaguarundi	*Puma yagouaroundi*	É. Geoffroy Saint-Hilaire, 1803	4	3	0.5	0.12
Striped hog-nosed skunk	*Conepatus semistriatus*	Boddaert, 1785	3	2	0.4	0.08
Nine-banded armadillo	*Dasypus novemcinctus*	Linnaeus, 1758	1	1	0.1	0.04
White-tailed deer	*Odocoileus virginianus*	Zimmermann, 1780	1	1	0.1	0.04
Small mammals						
Grey four-eyed opossum[b]	*Philander opossum*	Linnaeus, 1758	76	15	10.1	0.58
Mice and rats	Muridae	Illiger, 1811	18	10	2.4	0.38
Squirrels	Sciuridae	Fischer de Waldheim, 1817	3	1	0.4	0.04
Birds						
Grey-necked wood rail[c]	*Aramides cajaneus*	Müller, 1776	79	15	10.5	0.58
Doves and pigeons	Columbidae	Illiger, 1811	14	5	1.9	0.19
White ibis[d]	*Eudocimus albus*	Linnaeus, 1758	13	4	1.7	0.15
Great egret[d]	*Ardea alba*	Linnaeus, 1758	7	1	0.9	0.04
Snowy egret[d]	*Egretta thula*	Molina, 1782	5	1	0.7	0.04
Little blue heron[d]	*Egretta caerulea*	Linnaeus, 1758	4	1	0.5	0.04
Bare-throated Tiger Heron	*Tigrisoma mexicanum*	Swainson, 1834	1	1	0.1	0.04
Agami heron	*Agamia agami*	Gmelin, 1789	1	1	0.1	0.04
Green heron	*Butorides virescens*	Linnaeus, 1758	1	1	0.1	0.04
Wood stork	*Mycteria americana*	Linnaeus, 1758	1	1	0.1	0.04

[a]A detection was considered independent of a prior detection of the same species if it occurred ≥30 min after the completion of a previous photo series.
[b]Of these detections, 32 were confirmed *P. opossum*. The remaining detections are likely of this species.
[c]All except three detections were confirmed *A. caianeus*. The remaining detections are likely of this species.
[d]One of the detections for each of these species was not confirmed, but considered likely to be of the species listed.

for the possibility that the individuals detected were using *Raphia* stands in combination with other habitats. Forest cameras detected this species most frequently (18% of cameras in the forest sites compared with 8% in *Raphia*, 8% in oil palm, and 4% in grassland sites).

Only three species were detected at a single site: paca (*Cuniculus paca*), nine-banded armadillo (*Dasypus novemcinctus*), and white-tailed deer (*Odocoileus virginianus*). The paca site was located 1 km from an edge and 70 m (with a 30 m river crossing) from a hog plum swamp forest. The four detections at this site occurred over a 19-day period. Paca home ranges are 2–3 ha in size (Beck-King et al. 1999), pointing to the possibility that paca can persist in *Raphia* stands for extended periods. The armadillo site was near a grassland (<100 m) and a forest (300 m). Although this species is known to use grasslands and human-inhabited areas (Emmons 1997), it was never detected in grassland sites in the study. Detections in the *Raphia* (4%) sites were low compared with those in the grey teak (60%), forest (30%), and oil palm (12%) sites. The white-tailed deer was detected only once at a site 50 m from grasslands in a mixed *Raphia*, forest, and grassland area. A grassland site was the only other site where this species was detected.

Other species detected in the landscape but not in *Raphia* sites were the white-lipped peccary (*Tayassu pecari* Link, 1795), Baird's tapir (*Tapirus bairdii* Gill, 1865), jaguar (*Panthera onca* Linnaeus, 1758), puma (*Puma concolor* Linnaeus, 1771), margay (*Leopardus wiedii* Schinz, 1821), red brocket deer (*Mazama temama* Kerr, 1792), tayra (*Eira barbara* Linnaeus, 1758), greater grison (*Galictis vittata* Schreber, 1776), coyote (*Canis latrans* Say, 1823), mantled howler monkey (*Alouatta palliata* Gray, 1849), and Neotropical river otter (*Lontra longicaudis* Olfers, 1818).

Figure 3 Photos of four of the twelve species detected on cameras in *Raphia taedigera* stands (clockwise from top left): white-faced capuchin monkey (*Cebus capucinus*), paca (*Cuniculus paca*), collared peccary (*Pecari tajacu*), nine-banded armadillo (*Dasypus novemcinctus*).

The white-lipped peccary, jaguar, and Baird's tapir are of particular interest because of their high conservation status. The white-lipped peccary was only detected in a subset of cameras at Sirena Research Station in Corcovado National Park (CNP), but not in any other part of the corridor sampled during this study. This species has been

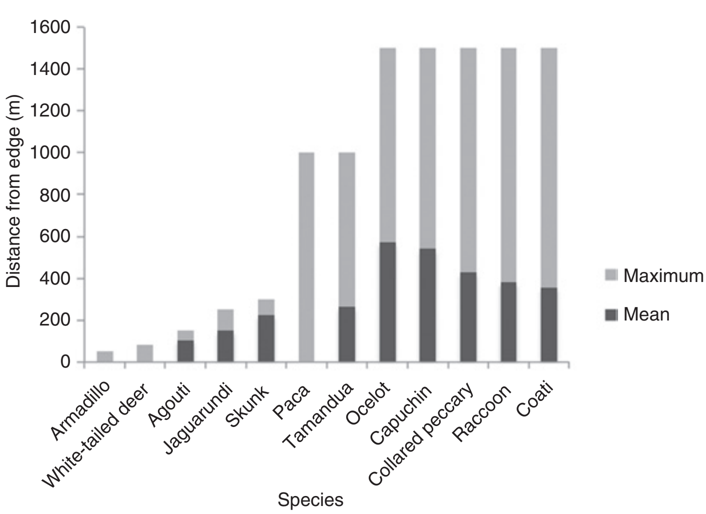

Figure 4 Distance from the edge of a *Raphia taedigera* stand where each species was detected and the average distance from edge for species that were detected at multiple sites.

documented using *Raphia* stands seasonally (October–January) in nearby CNP (Carrillo et al. 2002), but based on interviews with the locals, it is only known to occasionally migrate into the western end of the study area where large *Raphia* stands are absent. Baird's tapir was detected in the corridor, about 10 km from the nearest *Raphia* site. Tapir reportedly use *Raphia* in CNP during the dry season, when palm fruits are falling (Janzen and Wilson 1983, Naranjo 2009), and in Nicaragua (Jordon et al. 2010). The jaguar was reported by farmers living on the edge of the *Raphia* stands to use this habitat, but it was not detected by any of the cameras placed in the *Raphia* sites. One farmer on a property bordered by an extensive *Raphia* stand and forest with a small area of pastureland provided a detailed report of sighting two jaguars passing through the stand abutting his property. His story was supported by the detection of a jaguar by one of our cameras in his pasture.

The other species (1) had low detection rates in the present study, being detected by three or fewer cameras (greater grison, coyote, howler monkey, and otter), (2) are largely arboreal (margay and howler monkey), and/or (3) had a strong preference for forest habitats in this study (puma, tayra, and red brocket deer).

We conclude that *Raphia* forests provide useful habitat and a connectivity function in the Osa Biological Corridor for the coati, raccoon, collared peccary, white-faced capuchin, ocelot, tamandua, and paca. *Raphia* forests may also provide habitat and connectivity for the jaguarondi, agouti, and striped hog-nosed skunk, although detections were infrequent and these species remained near the edges of *Raphia* stands. Detection probabilities were low for many of the species, which may account for the low number of detections in *Raphia* sites, rather than their aversion to this habitat. On the basis of the data from other studies and our camera and interview data, we have confirmed that the tapir and white-lipped peccary do use *Raphia* but are unlikely to be present in *Raphia* stands in the study area because of hunting and habitat fragmentation. Finally, on the basis of interview data, a detection adjacent to *Raphia* sites, and the high number of collared peccary detections (a jaguar prey species – Polisar et al. 2003, Carillo et al. 2009), we postulate that jaguar will likely use *Raphia* stands, making these sites an important habitat to maintain connectivity across the Osa Biological Corridor. *Raphia* stands are likely to provide a similar habitat and connectivity function for large mammals in other Central and South American landscapes.

Separate to this manuscript, more sophisticated analyses are being conducted with the complete data set across all habitats. Raw data obtained during the 753 trap nights are available upon request from the senior author.

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