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THE EFFECT OF INTRODUCED ROOF RATS ON BIRD DIVERSITY OF ANTILLEAN CAYS

EARL W. CAMPBELL[1]
Department of Biological Sciences
Bowling Green State University
Bowling Green, Ohio 43403 USA

Abstract.—The purpose of this study was to document the impact of introduced roof rats (*Rattus rattus*) on the diversity of island birds of selected Antillean cays. Ten sites on seven islands near Puerto Rico and the U.S. Virgin Islands were studied from 19 Feb. to 28 Mar. 1988. Islands ranged from 0.83 to 5500 ha. On each island bird surveys and rat trapping were employed to evaluate rat abundance and bird diversity. Transects, 50–135 m in length, were used for all surveys and trapping. The abundance of rats varied from 0 to 0.082 rats/h. Increasing rat abundance was negatively correlated with a significant decline in bird diversity in xeric forest habitats, suggesting roof rats may affect bird diversity on Antillean Cays.

EL EFECTO DE *RATTUS RATTUS* INTRODUCIDAS EN CAYOS DE LAS ANTILLAS, EN LA DIVERSIDAD DE AVES

Sinopsis.—El propósito de este trabajo es documentar el impacto de ratas (*Rattus rattus*), introducidas en un grupo de cayos de las Antillas, en la diversidad de aves. Del 19 de febrero al 28 de marzo de 1988, se estudiaron diez localidades en siete islas cerca de Puerto Rico y las Islas Vírgenes Norteamericanas. El tamaño de las islas varió de 0.83 a 5500 he. En cada isla, se emplearon las técnicas de captura y conteo para evaluar la abundancia de ratas y la diversidad de pájaros, respectivamente. Las capturas y conteos, se llevaron a lo largo de transectos de 50-135 m. La abundancia de ratas varió de 0 a 0.082 ratas/h. Hubo una correlación negativa entre el incremento en la abundancia de ratas, y disminución (significativa) en la diversidad de aves en hábitats xerofíticos, lo que sugiere que las ratas podrían afectar la diversidad de aves en cayos de las Antillas.

European exploration and colonization in the sixteenth century introduced the roof rat (*Rattus rattus*) of continental Europe to the Caribbean islands. In the early eighteenth century the Norway rat (*Rattus norvegicus*) spread north from the Caspian Sea to mainland Europe, often displacing the roof rats in European harbors and ships heading to the colonies (Atkinson 1985). As a result, many Caribbean islands now have both species of rats.

Colonization of islands by rats frequently results in the extinction of native birds. For example, 40% of the indigenous land birds species on Lord Howe Island became extinct within a few years after 1918, when the S. S. *Makambo* ran ashore and introduced roof rats (Recher and Clark 1974). Similarly, roof rats were introduced to Midway Island in 1943 when a military base was constructed, and within 18 mo two species of land birds were extinct (Fisher and Baldwin 1946).

This study documents the impact of roof rats on the diversity of indigenous birds on cays and islands of the Puerto Rican Bank. Islands

[1] *Current address: Department of Zoology, The Ohio State University, Columbus, Ohio 43210 USA.*

with heavy, moderate, low or no rat infestations were included to observe the effects of different levels of rat abundance. I expected that the abundance of roof rats would be negatively correlated with avian diversity.

METHODS

Study area.—This study was conducted from 19 Feb. to 28 Mar. 1988. Seven islands were evaluated: Cayo Icacos (2.3 km off the northeast coast of Puerto Rico), Isla Mona (approximately 70 km west of Puerto Rico), Great Saint James Island (0.4 km southeast of St. Thomas, U.S.V.I.), Buck Island (3.0 km south of St. Thomas), Congo Cay (2.2 km northwest of St. John, U.S.V.I.), Steven Cay (0.8 km west of St. John) and Outer Brass Island (2.2 km north of St. Thomas). These Islands range in size from 0.83 to 5500 ha (Table 1). All the islands except Mona are part of a geological region referred to as the Puerto Rican Bank, which was connected as a single land mass until about 10,000 yr ago when global warming caused the sea level to rise (Heatwole et al. 1981).

All 10 sites I surveyed were classified as xeric forest (following Heatwole et al. 1981). Xeric forests are defined as deciduous, open forests that may have a sparse understory of cactus, thorny shrubs, vines and annual grasses. All study sites, except Buck 3, had the following characteristic trees: *Acacia macracantha, Bursera simaruba, Ficus* spp., *Hippomane mancinella* and *Metopium toxiferum.* The survey site on Buck 3 was in an *Acacia macracantha* stand.

Goats (*Capra hircus*), pigs (*Sus domestica*) and cats (*Felis catus*) were present on Mona Island. Goats were present on Outer Brass, and cats were present on Cayo Icacos.

Survey techniques.—On each island, transects ranging from 50 to 135 m in length were established in xeric forest habitat and were used for trapping rats and surveying birds. Roof rat populations were indexed by removal trapping with snap traps. Traps were tied on tree trunks 0.5 m above the ground, spaced at 5-m intervals along transects and baited with peanut butter and rolled oats. Because of trap disturbance by land crabs, traps were set at dusk and checked hourly for 3 h. Tripped traps were reset when found and the prior hour was excluded from analysis (Table 1). Rat abundance was indexed as the mean number of rats caught per trap hour.

Avian surveys were done by direct species counts along each transect on each island. Once each morning, between 0700 and 0800 hours, and again each afternoon, between 1600 and 1700 hours, transects were walked at a constant pace, and birds observed or heard within 10 m of either side of the transect were counted. Bird species diversity, using Simpson's index was calculated as

$$D = 1 - \sum p_i^2,$$

where p_i is the proportion of individuals of species i in the community (Krebs 1989). The average number of individuals of species i observed

TABLE 1. Description of study sites on the Puerto Rican Bank and Mona.

Island/ transect	Size (ha)	Transect length (m)	Trap hours	Total rats trapped	Species diversity	Total species	Mean birds/km² (SE)
Steven	0.83	95	196	0	0.47	5	1.2 (0.24)
Buck	16.81	50	112	8	0.18	2	1.1 (0.8)
Congo 1	10.60	50	96	6	0.00	1	0.5 (0.21)
Congo 2		50	110	9	0.00	1	0.37 (0.24)
Outer Brass 1	43.69	100	183	7	0.27	3	3.5 (1.34)
Outer Brass 2		50	88	2	0.13	2	7.5 (0.95)
Gt. St. James 1	63.48	50	218	9	0.58	3	1.25 (0.37)
Gt. St. James 2		50	131	4	0.57	3	1.62 (0.43)
Icacos	398.1	100	179	0	0.79	8	0.85 (0.15)
Mona	5500.0	100	190	3	0.23	2	3.75 (1.03)

on each transect was used to calculate the proportion of species i in this study. Diversity values can range from 0 (low) to 1 (high). Simpson's index of diversity was used in this study because it is a measure of two separate concepts of diversity, species richness and evenness (Krebs 1989).

RESULTS AND DISCUSSION

Rat populations.—Roof rat abundance ranged from 0 rats on Steven and Icacos to 0.082 rats trapped per trap hour on Congo 2 (Table 1). On two transects with high rat abundances, Buck and Great Saint James 1, daytime foraging of roof rats was observed. Numerous trees on Buck had chewed buds and bark, resulting from roof rats because they were the only animal present on Buck Island capable of inflicting this damage. Rat droppings and runways were observed near Red-billed Tropicbird (*Phaethon aethereus*) nests on Buck Island.

Bird species diversity and the impact of roof rat abundance.—Nine species of birds were observed on the transects (Table 2). Of these, only three species were present on more than two transects. The Pearly-eyed Thrasher (*Margarops fuscatus*) was the most common bird species along transects; it was seen on eight transects. The Bananaquit (*Coereba flaveola*) and the Zenaida Dove (*Zenaida aurita*) were observed on seven and six transects, respectively. No relationship was found between the number of bird species present on islands and island size. No relationship was also found between bird species diversity and island size, island distance, log island size and log island distance. Similar non-significant results were found when Mona was excluded, due to its size and distance from Puerto Rico from analysis. Regression analysis indicated a significant decline in bird species diversity with increasing rat abundance (Fig. 1, $y = -0.006x + 0.553$, $r^2 = 0.455$, $P < 0.05$). These data suggest that roof rat population abundance might influence avian diversity on Antillean Cays.

TABLE 2. Mean number of individuals for each bird species observed on ten transects on seven Antillean cays (SE in parentheses), February–March 1988.

Species	Steven	Buck	Congo 1	Congo 2	Outer Brass 1	Outer Brass 2	Great Saint James 1	Great Saint James 2	Icacos	Mona
Smooth-billed Ani *Crotophaga ani*	0	2.25 (1.60)	0	0	0	0	0	0	0.10 (0.10)	0
Zenaida Dove *Zenaida aurita*	0.28 (1.77)	0.25 (0.50)	0	0	0.13 (0.25)	0	0.25 (0.25)	0	0.10 (0.10)	0.50 (0.29)
Green-throated Carib *Sericotes holosericeus*	0.19 (0.19)	0	0	0	0	0	0	0	0.50 (0.39)	0
Antillian Crested Hummingbird *Orthorhyncus cristatus*	0	0	0	0	0	0	0	0	0.60 (0.19)	0
Puerto Rican Emerald *Chlorostilbon maugeus*	0	0	0	0	0	0	0	0	0.10 (0.10)	0
Caribbean Elaenia *Elaenia martinica*	0	0	0	0	0	0	0	0.25 (0.25)	0	0
Pearly-eyed Thrasher *Margarops fuscatus*	0.09 (0.09)	0	1.00 (0.41)	0.75 (0.48)	2.88 (1.01)	7.00 (1.78)	1.00 (0.46)	1.50 (0.65)	0.80 (0.12)	3.25 (0.75)
Bananaquit *Coereba flaveola*	0.09 (0.09)	0	0	0	0.58 (0.35)	0.50 (0.29)	1.25 (0.25)	1.50 (0.50)	0.20 (0.12)	0
Yellow Warbler *Dendroica petechia*	1.58 (0.93)	0	0	0	0	0	0	0	0.10 (0.10)	0

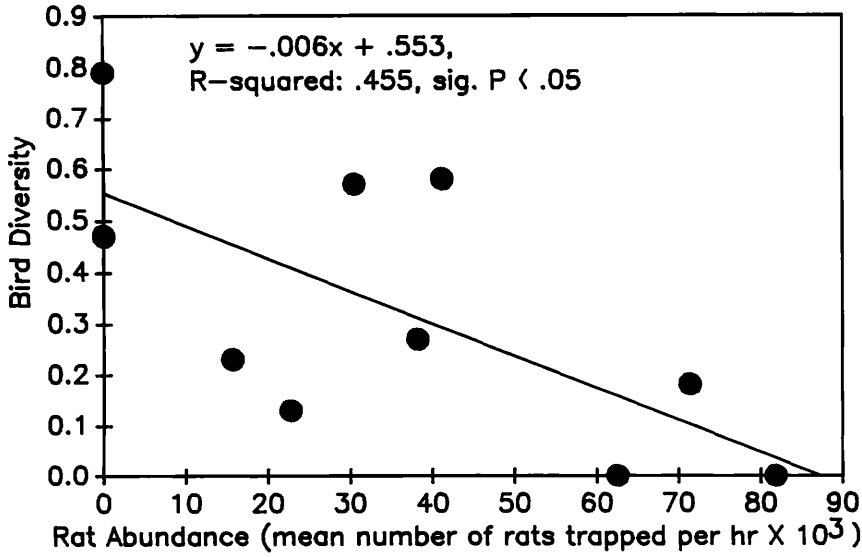

FIGURE 1. Regression of bird species diversity versus roof rat abundance using data collected on nine Antillean cays, February–March 1988. Bird species diversity was calculated using Simpson's Index of Diversity, which can range from 0 (low) to 1 (high).

Roof rats in xeric forests might reduce avian species diversity through competition for food resources, alteration of important habitat parameters, and predation on eggs, nestlings and adult birds. Atkinson (1985) found 39 examples of roof rat predation on oceanic island birds. He found that roof rats preyed on birds in burrows, on the ground, and in cavities and branches and foliage above and below 3 m. Sixty four percent of the bird species preyed on by roof rats were perching birds.

In the U.S. Virgin Islands only two species of seabirds commonly nest on islands with roof rat infestations: the Red-billed Tropicbird and the Brown Pelican (*Pelecanus occidentalis*) (Nellis, pers. comm.). These species also nest on uninfested islands. Red-billed Tropicbirds are aggressive at nest sites and may not be affected by rats for this reason (Halewyn and Norton 1984). On Little Saint James, an island not included in this study, roof rats may be responsible for the 100% mortality of two separate Roseate Tern colonies (*Sterna dougallii*) (Dewey and Nellis 1980).

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