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Diversity and distribution of small terrestrial rodents along a disturbance gradient in montane Costa Rica

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Abstract: A total of 389 rodent captures in five unequally disturbed habitats in a Costa Rican montane cloud forest corresponded to 185 individuals (seven species, two families). Species richness was similar for all habitats, averaging 4-5 species/habitat. Population density and capture frequency were higher in moderately disturbed habitats; *Peromyscus mexicanus* and *Scotinomys xerampelinus* were four to five times more common than other murids. These species represented 79.4 % of all captures and 73.5 % of all captured individuals. Heteromyid species were rarely trapped. The importance of disturbance-mediated within-habitat microenvironmental heterogeneity for terrestrial small-sized rodent populations is stressed.

Key words: Costa Rica, disturbance, montane cloud forest, rodents.

Terrestrial rodents are known to be important seed dispersers and predators in tropical forest ecosystems (*e.g.* Adler 1995). Often they form the staple food of many avian and mammal predators and therefore play a prominent role in maintaining the structure and composition of species-rich tropical habitats.

However, little is known about their response to changes in the environment and particularly to disturbance by man (Adler 1994). Indeed, it has been recorded that some rodent species populations may flourish due to human activities in natural and seminatural ecosystems (Johnson and Vaughan 1993). Untill now, knowledge on the effects of deforestation and habitat fragmentation on the presence and abundance of small terrestrial rodents in tropical forests is still limited. This is particularly the case in tropical upland regions where we count with just a few studies (Lanzewizki 1991, Johnson and Vaughan 1993). Even less is known on the role terrestrial Rodentia play in forest succession, canopy closure and biodiversity recovery following clearing and burning.

In order to gain insight in the intrinsic recovery capacity of the biodiversity inhabiting a shredded Costa Rican montane cloud forest area and to provide knowledge needed for the conservation and sustainable use of this threatened ecosystem, we studied the diversity and distribution of small terrestrial rodent species along a disturbance gradient, ranging from undisturbed mature primary oak forest to graminoid dominated pastureland suffering from intensive cattle grazing. The principal aim

of the present study is to identify key indicator rodent species characteristic for certain levels of disturbance and recovery.

MATERIALS AND METHODS

This study was conducted in the Los Santos Forest Reserve near San Gerardo de Dota in the NW part of the Costa Rican Cordillera de Talamanca (9°35'40" N; 83°44'30"). Originally, the watershed area (2000-3200 m altitude) was completely covered with mature, primary *Quercus* dominated montane cloud forest, but since the 1950s forest conversion for agricultural purposes has led to a landscape mosaic with vegetation patches of different size, structure, composition, level of disturbance and successional age (Kappelle and Juárez 1995, Kappelle *et al.* 1995). In Villa Mills, at a distance of 10 km E of the selected forest plot, the average annual temperature is 10.9°C and the average annual rainfall is 2812 mm. A detailed description of the study area's physical setting and botanical aspects can be found in Kappelle (1993, 1996).

At the end of the dry season (March-April 1996), using B&W aerial photographs (1992, scale 1: 15,000) five different habitats were selected along a man induced disturbance gradient in the upper montane forest belt (2200-2800 m a.s.l.). These habitats are, from low to high levels of disturbance: (i) 30 to 40 m tall, dense oak dominated 'Closed Mature Forest' (CMF); (ii) oak dominated 'Open Mature Forest' with a relatively open, 30 to 35 m high canopy (OMF); (iii) 3 to 7 m high secondary 'Successional Shrubland' (SSL); (iv) 0.5 to 2 m tall secondary 'Abandoned Pastureland' (APL); and (v) less than 0.5 m high 'Grazed Pastureland' (GPL); see Table 1. At each habitat site a 0.25 ha plot (50 x 50 m) was established, with exception of APL where a 0.28 ha plot (37.5 x 75 m) was laid out, since the site's patch dimensions required so.

In all but APL a total of 25 Sherman traps (trap size: 23 x 9 x 8 cm) were placed in a 5 x 5 grid with a 12.5 m distance between two neighbouring traps. Similarly, in APL 28 traps were located in a 4 x 7 grid. A standardized capture-recapture method was used to estimate species diversity, distribution and abundance in each habitat type (Leslie *et al.* 1952). Plots were studied from April to June 1996, covering the transition from the dry to the wet season. Sherman traps were checked ten consecutive days before noon. Only in OMF traps were checked nine days. Bait consisted of a mixture of rolled oats and peanut butter with a touch of vanilla flavour. In the afternoon traps were checked for diurnal catches and bait was renewed for the next trap-night. Traps were covered with litter and/or leaves for camouflage and insulation.

Data on the presence, sex, weight and length of trapped individuals were recorded. Weight was measured using a Pesola pocket scale (max. weight 300 g). Length measurements included the head-body length measured from the tip of the nose to the inflection point of the tail, and the tail length measured from the inflection point with the body to the fleshy tip of the tail. *In situ* species identification was done with the aid of Emmon & Feer's (1990) field guide, after studying rodent specimens in Costa Rica's national collections. Control specimens were collected and stored at the Museo Nacional. Specimens were identified with help of B. Rodríguez (pers. com.) and on basis of field guides (Mora & Moreira 1984, Emmons & Feer 1990). Trapped individuals were marked upon first capture with acrylic paint before being released. Additionally, terrestrial vascular plant inventories were undertaken in each habitat and collected plant specimens stored and identified at the Museo Nacional. Species data were grouped and analysed for habitat sites along the disturbance gradient. Richness, abundance, density and capture frequency were assessed and preliminar conclusions drawn.

TABLE 1

General data on physiographic aspects, vegetation layering and terrestrial rodent populations of five different habitat sites in the montane cloud forest zone of the upper Río Savegre watershed area, Cordillera de Talamanca, Costa Rica

Habitat site		Closed Mature Forest	Open Mature Forest	Successional Shrubland	Abandoned Pastureland	Grazed Pastureland	All habitat sites
Plot size (ha)		0.25	0.25	0.25	0.28	0.25	1.28
Altitude (m a.s.l.)		2750	2330	2360	2780	2260	-
Exposition		E	SW	W	N	W	-
Slope angle		10 o	33 o	35 o	15 o	5 o	-
Vegetation layering [1]:							
Canopy layer	- height (m)	40	35	-	-	-	-
	- cover (%)	90	80	-	-	-	-
Subcanopy layer	- height (m)	18	18	7	-	-	-
	- cover (%)	70	65	10	-	-	-
Shrub layer	- height (m)	3	3	3	2	-	-
	- cover (%)	50	35	90	20	-	-
Herb layer	- height (m)	0.5	0.5	0.5	0.5	0.4	-
	- cover (%)	20	10	30	90	98	-
Nr. of trap nights		10	9	10	10	10	49
Species richness (nr. spp. per plot)		4	5	4	4	4	7
Density (nr. indiv. per ha)		92	180	160	196	80	142*
Capture frequency [2]		3.2	10.7	11.6	8.0	5.8	7.9*
Capture frequency per ha		12.8	42.8	46.4	28.6	23.2	30.8*

* Mean values with n = 5 habitat sites.

1 Vegetation layering is expressed in maximum height and relative aerial crown cover of each stratum.

2 Capture frequency = mean number of captures per trap night.

RESULTS

A total of 389 captures corresponded to 185 individuals distributed over 7 species in 2 families. The captured species were: (i) Muridae (Cricetidae): *Peromyscus mexicanus* (Mexican Deer Mouse, ratón pata blanca, closely related to *P. nudipes*, the Naked-footed Deer Mouse), *Scotinomys xerampelinus* (Singing Mouse, ratón cantante), *Oryzomys albigularis* (White-throated Rice Rat, ratón arrocero), *Reithrodontomys creper* (Chiriquí Harvest Mouse, ratón de las cosechas), and *R.* cf. *sumichrasti* (Sumichrasti's Harvest Mouse, ratón de las cosechas); and, (ii) Heteromyidae: *Heteromys oresterus* and *H.* cf. *desmarestianus*, being Spiny Pocket Mice (ratas de campo).

Table 1 presents some general data on the terrestrial rodent population in the five habitats. Richness was very similar for all habitat sites, with 4 to 5 species per habitat regardless its position along the disturbance axis. Population density and capture frequency (absolute and per area values), however, were particularly higher in habitats with intermediate levels of disturbance, being twice as high in OMF, SSL and APL when compared to both undisturbed CMF and intensively-used GPL. Abundance values differed strongly among species (Table 2).

DISCUSSION

The varied abundance values were concordant with classical rank-abundance Figs. (Magurran 1988). High abundances (60 - 75 individuals) were recorded for *P. mexicanus*

TABLE 2

Abundance data of seven terrestrial rodent species found in five different habitat sites in the montane cloud forest zone of the upper Río Savegre watershed area, Cordillera de Talamanca, Costa Rica. Abundance data are subdivided per sex

Habitat site		Closed Mature Forest		Open Mature Forest		Successional Shrubland		Abandoned Pastureland		Grazed Pastureland		All habitat sites	
Abundance [1]		ab.	capt.	ab.	capt.	ab.	capt.	ab.	capt.	ab.	capt.	ab.	capt.
	sex												
Peromyscus mexicanus	both	19	26	21	67	17	58	13	26	5	30	75	207
	male	14	19	11	33	9	28	8	13	1	9	43	102
	female	5	7	10	34	8	30	5	13	4	21	32	105
Scotinomys xerampelinus	both	3	3	7	12	20	44	24	29	7	14	61	102
	male	2	2	4	8	8	13	17	22	5	10	36	55
	female	1	1	3	4	12	31	7	7	2	4	25	47
Oryzomys albigularis	both	1	1	7	12	1	1	-	-	6	9	15	23
	male	-	-	4	8	1	1	-	-	3	3	8	12
	female	1	1	3	4	-	-	-	-	3	6	7	11
Reithrodontomys creper	both	-	-	6	9	-	-	9	15	-	-	15	24
	male	-	-	6	9	-	-	7	12	-	-	13	21
	female	-	-	-	-	-	-	2	3	-	-	2	3
R. cf. *sumichrasti*	both	-	-	-	-	-	-	9	10	2	5	11	15
	male	-	-	-	-	-	-	3	4	1	1	4	5
	female	-	-	-	-	-	-	6	6	1	4	7	10
Heteromys oresterus	both	2	2	4	4	-	-	-	-	-	-	6	6
	male	1	1	1	1	-	-	-	-	-	-	2	2
	female	1	1	3	3	-	-	-	-	-	-	4	4
H. cf. *desmarestianus*	both	-	-	-	-	2	12	-	-	-	-	2	12
	male	-	-	-	-	1	6	-	-	-	-	1	6
	female	-	-	-	-	1	6	-	-	-	-	1	6
all species	both	25	32	45	104	40	115	55	80	20	58	185	389
	male	17	22	26	59	19	48	35	51	10	23	107	203
	female	8	10	19	45	21	67	20	29	10	35	78	186

1 ab. = abundance measured as the total number of individuals captured; capt. = total number of captures including recaptures.

and *S. xerampelinus*, whereas the other three Muridae, *O. albigularis*, *R. creper* and *R.* cf. *sumichrasti*, appeared to be four to five times less common. Together, *P. mexicanus* and *S. xerampelinus* represented 79.4 % of all captures (including recaptured individuals) and 73.5 % of all captured individuals. Both Heteromyidae species, in their turn, seemed to be rather rare in the area (≤ 6 indiv.) and appeared to avoid both abandoned and grazed pasturelands (Table 2). *P. mexicanus* and *S. xerampelinus* occured at all five sites, although they differed in habitat preference with *P. mexicanus* appearing with higher numbers in CMF and OMF, and *S. xerampelinus* showing a higher abundance in SSL and APL. This difference is explained by the fact that the latter, more insectivorous species requires a rather dense vegetation cover at ground level, as its peak in activity is during morning hours (Hooper 1972). The species *O. albigularis* preferred OMF as well as the edge of GPL bordering mature forest. This observation concides with data earlier presented by Timm *et al.* (1989) for the Braulio Carrillo Park. *R. creper* and *R.* cf. *sumichrasti* were most abundant in APL (Table 2). These observations are concordant with data on habitat

preferences of Nicaraguan *Reithrodontomys* species (Jones and Genoways 1970). *R. creper* was also trapped in OMF, but in lower numbers. Similarly, two individuals of *R.* cf. *sumicharsti* occured in GPL. Low capture results of *H. oresterus* and *H.* cf. *desmarestianus* suggest these species' rarity in the area. While *H. oresterus* preferred mature forest habitats, *H.* cf. *desmarestianus* was only recorded in SSL. *H. oresterus* may be qualified as an indicator species referring to low levels of disturbance.

In general, male individuals were more often trapped in CMF and OMF as well as APL, while males and females appeared equally in SSL and GPL (Table 2). Whether these capture differences between sexes is due to behaviour or population make up remains unknown. *O. albigularis* was the largest terrestrial rodent species captured, being over six times as heavy and twice as long as *R.* cf. *sumichrasti* (Table 3). Data on weight and head-body and tail length of captured individuals were in accordance with data in Emmons and Feer (1990), with exception of values recorded for *H.* cf. *desmarestianus*. Individuals of the latter appeared to be much smaller in this study (mean weight 24.0 g; mean head-body length 8.8 cm) than the data

TABLE 3

Weight and length data of captured individuals belonging to seven terrestrial rodent species. Data are subdivided per sex and based on all five habitat sites in the montane cloud forest zone of the upper Río Savegre watershed area, Cordillera de Talamanca, Costa Rica

Species	Sex	Weight [1] (g)		Head-body length [1,2] (cm)		Tail length [1,3] (cm)	
		mean + s.d.	(n)	mean + s.d.	(n)	mean + s.d.	(n)
P. mexicanus	both	51.6 + 4.6	(56)	11.9 + 0.7	(74)	12.3 + 0.6	(74)
	male	54.8 + 3.4	(26)	12.1 + 0.7	(42)	12.3 + 0.6	(42)
	female	48.8 + 4.4	(30)	11.6 + 0.7	(32)	12.3 + 0.6	(32)
S. xerampelinus	both	14.0 + 2.2	(48)	6.9 + 0.4	(57)	5.9 + 0.8	(58)
	male	13.2 + 1.8	(24)	6.9 + 0.4	(35)	5.9 + 0.8	(35)
	female	14.8 + 2.2	(24)	6.8 + 0.5	(22)	5.8 + 0.8	(23)
O. albigularis	both	93.4 + 14.2	(11)	14.8 + 0.9	(12)	17.1 + 2.8	(14)
	male	93.4 + 13.1	(07)	14.2 + 1.3	(07)	17.3 + 3.4	(08)
	female	88.0 + 17.1	(04)	15.0 + 0.6	(05)	16.8 + 1.1	(06)
R. creper	both	22.8 + 2.9	(14)	8.7 + 0.8	(14)	13.0 + 1.0	(14)
	male	22.7 + 3.0	(12)	8.6 + 0.7	(12)	13.0 + 0.9	(12)
	female	23.0 + 0.0	(01)	9.0 + 1.0	(02)	13.0 + 1.0	(02)
R. cf. *sumichrasti*	both	14.9 + 2.5	(08)	7.4 + 0.5	(12)	8.7 + 0.8	(12)
	male	13.5 + 1.7	(04)	7.1 + 0.4	(05)	8.7 + 0.9	(05)
	female	16.3 + 2.5	(04)	7.6 + 0.4	(07)	8.7 + 0.8	(07)
H. oresterus	both	74.8 + 3.8	(03)	12.7 + 0.8	(03)	17.0 + 0.7	(03)
	male	71.0 + 0.0	(01)	13.0 + 0.0	(01)	16.0 + 0.0	(01)
	female	76.0 + 3.6	(02)	12.6 + 0.8	(02)	17.3 + 0.3	(02)
H. cf. *desmarestianus*	both	24.0 + 5.0	(02)	8.8 + 0.3	(02)	9.8 + 1.3	(02)
	male	29.0 + 0.0	(01)	9.0 + 0.0	(01)	11.0 + 0.0	(01)
	female	19.0 + 0.0	(01)	8.5 + 0.0	(01)	8.5 + 0.0	(01)

1 Weight and length values are based on measurements taken at each individual's first catch.
2 Head-body length is measured as the length from the tip of the nose to the inflection point of the tail.
3 Tail length is measured as the length from the inflection point with the body to the fleshy tip of the tail.

range given by these authors would suggest (49-103 g; 10.8-14.8 cm). This outcome stresses the difficulties that occurred in the preliminary species identification. The weight distribution for male and female individuals of the most abundant species, *P. mexicanus*, clearly illustrates within-species weight differences found between sexes in rodents (Fig. 1). Whereas the weight distribution (expressed in 3 g weight classes) for males depicts a normal bell curve, the weight distribution for female individuals is asymmetrical, with an abrupt change at the 53 g weight level. This striking discrepancy may be explained by the presence of a number of pregnant adults in the 50-53 g weight class. If non-pregnant, these individuals would have been recorded in lower weight classes such as the 44-47 and 47-50 g classes. Indeed, four heavy adults (13 %) out of a total of 32 females were in a certain stage of pregnancy.

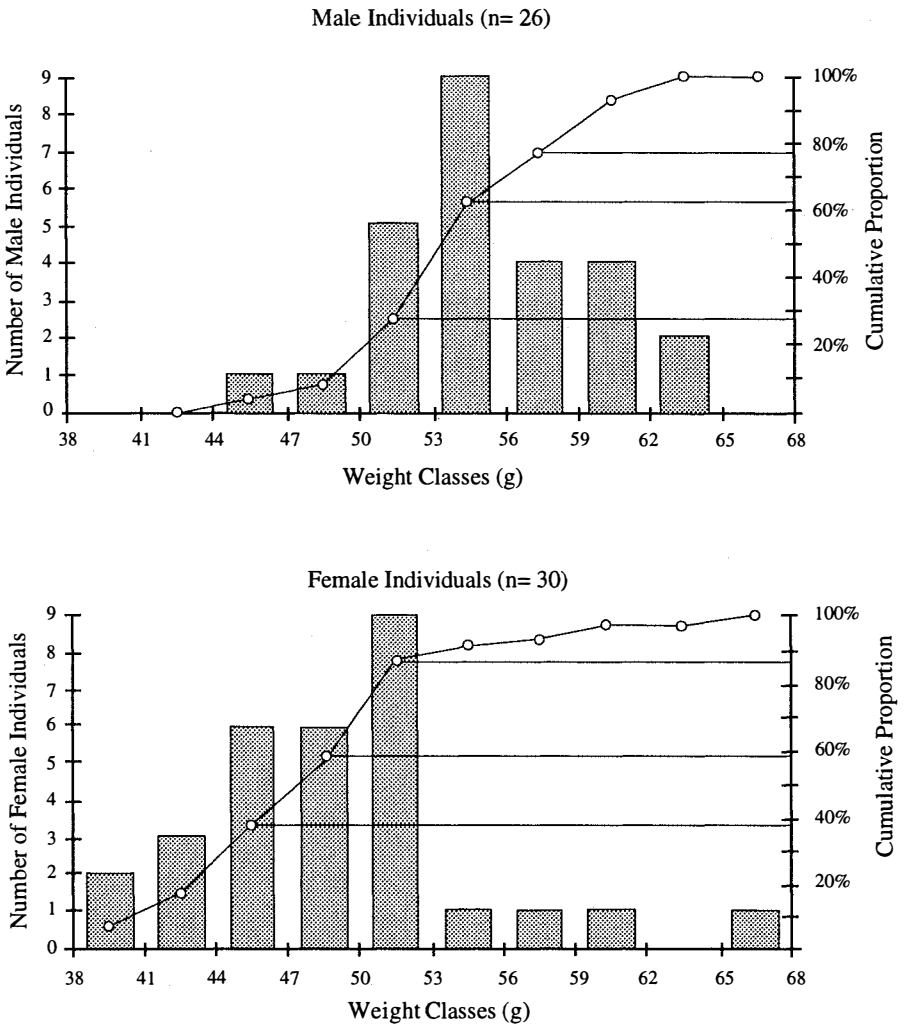

Fig. 1. Weight distribution for male and female individuals of *Peromyscus mexicanus* in the montane cloud forest zone of the upper Río Savegre watershed area, Cordillera de Talamanca, Costa Rica.

This study's results are in general consistent with those from two previous studies conducted in the same region (Lanzewizki 1991; Johnson and Vaughan 1993). Johnson and Vaughan (1993) recorded five Myomorph species of which *P. mexicanus* (*P. nudipes*, in their study) and *S. xerampelinus* were the most common. This study revealed seven species of terrestrial Myomorph rodents, including *O. albigularis* and *H. oresterus* as new local records. Both our data and those collected by Johnson and Vaughan (1993) indicate the importance of within-habitat microenvironmental heterogeneity for rodent populations in tropical montane cloud forests.

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RESUMEN

Se estudió la distribución y diversidad de roedores terrestres en cinco hábitats perturbados en un área de bosque montano nuboso en Costa Rica. Un total de 389 capturas correspondió a 185 individuos (siete especies en 2 familias). La riqueza de especies resultó muy similar para todos los hábitats, con 4-5 especies/hábitat. La densidad de población y la frecuencia de captura fueron más altas en hábitats con niveles intermedios de perturbación; *Peromyscus mexicanus* y *Scotinomys xerampelinus* fueron cuatro a cinco veces más comunes que otras especies de Muridae. Estas representaron el 79.4 % de todas las capturas y el 73.5 % de todos los individuos. Se capturo pocos Heteromyidae.

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