Comparison of traps and baits for censusing small mammals in Neotropical lowlands.

COMPARISON OF TRAPS AND BAITS FOR CENSUSING SMALL MAMMALS IN NEOTROPICAL LOWLANDS

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Snap-traps, live-traps, and baits affect the ability to capture small mammals, but few previous studies have involved sampling communities of small mammals in tropical environments. We tested differences in captures of small marsupials and rodents by Victor snap-traps versus Sherman live-traps and by two types of bait in lowland rainforest at Reserva Cuzco Amazónico, southeastern Peru. Snap-traps took ca. 3.5 times as many individuals as live-traps. Snap-traps also captured more species (and more rare species), but we attribute this to more numerous captures overall because the relative proportions of species captured by the two traps generally were the same. Type of bait had little impact on our trapping results.

Key words: bait, community structure, Neotropics, Peru, Sherman traps, small mammals, snap-traps

Biologists long have recognized the tremendous diversity of organisms found in the tropics. Recent awareness of the rapid disappearance of tropical rainforests (Myers, 1988) has increased interest in understanding and conserving this diversity (Wilson, 1988, 1992). In recent years, the biological community has attempted to characterize the diversity of particular organisms at various tropical sites, and to compare and contrast this diversity among sites (Gentry, 1990; McDade et al., 1994; Peters and Hutterer, 1990). Comparisons among sites in the tropics and also between tropical and temperate sites are valuable in understanding the structure and complexity of ecosystems, which in turn is essential for implementing effective conservation efforts.

Our ability to sample communities at various sites accurately is critical to studies of mammalian diversity. However, few researchers have questioned the completeness of sampling at a particular site prior to making comparisons between sites. Based on data covering several decades of species discovery in lowland, tropical rainforest at La Selva, Costa Rica, Timm (1994) concluded that erroneous comparisons easily are (and have been) made when investigators have an inadequate picture of mammalian community diversity because of incomplete sampling.

The majority of species of mammals are small (<0.5 kg), nocturnal, and secretive. Therefore, attempts to estimate mammalian community structure and population density must include an effective regime for sampling small mammals. There is a rich, albeit mostly anecdotal, literature discussing the effectiveness of standard traps in sampling populations of small mammals in temperate regions. In many habitats, live-traps and snap-traps sample small mammal communities unevenly (Cockrum, 1947; Duran and Samz, 1973; Goodnight and Koestner, 1942; Hansson and Hoffmeyer, 1973; Pizzimenti, 1979; Sealander and James, 1958; Wiener and Smith, 1972), and studies have shown that the two types of traps may provide significantly different estimates of weight (Neal and Cock, 1969; Pizzimenti, 1979), sex, or age structure (Galindo-Leal, 1990) of populations as well as communities. Differences in captures also have been shown between different models of snap-traps (Neal and Cock, 1969; Pizzimenti, 1979; Smith et al., 1971; Wiener and Smith, 1972) and among different sizes and designs of live-traps (Dalby and Straney, 1976; Morris, 1968; O'Farrell et al., 1994; Quast and Howard, 1953; Sealander and James, 1958; Slade et al., 1993). Additionally, choice of bait used in trapping may affect rates of capture significantly (Beer, 1964; Buchalczyk and Olszewski, 1971; Fowle and Edwards, 1954; Laurance, 1992; Patric, 1970; Rickart et al., 1991; Willan, 1986). Despite the availability of data on effectiveness and biases of traps for capturing small mammals in temperate communities (Slade et al., 1993, and references therein), there have been few rigorous comparisons of effectiveness of traps or baits in the lowland Neotropics.

As part of the Neotropical Biological Diversity Program (BIOTROP) of The University of Kansas Museum of Natural History, and working in collaboration with the Museo de Historia Natural "Javier Prado," Lima, and the Missouri Botanical Garden, we had the opportunity to develop and test a protocol for surveying the poorly known mammalian community at a lowland tropical rainforest site—Reserva Cuzco Amazónico—in the western Amazon Basin of extreme southeastern Peru. The original goals of our fieldwork were to document the mammalian diversity of the site and to provide important specimens of relatively rare species for systematic studies (Woodman et al., 1991). Specimens were collected in a systematic fashion that provided quantitative data regarding the structure of the small mammal community (Woodman et al., 1995). Here we compare effectiveness of snap-traps and live-traps and two different baits in the lowland tropics. Our results provide a better understanding of the strengths and shortcomings of standard sampling techniques for small mammals and will assist future investigators in planning studies of biodiversity and community structure of small mammals in the tropics.

Materials and Methods

The study site, Reserva Cuzco Amazónico, is located along the north bank of the Río Madre de Dios 14 km E of Puerto Maldonado, Tambopata Province, Madre de Dios Department, southeastern Peru (12°33'S, 69°03'W). This is ca. 50 km west of the Bolivian border. Elevation of Cuzco Amazónico is ca. 200 m, and there is little topographic relief. Vegetation in the ca. 10,000-ha reserve is typical of the region and consists primarily of evergreen, lowland, tropical forest. Following the Holdridge system (Tosi, 1960), Cuzco Amazónico is transitional between humid tropical forest and dry tropical forest. The climate of the region is seasonal with a rainy season from October through March and a pronounced dry season from April through September. Details of the Cuzco Amazónico site, including maps, were provided by Duellman and Koechlin (1991) and Woodman et al. (1995).

Trapping was conducted along one trail (E trail) within each of two 500 by 500-m study zones for 12 consecutive days, after which traps were moved to a second trail (U trail) within each zone. We did this during the dry season (June–July, 1989) and again during the wet season (January–March, 1990). The zones were divided into 20 by 20-m quadrats, and one trapping station was placed within each of the 25 quadrats along each trail. Trap stations consisted of two Victor snap-type rat traps (8.7 by 17.5 cm) and two collapsible Sherman live-traps (8 by 9 by 23 cm); one of each type of trap was placed on the ground and one of each was placed above the ground (0.25–2.80 m). Additional details on study zones, trapping methods, and results were provided by Woodman et al. (1991, 1995). All animals captured were removed, prepared as voucher specimens, and deposited at the Museo de Historia Natural "Javier Prado" or The University of Kansas Museum of Natural History.

We used two types of bait; suet bait (finely ground beef suet, ground raisins, rolled oats, millet, grain sorghum, cracked corn, vanilla) and

TABLE 1.—*Captures of small mammals at Cuzco Amazónico by type of trap. Taxa are listed by total numbers of captures.*

Species	Dry season (1989)		Wet season (1990)		Total
	Snap	Live	Snap	Live	
Oryzomys capito	69	11	83	24	187
Oryzomys nitidus	33	5	41	16	95
Oecomys bicolor	13	4	36	4	57
Micoureus regina	12	12	18	3	45
Marmosops noctivagus	8	6	11	4	29
Proechimys[a]	14	1	7	5	27
Mesomys hispidus	3	4	8	1	16
Rhipidomys[b]	1	0	7	4	12
Oecomys roberti[c]	4	0	3	0	7
Oryzomys yunganus	2	2	1	2	7
Neacomys spinosus	2	0	3	1	6
Metachirus nudicaudatus[d]	5	0	0	0	5
Didelphis marsupialis[d]	0	0	2	1	3
Marmosops parvidens	2	0	1	0	3
Marmosa murina	0	0	2	0	2
Neacomys tenuipes	0	0	0	1	1
Oecomys superans	1	0	0	0	1
Isothrix bistriata[d]	0	1	0	0	1
Sciurus ignitus[d]	1	0	0	0	1
Total	170	46	223	66	505

[a] Includes *P. brevicauda, P. simonsi,* and *P. steerei.*

[b] A single, undescribed species (C. Tribe, pers. comm.).

[c] We follow Musser and Carleton (1993) in treating the mid-sized *Oecomys* of the western Amazon as *O. roberti,* rather than *O. tapajinus* as reported by Woodman et al. (1991).

[d] Only juveniles of these species were captured.

peanut-butter bait (locally purchased peanut butter and rolled oats). During the dry season, suet bait was used for 6 days followed by 6 days of peanut-butter bait. During the wet season, types of bait were alternated after every 2 nights, beginning with suet bait.

We compared total numbers of captures in live-traps and snap-traps within each season to determine whether each type of trap provided equal numbers of captures, the same community of animals, similar proportions of each of the most-frequently captured species, or biases in sex or body mass of captured individuals. We made similar comparisons between the two types of bait, and we tested for interactions between trap and bait.

Observed frequencies of captures were compared with distributions of traps and baits using chi-square goodness-of-fit tests (χ^2). For dichotomous comparisons with $n \geq 10$ captures, we used chi-square tests with a single degree of freedom; when $n < 10$ we calculated probabilities of Type I errors directly from a binomial distribution. In all statistical analyses, a probability of $P \leq 0.05$ was considered significant. Because of small sample size, some analyses of individual species were limited to the most frequently captured species, which we defined as those with nine or more captures over both seasons (Table 1).

RESULTS

Six species of marsupials and 15 species of rodents were taken in live-traps and snap-traps set along the four trails in the two study zones. We captured a total of 505 individuals (Table 1) during 9,600 trap-nights; our overall trap success was 5.3%. A total of 216 individuals was captured during the dry season and 289 in the rainy season.

In analyses of our trapping data, we combined three species of *Proechimys* (*P. brevicauda, P. simonsi,* and *P. steerei*), because

TABLE 2.—*Captures of small mammals at Cuzco Amazónico by type of bait. Taxa are listed by total numbers of captures.*

	Dry season (1989)		Wet season (1990)		
Species	Suet	Peanut butter	Suet	Peanut butter	Total
Oryzomys capito	52	28	46	61	187
Oryzomys nitidus	22	16	24	33	95
Oecomys bicolor	12	5	17	23	57
Micoureus regina	15	9	14	7	45
Marmosops noctivagus	10	4	10	5	29
Proechimys	2	13	6	6	27
Mesomys hispidus	6	1	5	4	16
Rhipidomys	0	1	5	6	12
Oecomys roberti	3	1	2	1	7
Oryzomys yunganus	3	1	1	2	7
Neacomys spinosus	2	0	2	2	6
Metachirus nudicaudatus	1	4	0	0	5
Didelphis marsupialis	0	0	2	1	3
Marmosops parvidens	1	1	1	0	3
Marmosa murina	0	0	2	0	2
Neacomys tenuipes	0	0	0	1	1
Oecomys superans	1	0	0	0	1
Isothrix bistriata	1	0	0	0	1
Sciurus ignitus	1	0	0	0	1
Total	132	84	137	152	505

they were difficult to distinguish ecologically, behaviorally, or morphologically, especially juveniles and subadults.

Type of trap.—More than three times as many animals were captured in snap-traps (n = 393; 78%) as in live-traps (n = 112; 22%), although the two types of traps were distributed evenly between the zones and between seasons (Table 1). This pattern persisted through both seasons. During the dry season, 170 (79%) animals were captured in snap-traps and 46 (21%) in live-traps ($\chi^2 = 72.001$, $d.f. = 1$, $P < 0.01$). During the rainy season, 223 (77%) individuals were taken in snap-traps, and 66 (23%) were taken in live-traps ($\chi^2 = 85.291$, $d.f. = 1$, $P < 0.01$).

Because of the strong preference for snap-traps, we checked whether captures in live-traps may have occurred only when the accompanying snap-trap was occupied. In only three (6.5%) of the 46 captures in live-traps during the rainy season, was the snap-trap also occupied; each of these double captures occurred in traps set on the ground, and in each instance, individuals of the same species occupied both types of trap. Of 64 captures in live-traps during the dry season, 11 (14%) occurred while the snap-trap also was occupied. In six instances, both individuals were of the same species. Thus, most (86–93.5%) captures in live-traps occurred when the accompanying snap-trap was unoccupied.

Type of bait.—During the dry season there was an apparent significant difference between captures by the two baits; suet took more animals than did peanut butter ($\chi^2 = 10.180$, $d.f. = 1$, $P < 0.01$; Table 2). However, because suet was used first for 6 days of removal trapping, there were fewer animals available to be captured with peanut butter. Woodman et al. (1995) estimated a total population of 349 individuals available along the trails in the dry season. In the 1st 6 days, suet caught ca. 38% of the estimated number available, and in the subsequent 6 days, peanut butter captured 39% of the animals remaining. Thus, the baits actually were equally effective during this season. This conclusion is reinforced by our finding no significant difference during the rainy season, when baits were alternated every 2 days; 137 animals were captured with suet and 152 with peanut butter ($\chi^2 = 0.779$, *d.f.* = 1, $P = 0.38$; Table 2). Because they were alternated every 2 days, comparison of baits was much more straight forward using the wet-season data; hence, all additional tests of baits were restricted to data from the wet season.

Species richness.—More species were captured in snap-traps than in live-traps. Of the 19 taxa captured, 17 were taken in snap-traps and 13 in live-traps (Table 1). Rare species of small mammals (five or fewer captures within a season) also were taken more frequently in snap-traps than in live-traps. During the dry season, snap-traps took seven rare species not captured in live-traps, and live-traps took one species not captured by snap-traps. In the rainy season, three rare species were captured exclusively in snap-traps and one only in a live-trap. In both seasons, rare species were captured irregularly throughout the 12-day trapping period along each trail (Woodman et al., 1995).

Reduced species richness among animals in live-traps could result from live-traps capturing lower proportions of rare species or simply from fewer total captures (rarefaction sensu Sanders, 1968). To test these hypotheses, we drew repeated random samples, with replacement, from a population consisting of all of our 505 captures. We drew 500 samples each of sizes 112 and 394 (the numbers of animals captured in live-traps and snap-traps, respectively). The mean, median, and modal numbers of species in our randomization experiment were 13 ($SE = 0.065$) for $n = 112$ and 17 ($SE = 0.052$) for $n = 394$. The match between random drawings and our actual field captures suggests that the additional species captured in snap-traps resulted solely from increased numbers of captures rather than from differential effectiveness for rare species.

Relative abundances of species.—Relative abundances of the most frequently captured species taken in live-traps versus snap-traps were not significantly different either with both seasons combined ($\chi^2 = 10.889$, *d.f.* = 7, $P = 0.143$), or in the rainy season ($\chi^2 = 9.993$, *d.f.* = 7, $P = 0.190$). However, in the dry season there was a significant difference in the relative abundances of species indicated by the two types of traps ($\chi^2 = 22.256$, *d.f.* = 5, $P < 0.01$). This difference was attributable mainly to two species of mouse-opossums, *Marmosops noctivagus* and *Micoureus regina,* which tended to be captured nearly equally in both types of traps (Table 1). This was in contrast to other species, which had proportionally higher rates of capture in snap-traps. Our comparisons of relative abundances of the most common species trapped by suet versus peanut butter in the rainy season revealed no differences between numbers of captures by the two baits ($\chi^2 = 7.467$, *d.f.* = 7, $P = 0.380$).

Body mass.—To test for size differences among animals captured, we compared the distribution of classes of body mass (≤60, 61–140, and >140 g) between traps and between baits without regard to species. There were no differences in classes of body mass sampled by snap-traps versus live-traps in either the dry ($\chi^2 = 3.252$, *d.f.* = 3, $P = 0.350$) or wet ($\chi^2 = 4.864$, *d.f.* = 3, $P = 0.182$) season, and no differences by baits in the wet season ($\chi^2 = 1.878$, *d.f.* = 5, $P = 0.866$).

Sex.—There was no difference in sex detected between the populations sampled by snap-traps and live-traps in the dry season ($\chi^2 = 0.088$, *d.f.* = 1, $P = 0.767$). However, in the wet season proportionally more males (27% of all wet-season captures) than females (15%) were captured in live-traps ($\chi^2 = 5.406$, *d.f.* = 1, $P = 0.020$). There was no difference in sex of animals sampled by the two baits in the wet season ($\chi^2 = 0.757$, *d.f.* = 1, $P = 0.384$).

DISCUSSION

The small mammal fauna at Cuzco Amazónico includes at least 23 species of native rodents and 9 species of marsupials (Woodman et al., 1991). This diversity is comparable to that seen at the few other sites in the western Amazonian lowlands that have been studied, such as Cocha Cashu (9 marsupials, 23 rodents—Pacheco et al., 1993), Pakitza (9 marsupials, 22 rodents—Pacheco et al., 1993), and the lower Río Cenepa drainage (9 marsupials, 19 rodents—Patton et al., 1982). Species richness is higher than that reported in lowland faunas from other Neotropical regions, such as Manaus in the central Amazon (7 marsupials, 16 rodents—Malcolm, 1990), and Barro Colorado (6 marsupials, 13 rodents—Glanz, 1990) and La Selva (5 marsupials, 15 rodents—Timm, 1994) in Central America.

It may seem incongruous to use snap-traps or removal trapping for assessing biodiversity for conservation purposes. However, at Cuzco Amazónico, as at most tropical sites, the small mammal fauna was so poorly known that it was necessary to collect specimens for accurate identifications of species. Several rare, cryptic species would have been incorrectly identified in the field had individuals not been preserved as specimens. Previously, we estimated that we removed only 47–66% (Woodman et al., 1995) of the small mammal fauna from the narrow area sampled by our transects. If our conclusion, that snap-traps and live-traps did not differentially sample the fauna, is correct and the difference in species richness was simply attributable to more captures in snap-traps, then one could obtain the same results with live-traps, but with the expenditure of more trapping effort. However, this argument cannot be extended to include capture-and-release trapping. Numerous studies have demonstrated that certain individuals within populations (e.g., Davis and Emlen, 1956; Joule and Cameron, 1974; Smith, 1968) can dominate traps. Thus, subordinate individuals or more trap-shy species may be revealed only after removal of some animals.

Previous studies of a variety of baits in a number of habitats have shown that baits can affect numbers of individuals and the species composition of small mammals captured (Beer, 1964; Buchalczyk and Olszewski, 1971; Fowle and Edwards, 1954; Laurance, 1992; Patric, 1970; Rickart et al., 1991; Willan, 1986). Our two baits differed in odor, appearance, and nutrient content, but, in general, we found them to be equally effective.

Adequately censusing a diverse community inhabiting a complex, three-dimensional environment, such as is found in tropical rainforests, requires a variety of techniques. We repeat the recommendation made by other investigators (Pizzimenti, 1979; Sealander and James, 1958) that an assortment of traps be used to account for possible biases of the species involved.

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