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EFFICIENCY OF FOUR TRAP TYPES IN SAMPLING SMALL MAMMALS IN FOREST FRAGMENTS, MATO GROSSO, BRAZIL

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ABSTRACT: We sampled the small mammal community inhabiting semi-deciduous forest fragments in Mato Grosso, Brazil, using 4 different types of traps, Tomahawk, Sherman, snap, and pitfall, in order to evaluate the efficiency of different trap types in sampling efforts. During our study, we captured a total of 984 individuals of 27 species over 33 800 trap/nights. Sherman traps captured a significantly greater abundance of individuals and higher species richness than the other 3 types of traps. The Tomahawk and snap traps exhibited similar capture rates, in both the number of individuals and species captured. Pitfall traps captured the fewest numbers of individuals and species and were the only trap type to have different, although not significant, capture rates between seasons. Pitfall traps captured four times more individuals during the wet season than during the dry season. Despite their relative inefficiency and the large effort it takes to install pitfall traps, we found that these types of traps can be useful in augmenting trapping efforts, as they often capture species that do not, or rarely, fall into other types of traps.

RESUMEN: La eficiencia de cuatro tipos de trampas en un relevamiento de micromamíferos en fragmentos de bosques en Mato Grosso, Brasil. Una comunidad de pequeños mamíferos fue estudiada en fragmentos de bosques semideciduos en el estado de Mato Grosso (Brasil) usando 4 tipos de trampas, de captura viva (Tomahawk y Sherman), de captura muerta (trampa de golpe: snap) y trampa de caída (pitfall). Considerando todos los tipos de trampas tuvimos un esfuerzo total de 33 800 trampas/noche, habiendo capturado 984 individuos de 27 especies. Las trampas Sherman demostraron ser significativamente más eficientes que los otros tipos utilizados tanto para abundancia, como para riqueza de especies. Las trampas Tomahawk y snap demostraron tener eficiencias similares en número de individuos y en número de especies capturadas entre las áreas estudiadas. Cuando se comparó la eficiencia entre las dos estaciones del año, verano e invierno, solamente las pitfall capturaron más individuos durante la estación de invierno en relación al verano; a pesar de haber tenido casi cuatro veces más de capturas durante este período, los resultados no fueron significativos. Pese al gran esfuerzo para el montaje de las pitfall, es fundamental su uso como complemento de los muestreos, por ser este método capaz de capturar especies que difícilmente, o raramente, logran ser colectadas usando otros tipos de trampas.

Key words. Marsupials. Mato Grosso. Rodents. Semi-deciduous forest fragments. Traps.

Palabras clave. Fragmentos de bosques. Marsupiales. Mato Grosso. Roedores. Trampas.

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INTRODUCTION

Tropical forests in the Neotropical region are structurally complex, inhabited by a highly rich community of small mammals, ranging from semifossorial to arboreal (Hice and Schmidly, 2002). Inventories of small Neotropical mammal communities are inherently biased. Each species has unique life history traits and the structure and/or placement of traps can be selective, capturing only some of the species in the community (Pizzimenti, 1979; Mengak and Guynn, 1985; Slade et al., 1993; O'Farrell et al., 1994; Lee, 1997). Because of this, each sampling method samples the species richness and abundance of only a fraction of the community. In order to achieve a more complete sample, it is necessary to use a combination of sampling methods (Fleming, 1975; Voss and Emmons, 1996; Woodman et al., 1996; Voss et al., 2001; Hice and Schmidly, 2002). Most studies that use more than one type of trap obtain more accurate estimates of the species richness and abundance of the small mammal communities they sample (Woodman, et al., 1996; Santos-Filho, 2000; Lacher and Alho, 2001; Voss et al., 2001). According to Voss and Emmons (1996), the principle methods of sampling small mammal communities are: trapping with conventional live traps, arboreal traps, or pitfall traps; undertaking diurnal or nocturnal hunting; performing interviews; placing mist nets at ground level or in the canopy; and locating dens.

The object of this study is to compare the efficiency of four trap types, Sherman, Tomahawk, snap, and pitfall, in the capture of small mammals in seasonal semi-deciduous sub-montane forest, in order to improve our knowledge of sampling techniques and aid future inventories and ecological studies of small mammals in the tropics.

MATERIALS AND METHODS

We sampled the small mammal community of 22 sites located in the microbasins of the Jauru and Cabaçal Rivers, tributaries of the Paraguai River, in southwest Mato Grosso, Brazil. Our study sites were located between latitude S 15° 15' 06", longitude W 58° 42' 56" and latitude S 15° 33' 43", longitude W 58° 00' 17" in the municipalities of Figueirópolis D'Oeste; Indiavaí, Araputanga, IV Marcos, Mirassol D'Oeste, Curvelândia, Lambari D'Oeste and Rio Branco. Three of our 22 study sites were located in continuous forest (larger than 1000 ha) and 19 were located in forest fragments ranging from 41 to 468 ha.

We collected trap data for ten consecutive nights in each study site between November 2002 and August 2004, for a total of 310 nights of sampling. We sampled eight fragments and one continuous forest site twice during the same year, once during the dry season and once during the wet season. All other study sites were sampled only one time during the study period. We sampled the community of small rodents and marsupials using Sherman (80 mm x 90 mm x 230 mm), Tomahawk (145 mm x 145 mm x 410 mm), and snap (90 mm x 150 mm) traps, as well as pitfall traps. We checked the traps during regular nocturnal transects on a system of parallel, approximately 135 m-long, trails spaced 50 m apart. Each transect of conventional traps (Sherman, Tomahawk, and snap) had 10 collection points located at intervals of about 15 m, for a total of 80 traps per transect and 24 800 conventional trap-nights over the entire study. We placed two identical traps at each collection point, one on the ground and one secured to vegetation at a height of approximately 2 m. We alternated the type of conventional trap among collection points along the transect lines. We baited the traps with banana and peanut butter and checked the bait daily during the sampling period.

We installed six 50-m long lines of pitfall traps at each study site. Each line contained five traps spaced 10 m apart. Traps were constructed of 23.6 liter plastic barrels in the form of a cone (37 cm high, 30 cm in diameter at the top, and 26 cm in diameter at the bottom), buried in the ground up to their rims. An 80-cm tall fence, made from a black plastic tarp stapled to wooden stakes, linked the traps along each transect. The bottom of the fence was buried 5 cm deep into the soil, to discourage animals from avoiding the traps. During the construction of the pitfall trap lines, we tried to make as little impact as possible in the area. We sampled each study site by leaving the pitfall traps open for ten consecutive days during each sampling period, for a total of 9000 pitfall trap-nights during the study.

The species were identified through comparisons with specimens deposited in Museu Nacional/

UFRJ's (Universidade Federal do Rio de Janeiro) collections and INPA (Instituto Nacional de Pesquisa da Amazônia)/Manaus.

We calculated capture rates for each trap type as the total number of individuals captured divided by the number of traps, multiplied by 100.

We compared the capture rates of the different trap types in forest fragments and control sites using paired, non-parametric Wilcoxon signed rank tests. To compare capture rates among traps between seasons, we sampled nine study sites during both the wet (December, January and February) and dry seasons (June, July and August) of the same year. We combined the capture data from these study sites and used paired t-tests to look for differences in number of individuals and species richness captured between seasons. We used analysis of variance (ANOVA), with an *a posteriori* Tukey test, to examine differences in the efficiency of the 4 trap types in capturing different species. We performed all analyses using SYSTAT (Wilkinson, 1990) and considered p-values ≤ 0.05 significant.

RESULTS

Species abundance

We found an overall capture rate of 3% for all traps used in the study. The overall capture rates for the four trap types examined were 1.3% for pitfall, 2.7% for Tomahawk, 2.9% for snap, and 4.7% for Sherman.

Overall, Sherman traps captured the greatest number of individuals and had significantly higher capture rates than all other traps in the study (Wilcoxon signed ranks test, Tomahawk versus Sherman Z=3.050, p=0.002; snap versus Sherman Z=-3.517, p<0.001; pitfall versus Sherman Z=-3.808, p<0.001; **Fig. 1**). Pitfall traps had significantly lower capture rates than Tomahawk (Z=-2.298, p=0.022) and snap traps (Z=-3.429, p=0.001; **Fig. 1**). We found no significant difference in capture rates between Tomahawk and snap traps (Z=0.626, p=0.531).

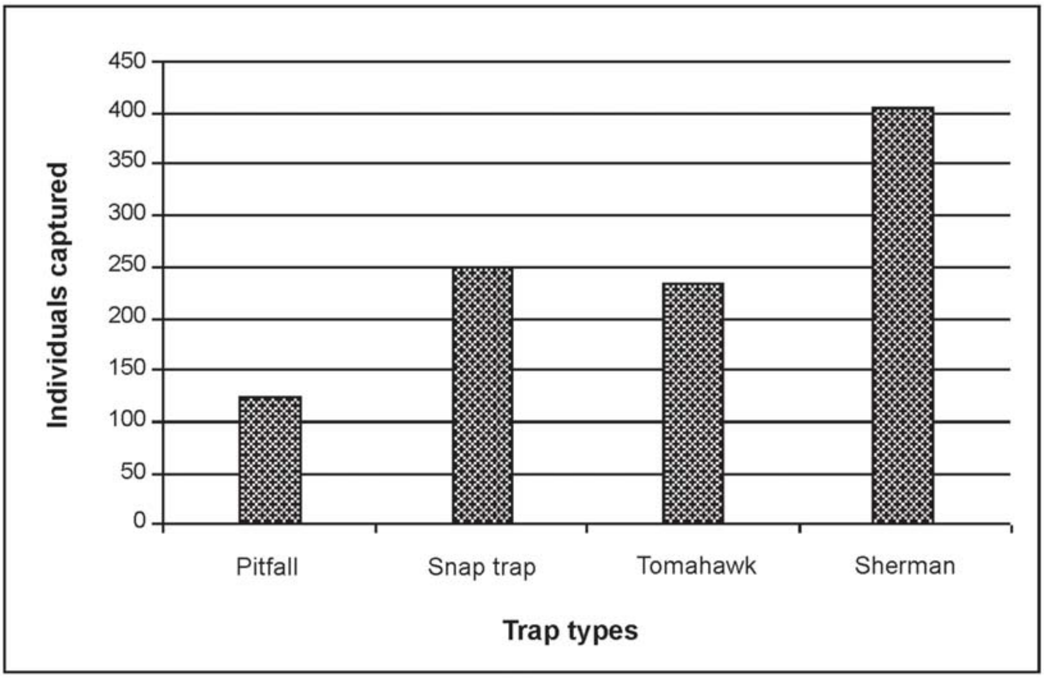

Fig. 1. Number of individuals captured in the 4 trap types sampling the small mammal community of 22 study sites in seasonal semi-deciduous sub-montane forest of Mato Grosso, Brazil, between November 2002 and August 2004.

Sherman traps captured high numbers of individuals of three species, *Oecomys bicolor*, *Gracilinanus agilis*, and *Marmosops noctivagus*. Only *Marmosops noctivagus* had capture rates high enough for statistical analysis, and despite the large numbers captured in Sherman traps compared to other trap types, we found no significant difference in capture rates of *Marmosops noctivagus* among trap types.

We captured a total of 27 species of small mammals during our study. Eleven of these had more than 10 individuals captured and were considered as common. Six of these 11 species were most abundant in Sherman traps and 3 were most abundant in pitfall traps, together they captured 9 of the 11 most common species in the study. Snap and Tomahawk traps had high capture rates for only 1 species each, *Oryzomys megacephalus* and *Oecomys roberti*, respectively (**Table 1**).

All individuals of *Monodelphis adusta* captured during our study were captured in pitfall traps, and despite Sherman traps capturing the greatest number of individuals, only two species were captured only in this type of trap (**Table 1**). Only snap traps did not have a restricted species (**Table 1**).

Among the four types of traps, Sherman traps captured almost twice the individuals of *Marmosops noctivagus* when compared to the other three types combined ($F_{3.80}$ =6.030, p=0.001; **Table 1**). In an a posteriori test, we found that the capture rates of Sherman traps were much higher than those of pitfall traps (Tukey HSD, p<0.001). We found no significant difference among the other three trap types.

The number of *Micoureus demerarae* individuals captured varied among trap types ($F_{3.80}$= 9.903, p<0.001), with only one individual captured in pitfall traps. This type of trap showed to be very inefficient when compared with Sherman and Tomahawk traps that were very efficient in capturing this species, with Tukey HSD test results of p<0.001 for both trap types. However, we found no variation in the number of captures between pitfall and snap traps (Tukey HSD, p=0.216). For Sherman and snap traps, there was a significant difference in the capture rate of this species (Tukey HSD, p=0.033), but not between snap trap and Tomahawk (Tukey HSD, p=0.076), and Sherman and Tomahawk (Tukey HSD, p=0.987).

The number of *Oryzomys megacephalus* individuals captured across our study sites was not related to trap type ($F_{3.80}$=0.810, p= 0.492).

Species Richness

In our study, Tomahawk traps captured the highest number of species of all trap types. Overall, 19 species were captured in Tomahawk traps, with six species captured exclusively by this trap type (**Table 1**, **Fig. 2**). Sherman traps captured the second highest number of species, capturing 18 species over all study sites. Pitfall and snap traps both captured 15 species each (**Fig. 2**).

We found significant differences in the number of species captured in each trap type among our 22 study sites. Sherman traps lead to the highest species richness, when compared to snap, Tomahawk, and pitfall traps (Sherman vs. snap, Z=2.575, p=0.010; Sherman vs. Tomahawk, Z=2.886, p=0.004; Sherman vs. pitfall, Z=3.550, p<0.001). Species richness as sampled by pitfall traps was significantly lower than Tomahawk and snap traps (pitfall vs. Tomahawk, Z=2.221, p=0.026; pitfall vs. snap, Z=2.559, p=0.011).

Seasonality

Of the four trap types used, only pitfall traps exhibited higher capture rates during the wet season (**Fig. 3**). Despite the fact that pitfall traps captured almost four times the number of individuals during the wet season (n=35, 80%) than during the dry season (n=9, 20%), the difference was not significant between seasons (t=-1.579, p=0.153). Of the 44 individuals captured in pitfall traps during out study, 12 were juveniles. Ten juveniles (83%) were captured during the wet season and two (17%) were captured during the dry season.

Of the 97 individuals captured in snap traps, 59 (61%) were captured during the dry season

Tabla 1

List of species captured across 22 study sites in seasonal semi-deciduous sub-montane forest, Mato Grosso, Brazil. Four trap types were used to sample the small mammal community between November 2002 and August 2004.

SPECIES CAPTURED	**TRAP TYPES**				**TOTAL**
	Pitfall	Snap	Tomahawk	Sherman	
RODENTS					
Akodon toba	0	0	0	2	2
Necromys lasiurus	5	11	5	11	32
Calomys sp.	21	7	4	17	49
Dasyprocta azarae	0	0	1	0	1
Mesomys hispidus	0	1	0	1	2
Neacomys spinosus	13	3	1	11	28
Oecomys bicolor	9	13	12	37	71
Oecomys roberti	2	10	13	11	36
Oecomys sp.	3	3	0	4	10
Oligoryzomys microtis	6	0	0	2	8
Oryzomys maracajuensis	0	1	2	0	3
Oryzomys megacephalus	18	43	24	36	121
Oryzomys sp.	0	0	5	5	10
Proechimys sp.	0	12	10	1	23
Rhipidomys mastacalis	0	0	0	3	3
MARSUPIALS					
Caluromys philander	0	0	1	0	1
Didelphis marsupialis	0	0	5	0	5
Glironia venusta	0	0	1	0	1
Gracilinanus agilis	7	10	2	32	51
Marmosa murina	5	10	2	17	34
Marmosops noctivagus	6	75	59	122	262
Metachirus nudicaudatus	0	0	2	0	2
Micoureus demerarae	1	37	80	87	205
Monodelphis adusta	15	0	0	0	15
Monodelphis brevicaudata	1	0	0	1	2
Monodelphis domestica	4	2	0	0	6
Philander opossum	0	0	1	0	1
TOTAL ABUNDANCE	116	238	230	400	984
SPECIES RICHNESS	15	15	19	18	

and 38 (39%) were captured during the wet season. We found no significant difference in the number of individuals captured between seasons ($t=1.052$, $p=0.323$).

Despite Tomahawk traps having captured 61 individuals (62%) during the dry season and 38 individuals during the wet season (38%), this difference was not significant ($t=1.197$, $p=0.266$). In Sherman traps, a greater number of individuals were captured during the dry season ($n=115$, 60%) than during the wet season ($n=78$, 40%). Despite these two trap types having captured the majority of individuals during our study, with almost two times as many captured during the dry season, we found no significant difference in capture rates between seasons ($t=1.769$, $p=0.115$).

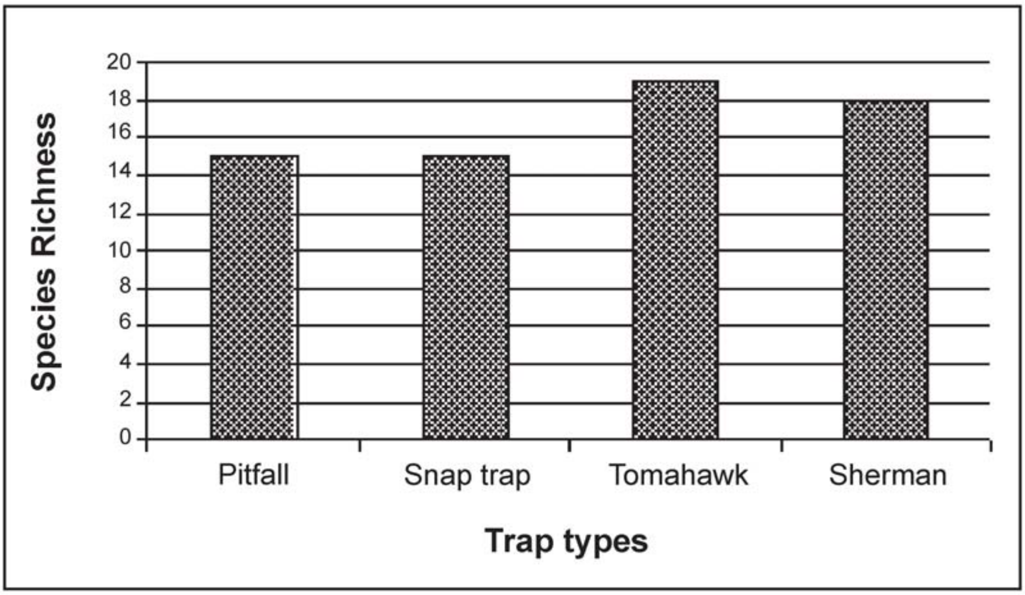

Fig. 2. Total species richness captured in 4 trap types sampling the small mammal community of 22 study sites located in seasonal semi-deciduous sub-montane forest of Mato Grosso, Brazil. Sampling occurred between November 2002 and August 2004.

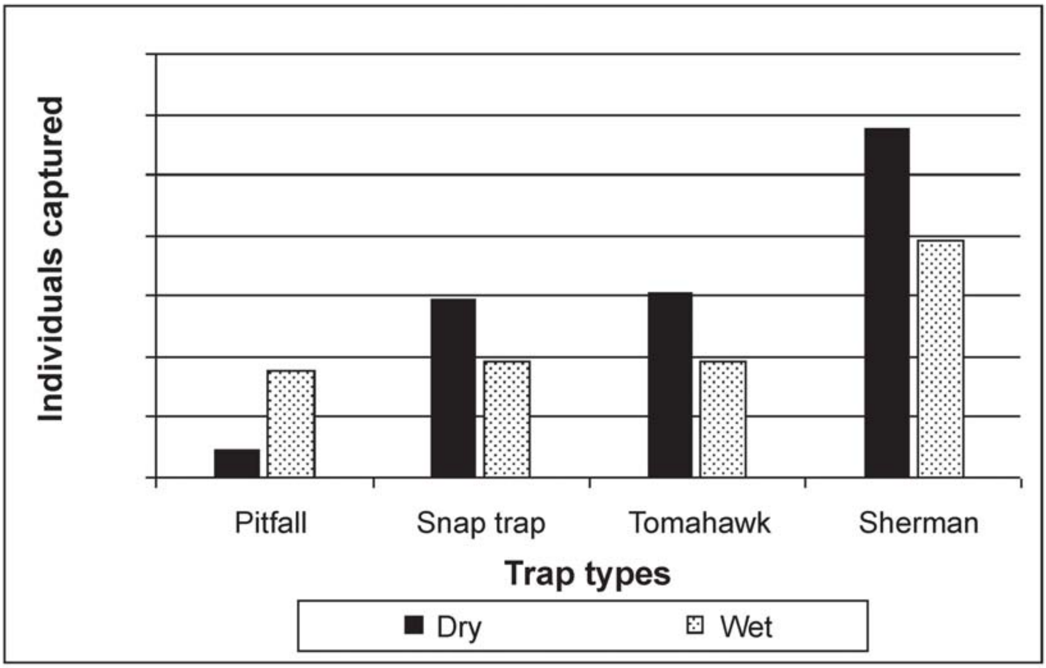

Fig. 3. Capture rates of 4 trap types during the dry and wet seasons across 22 study sites located in seasonal semi-deciduous sub-montane forest in Mato Grosso, Brazil. Traps were used to sample the small mammal community of forest fragments between November 2002 and August 2004.

DISCUSSION

Species abundance and Richness

The capture success in this study was low compared to other studies carried out in tropical forests using similar methods. Woodman et al. (1996) obtained an overall capture success of 5.3% in Peruvian tropical forests; O'Connell (1989) had a capture rate of 6% in the tropical forests of Venezuela; Stevens and Husband (1998) and Bergallo (1994) had capture rates of 11% and 15.1%, respectively, in the tropical Mata Atlântica forest of southeastern Brazil. Our capture rates are more comparable to those obtained in studies of the small mammal communities inhabiting Cerrado, where studies found capture rates of 2.6% (Santos-Filho, 2000) and 3.9% (Lacher and Alho, 2001). Lacher and Alho (2001) used Tomahawk and Sherman traps in their study in the Cerrado and found trap-specific capture rates very similar to ours, 2.2% for Tomahawk and 5.2% for Sherman traps. In Mexican deserts in Durango, Sherman traps had higher capture rates than pitfall traps (Petersen, 1980). In tropical forests, Woodman et al. (1996) had more success with snap traps than with live traps.

Despite the similarity in capture rates of individuals between Tomahawk and snap traps, the two traps captured a significantly different composition of species, demonstrating the importance of different trap types when attempting to sample the entire community.

The capture rate of each type of trap depends mostly on the model and size used (Pizzimenti, 1979; Mengak and Guynn, 1985; Slade et al., 1993; O'Farrell et al. 1994; Lee, 1997), as much as the type of habitat that is studied.

In our study, pitfall traps captured the lowest number of individuals of all trap types. However, Hice and Schimidly (2002), also working in the Amazon basin, used pitfall traps similar in size and structure to ours and found higher capture rates than those with Sherman or Tomahawk traps. The size and diameter of the barrel could have influenced the capture rates of some species. We recommend pitfall traps be used only as a complement to other trapping methods when sampling small mammal communities.

We captured very few individuals of the species *Marmosops noctivagus* and *Micoureus demerarae* in pitfall traps. Perhaps these species are more agile than other species, making it easy for them to escape from our pitfall traps. Our pitfall traps may have simply been too small and shallow to contain these species. We frequently captured these species in the other three trap types placed at ground level, so we doubt this trend is a result of pitfall traps being limited to one stratum.

Tomahawk traps captured species within a large range of sizes, from the tiny *Neacomys spinosus*, to larger species such as *Dasyprocta azarae, Didelphis marsupialis*, *Caluromys philander, Metachirus nudicaudatus,* and *Philander opossum,* that may have been too large to be captured in any of the other trap types.

Between Tomahawk and snap traps, we found no significant difference in the number of species captured, indicating that these trap types have similar effectiveness in sampling species richness, despite the fact that Tomahawk traps captured four more species than snap traps, with six species being captured by no other trap type.

Despite the large effort dedicated to the installation and uninstallation of pitfall traps, they are indispensable for studying the species richness of small mammal communities. They capture a unique group of species, including some rare species, such as *Monodelphis adusta*, which are not captured in conventional traps (Da Silva, 2001; Vargas et al., 2003). This type of trap is useful for sampling several species that do not depend on bait. Pitfall traps may capture scansorial species, such as *Micoureus demerarae*, *Marmosops noctivagus*, *Oecomys* sp., *Gracilinanus agilis, Marmosa* sp., and *Glironia venusta.* Marshall (1978) and Emmons and Feer (1997) consider *Glironia venusta* rare and extremely arboreal. Bernarde and Rocha (2003) captured this species in pitfall traps in tropical forest in Rondonia, Brazil. When compared to Sherman and Tomahawk traps, pitfall and snap traps captured fewer scansorial species, such as *Marmosops noctivagus* and *Micoureus demerarae*. This may be due to trap location, rather than structure, since pitfall traps are located only on the ground, while these species move through their habitat using mainly tree branches.

Our results are in agreement with previous studies with the four trap types tested, Sherman traps being the best for working with small mammals, capturing high species richness and abundance (Petersen, 1980; Lee, 1997; Lacher and Alho, 2001).

Seasonality

Considering the seasonal variation, Hice and Schmidly (2002), in Amazonian tropical forest, also found differences in capture rates between seasons, with capture rates of 0.14% during the dry season and 4.55% during the wet season.

Pitfall traps had very low capture rates during the dry season, suggesting that the species that fall into this type of trap could be less abundant or less active during the dry season. The capture of larger mammals in pitfall traps only is possible when large barrels are used, because they probably escape from small barrels. Voss et al. (2001), studying in tropical forests, found that keeping 15 cm of water in the bottom of pitfall trap barrels increases capture rates. Also, this can be a solution to augment this trap's efficiency during the dry season, since during the wet season, all the barrels maintain a little water, making it more difficult for the animal to escape, while during the dry season the barrels stay dry, allowing some individuals to escape. Besides this, the dry season may have higher predation rates, since resource availability in the forest decreases and predator home range size tends to increase during this time. This may increase the number of encounters a predator has with the traps in general, and pitfall traps in particular. However, we did not note the presence of blood or hair in the pitfall trap barrels during our study, but since most of the individuals in the pitfall traps were small, a potential predator may have been able to remove entire individuals and these events would escape our notice.

When compared between seasons, snap and Tomahawk traps captured the same number of individuals during the wet season, with only two more individuals captured in Tomahawk traps during the dry season. Almost all the species could be captured in these two types of traps. Only *Didelphis marsupialis*, the largest species captured in our study sites, was captured exclusively in Tomahawk traps, however it was not very abundant during our study.

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