Comparative effectiveness of Longworth and Sherman live traps

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Abstract Despite the widespread use of Sherman (H. B. Sherman Inc., Tallahassee, Flor.) and Longworth (Penlon Ltd., Oxford, U.K.) live traps in small-mammal-community assessment, few studies have directly compared the effectiveness of these 2 popular models. This study compared the relative efficacy of both trap types in capturing small mammals in southern Wisconsin grasslands. As trap size may cause capture bias, we compared Longworth traps with equal numbers of small and large, folding Sherman traps. We also deployed a small number of pitfalls. We carried out trapping at 12 sites over a 2-year period (1996–1997). We observed a significant year effect, so we analyzed differences in capture success, species diversity indices, and percent community similarity between trap types separately for each year. Two-way contingency table analyses indicated that all 3 trap types exhibited species-specific differences in capture rates. We assessed standardized deviates for each cell within this two-way design, and we considered departures greater than 2 standard deviations (SE±1.96) from the mean to show an either significantly positive (≥+1.96) or significantly negative (≤−1.96) association. In the first year, Longworth traps captured greater numbers of long-tailed shrews (*Sorex* spp.) whereas small Sherman traps captured more western harvest mice (*Reithrodontomys megalotis*) and white-footed or prairie deer mice (*Peromyscus* spp.). In the second year, small Sherman captures were greater for long-tailed shrews and western harvest mice while large Sherman traps captured more meadow voles (Microtus pennsylvanicus) and jumping mice (*Zapus hudsonius*). Although estimates of community diversity were similar between trap types, percent community similarity estimates were lowest for Longworth-Sherman trap comparisons. Mortality rates were highest for Longworth traps and small Sherman traps and lowest for large Sherman traps. Pitfalls caught proportionally more long-tailed shrews than conventional live traps in the first but not the second year of study. In general, body mass of the animal had little effect on trap capture rates. However, in the first year of this study, small Sherman traps caught lighter (P =0.028) long-tailed shrews than the large Sherman traps. Similarly, Longworth traps caught significantly lighter white-footed/prairie deer mice than either small (P=0.022) or large (P= 0.035) Shermans. When used in combination, both Longworth and Sherman traps can diminish overall sampling error and yield less biased estimates of species composition than either trap type alone. The use of new as opposed to used Sherman traps in the second year of this study might account for the greater capture efficacy of these traps and contribute to differences in relative trap type success between years.

Key words diversity, grassland, Longworth trap, prairie, Sherman trap, small mammals

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Numerous studies have demonstrated that no single trapping method can yield accurate and unbiased estimates of the structure and composition of small-mammal communities (Brown 1967, Williams and Braun 1983, Szaro et al. 1988, Handley and Kalko 1993). Each trap has its own inherent biases and mechanical limitations that are likely to favor capture of some species over others. Comparisons between conventional live traps, snap traps, and pitfall traps strongly suggest that a combination of different trap types is the best means of assessing overall composition and structure of small-mammal communities (Kalko and Handley 1993, McComb et al. 1991). Furthermore, many authors also have argued that pitfall traps are a crucial part of any community assessment because they sample shrews (*Sorex* spp., *Neomys* spp.) more effectively than other trap types (e.g., Briese and Smith 1974, Pucek 1969, Williams and Braun 1983, McComb et al. 1991).

Of the many commercial live traps available, the Longworth trap (Penlon Ltd., Oxford, U.K.) and the Sherman live trap (H. B. Sherman Inc., Tallahassee, Flor.) are probably the most widely used. The Longworth trap is commercially available as a 2-piece model. The trap itself consists of a nesting-chamber box attached to a tunnel with a treadle that trips the door of the trap when the animal enters the chamber (Chitty and Kempson 1949). In contrast, the Sherman live trap is a simple box trap that operates on a door-and-treadle system and is commercially available in a number of different sizes.

Several studies have attempted to compare Longworth traps with pitfalls, snap traps, and other live traps (Boonstra and Krebs 1978, Beacham and Krebs 1980, Innes and Bendell 1988, Lambin and MacKinnon 1997). Similarly, Sherman trap types also have been compared to a variety of other trap types (Sealander and James 1958, Williams and Braun 1983, O'Farrell et al. 1994, Whittaker and Feldhammer 2000). However, with the exception of an earlier, limited study (Morris 1968), little information is available on the relative capture rates of Longworth and Sherman traps.

The aim of this study was to compare the relative efficacy of Sherman and Longworth trap types at capturing grassland-associated small mammals and provide guidelines for their use. This study also set out to test the following hypotheses: 1) mortality rates do not differ between trap types, 2) pitfalls are equally as effective as conventional live traps in capturing shrews, 3) animal mass has no effect on capture efficiency, and 4) estimates of species diversity indices and community similarity do not differ between trap types.

Study area

We carried out this study in 12 grassland preserves located throughout southern Wisconsin (for a detailed description see Anthony et al. 2003). These sites encompassed examples of both dry ($n=7$) and mesic ($n=5$) grassland community types within the southwestern and southeastern natural divisions of Wisconsin (see Hole and Germaine 1994). Six grassland natural areas (Nature Conservancy preserves and State Natural Areas) were assessed in 1996 and a further 6 in 1997. We carried out trapping twice at intervals of at least 6 weeks apart between May and August at each site within the same year.

Methods

We laid out 3 trap grids at each site. Each grid was made up of 25 trap stations arranged in a 5 × 5 configuration. We marked each station with removable flags set 15 m apart on the grid. We employed the following 3 trap models: a 2-piece Longworth trap (13.8 cm × 6.4 cm × 8.4 cm), a small nonfolding Sherman trap (17.0 cm × 5.4 cm × 6.5 cm), and a large folding Sherman trap (23.0 cm × 7.7 cm × 9.1 cm). We placed one of each of these trap types within a 3-m radius of each trap station. We dug pitfall traps, consisting of 2 #10 tin cans (36 cm × 15 cm) held together by duct tape, at each of the 4 corners and at the center of each grid. The age of Sherman traps differed between years: traps used in the first year had been used extensively for several field seasons whereas traps for the second year were acquired new. In contrast, Longworth traps deployed in the study were approximately 30 years old. For all trap types, each trap was individually inspected and tested for functional reliability before and during trapping studies.

Preceding each survey, we left traps open within the grid and pre-baited them for 2 days with a 25-g peanut butter bag. Following the pre-baiting period, we rebaited and tested all traps before the trapping period began. The trapping period extended over 4 consecutive nights, and we checked traps once in the morning and once in the evening, except that when temperatures exceeded 27°C, we shut down traps during the day. Following capture, we identified, sexed, weighed, and ear-tagged each animal. We also recorded data for the trap type and trap station location for each captured animal and whether it was a new or recaptured animal. We ear-tagged rodents using Fingerling Monel tags (National Band and Tag Co., Newport, Kent.). Upon capture, we always checked animals for evidence of a torn ear that might indicate previous tagging. On the rare occasion where this was observed, we marked animals as recaptures and assigned each a new number. As long-tailed shrews (*Sorex* spp.) were too small to be ear-tagged, we marked them with a dab of nontoxic paint behind the ear. We color-coded paint for different days during the trapping period so that animals recaptured more than once could be identified. We made no distinction between white-footed mice (*Peromyscus leucopus*) and prairie deer mice (*P. maniculatus*), because discrimination between these 2 species in the field was often difficult in the absence of detailed external measurements (Stromberg 1979) or analysis of salivary amylase variation (Aquadro and Patton 1980, Feldhammer et al. 1983, Palas et al. 1992). Similarly, separation of the masked shrew (*Sorex cinereus*) from the pygmy shrew (*S. hoyi*) was impossible in the field, so we combined data for these two long-tailed shrew species.

Data analysis

We only analyzed nocturnal trapping data because of the need to intermittently shut traps down in the daytime during hot weather. Because prior experience is known to modify species capture rates in different ways (e.g., Getz 1961, Boonstra and Krebs 1978, Rose et al. 1977, Slade et al. 1993), only data for first-time-capture animals (new) were used to compare capture rates between trap types. We used a χ^2 test to test for differences in overall nocturnal captures rates between the first and second years of this study. We used a generalized linear model with a Poisson error structure to test for between-year interaction effects. Within years, trap-type data were combined across seasons because there was little evidence to support the hypothesis that relative capture rates were affected by season (see results). We used two-way contingency table analysis to test whether equal proportions of animals were caught by trap type and by species within each year. We assessed the standardized deviates for each cell within this two-way contingency design, and we considered departures greater than 2 standard deviations from the mean (± 1.96) significant (Feinberg 1977).

We compared estimates of small-mammal-community diversity between trap types using the Shannon diversity index (Shannon and Weaver 1949) and the Berger-Parker index (Magurran 1988). Both indices are a measure of species heterogeneity but differ in that the Shannon index is based on proportional abundances of species while the Berger-Parker index is a measure of dominance (Magurran 1988). As previously noted by Magurran (1988), Shannon diversity index values follow an approximate normal distribution. Berger-Parker index values were arcsine square-root transformed (Sokal and Rohlf 1997). We assessed differences in diversity measures between trap types by two-way analysis of variance where we treated site and trap type as categorical variables and suppressed the interaction term. We compared estimates of percent community similarity (PS) between the 3 principal trap types, using the following relationship adapted from Pielou (1977):

$$\%\,\mathrm{PS} = 200 \sum_{i=1}^{s} \min\left(\mathrm{P}_{ix},\ \mathrm{P}_{iy}\right),$$

where P_{ix} and P_{iy} were the minimum quantities of ith species captured in either trap type x or y, expressed as the proportion of the quantity of all s species in both traps combined. This value can vary from 0 (no similarity) to 100% (complete similarity). For all estimates of community structure, we considered only new captures. We used a one-way chi-square test to compare proportional mortality rates between the different trap types (expressed as number of deaths over the total number of captures for a given trap type) and assessed the relative efficacy of pitfalls at capturing shrews where the ratio of pitfalls to live traps was 1:15. We used an analysis of variance to test whether the mass of each species differed significantly between trap types. We used Bonferroni post hoc tests to compare between means. We carried out all statistical analyses using SYSTAT 6.0 for Windows (SPSS, Chicago, Ill.) and S-Plus (Insightful Corporation, Seattle, Wash.). Unless explicitly stated, we adopted a significance level of $\alpha<0.05$ for 1- and 2-way contingency table tests and analyses of variance.

Results

Species richness and overall abundance

We captured 9 species using a combination of

Table 1. Standardized residuals derived from a two-way contingency table analysis to test whether the 3 trap types (small Sherman, large Sherman, and Longworth) caught equal proportions of each species. Data are presented for animals trapped at 6 Wisconsin grassland sites in year 1 (1996) and 2 (1997). Residuals greater than ±1.96 are highlighted in bold.

		Trap types		
		Small	Large	
Year	Species	Sherman	Sherman	Longworth
1	Long-tailed shrew	**−2.12**	**−3.26**	**5.38**
1	Short-tailed shrew	1.03	−1.55	0.52
1	Western harvest mouse	2.22	−1.94	−0.28
1	White-footed/prairie deer mouse	**2.11**	**−3.12**	1.01
1	Meadow vole	0.79	1.88	**−2.66**
1	Meadow jumping mouse	Not tested	Not tested	Not tested
2	Long-tailed shrew	**5.86**	**−4.40**	−1.47
2	Short-tailed shrew	0.26	1.06	−1.32
2	Western harvest mouse	**2.26**	−0.87	−1.39
2	White-footed/prairie deer mouse	1.22	**2.31**	**−3.54**
2	Meadow vole	0.35	**3.24**	**−3.49**
2	Meadow jumping mouse	1.28	**2.10**	**−3.38**

small and large Sherman and Longworth traps. However, we captured only 6 of these in sufficient quantity for statistical analysis: long-tailed shrew (*Sorex* spp.), short-tailed shrew (*Blarina brevicauda*), western harvest mouse (*Reithrodonomys megalotis*), white-footed and prairie deer mice (*Peromyscus* spp.), meadow vole (*Microtus pennsylvanicus*), and meadow jumping mouse (*Zapus hudsonius*). Summed across all species, there were no differences between years in the number of new (χ^2_1= 1.315, P=0.251) animals captured.

Trap type efficiency

We observed a significant year effect ($P \leq 0.001$) so that we analyzed data from the first (Figure 1*a*) and second year (Figure 1*b*) of this study separately in all subsequent analyses. Contingency table analysis indicated that species were not caught uniformly across trap types in either the first (χ^2_{10}= 83.0, $P \leq 0.001$) or the second (χ^2_{10}= 125.6, $P \leq$ 0.001) year of study. In the first year, Longworth traps captured more long-tailed shrews than either of the other trap types while both Sherman trap models captured less long-tailed shrews than expected given a model of equal capture success between trap types (Table 1). White-footed and prairie deer mouse and western harvest mouse captures were greater in small Sherman traps whereas large Sherman traps captured fewer white-footed/prairie deer mice than expected. Meadow voles also were captured at lower frequencies in Longworth trap types than in either of the 2 other trap types. Short-tailed shrews failed to show any differences in relative capture rates between trap types in either year.

In the second year of trapping, long-tailed shrew capture rates shifted positively toward small Sherman traps and were negatively associated with large Sherman traps and Longworths. Western harvest mice still showed a positive association for small Sherman traps whereas white-footed and prairie deer mice captures were biased toward large Sherman traps and negatively biased toward Longworth traps. Both meadow voles and jumping mice were positively associated with large Sherman traps and negatively associated with Longworth traps, as suggested voles in the first year of trapping.

Although we did not take recapture rates into consideration for the present study, we also tested, where there was sufficient data, the hypothesis that trap types had similar recapture rates (i.e., the probability of an animal being recaptured was independent of trap type). Due to data limitations, it was possible to test this hypothesis with only 2 species: white-footed and prairie deer mice, and meadow voles. In the first year of this study all 3 trap types had similar recapture rates for both species. However, in the second year, meadow vole recaptures were greater than expected for small Sherman traps (χ^2_1= 18.9, P<0.005). Although seasonal differences in abundance were noted between trapping sessions within years (Anthony et al. 2003), we found little evidence for an effect of trapping session on differential rates of capture between species. For cases where there was sufficient data to test this hypothesis, contingency tests revealed only 1 comparison out of 8 where differences in capture rates between trapping periods were significant (χ^2_1= 8.7, P=0.01).

Although pitfalls failed to capture many species, long-tailed shrews made up the bulk of all captures. Taking into account the ratio of pitfalls:live traps (1:15), pitfalls caught more (χ^2_1=5.9, P<0.025) long-

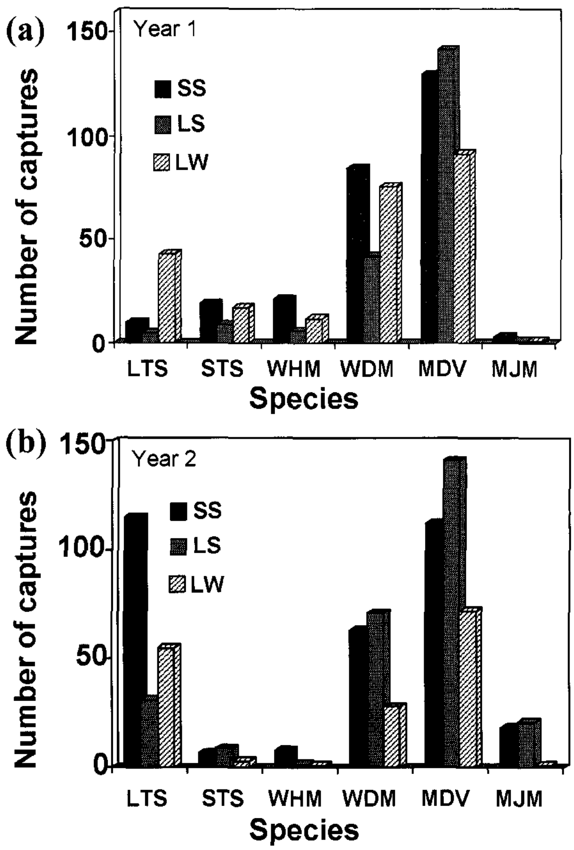

Figure 1. Histograms illustrating the number of newly captured animals captured in each trap type for the 6 most frequently encountered species caught in (a) year 1 (1996) and (b) year 2 (1997) from 12 Wisconsin grassland sites. Species are labeled as LTS (Long-tailed shrews), STS (Short-tailed shrews), WHM (Western harvest mice), WDM (White-footed/prairie deer mouse), MDV (Meadow vole) and MJM (Meadow jumping mouse). The 3 trap types are labeled as SS (Small Sherman), LS (Large Sherman), and LW (Longworth).

tailed shrews than live traps in the first year of the study. However, there were no differences (χ^2_1=4.0, P<0.25) in long-tailed shrew capture rates between pitfall and live traps in the second year.

Community composition

There were no apparent differences in small-mammal diversity estimates between the 3 trap types deployed in this study. Neither Shannon diversity nor Berger-Parker dominance indices differed in either the first year ($F_{2,10}$=0.151, P=0.862; $F_{2,10}$=0.407, P=0.676) or the second year ($F_{2,10}$= 0.721, P=0.510; $F_{2,10}$=0.930, P=0.426) of the study. However, consideration of pairwise community similarity estimates revealed some interesting differences. In the first year, although estimates of community composition did not differ much between the 2 sizes of Sherman trap (81.6%) or between small Sherman and Longworth traps (81.7%), large Sherman versus Longworth trap comparisons revealed a greater dissimilarity (69.5%). With the introduction of new Sherman traps in the second year, similarity estimates between the 2 types of Sherman remained high (77.9%), whereas Longworth traps produced lower similarity estimates for both small (66.7%) and large (62.5%) Sherman traps.

Trap mortality

Relative mortality rates showed slightly different patterns between years. In the first year, mortality was proportionally higher in Longworths (39/375 captures = 10.4%), intermediate in small Shermans (28/433 captures=6.5%), and zero in large Shermans (0/344=0%). With the introduction of new Sherman traps in the second year, mortality was higher in both Longworth (100/508=20%) and small Sherman traps (47/231 = 20.3%) and lowest in large Sherman traps (40/437 = 9.1%). Long-tailed shrew constituted the majority of trap deaths, representing 54.9% and 86% of deaths in the first and second year of this study, respectively. Long-tailed shrew proportional mortality rates (expressed as number of deaths over total number of captures for a given trap type) were independent of trap type for both year 1 (χ^2_2=2.15, P= 0.34) and year 2 (χ^2_2=0.91, P=0.63). The remaining trap deaths in year 1 were attributable to meadow voles (30.5%), short-tailed shrews (12.2%), western harvest mice (1.2%), and white-footed/prairie deer mice (1.2%). In year 2, proportions were similar in being made up of meadow voles (11.2%), short-tailed shrews (2.1%), and jumping mice (0.5%).

Body mass

Differences in body mass between trap types were noted for 2 species in the first year of study. Long-tailed shrew body mass differed ($F_{2,11}$=5.031, P=0.028) between trap types, with lighter animals being caught in small rather than large Sherman traps (P=0.028). White-footed/prairie deer mice also differed ($F_{2,176}$=4.877, P=0.009) in body mass between trap types and, in this case, were lighter in Longworths than in either small (P=0.022) or large (P=0.035) Sherman traps.

Discussion

Previous studies have compared the relative efficacy of different commercially available live traps, snap traps, and pitfall traps (e.g., Weiner and Smith 1972, Rose et al. 1977, Williams and Braun 1983, Slade et al 1993). It has long been recognized that many factors can affect trap success including trapping configuration, bait type, prior trap experience, seasonal change, lunar cycles, and inclement weather conditions (e.g. Getz 1961, Pernetta et al. 1977, Kaufman and Kaufman 1981, O'Farrell et al. 1994). Several studies also have reported sampling biases associated with different sizes of trap (e.g., Quast and Howard 1953, Slade et al. 1993, Whittaker et al. 1998). In particular, certain live trap types are believed to be unsuited to catching small shrews, and this has led to the belief that pitfalls generally are more effective than snap traps or conventional live traps (Williams and Braun 1983, Bury and Corn 1987, Mengak and Guynn 1987, McComb et al. 1991). Thus, the potential for under-sampling certain species due to inherent trap biases combined with variation in trap success due to species behavior and environmental variation can undermine efforts to quantify small-mammal-community structure and make valid comparisons between studies difficult. These considerations are important to base-line inventory (e.g., Anthony et al. 2003) and long-term monitoring where the use of different trap types could potentially confound estimates of species composition and studies of relative demographic change.

Results from our live-trap type analyses indicated substantial differences in overall capture rates between trap types. If abundance was used as a measure of trap type efficacy, then small Sherman traps consistently captured more individuals than either of the 2 other traps used in this study. This was likely to be due to the greater sensitivity of the treadle system and the fact that none of the target species were large enough to be excluded from these traps. Although large Sherman traps appeared to be more effective in capturing voles, our findings otherwise do not reflect the potential length bias noted in Sherman traps by Slade et al. (1993) and suggest that trap size dimensions per se do not present an obstacle to the species trapped in our study. In the case of field voles, however, the longer traps may have been more effective simply because larger voles may have escaped capture in smaller traps or Longworths by blocking the door with the back or rump (Boonstra and Rodd 1982).

We observed significant sampling biases for long-tailed shrews, western harvest mice, white-footed and prairie deer mice, meadow voles, and jumping mice. In the case of long-tailed shrews, Longworth traps proved to be the most effective means of capturing these small-bodied (2.5–5.0 g) species. This finding was not surprising given the fact that past studies on shrew population ecology have relied exclusively on Longworths (e.g., Hawes 1977, Pernetta 1977, Churchfield 1980). Lambin and MacKinnon (1997) also noted that the capture mechanism of Longworths was sensitive to masses as low as 5.0 g. However, results from the second year of this study also indicated a shift in success rates to small Sherman traps and suggested that live traps may be as effective as pitfalls in capturing shrews, as reported by Whittaker and Feldhammer (2000). This result has important implications as conventional live traps often are viewed as an inefficient method of sampling shrews. It should also be noted, however, that because of the configuration of the trapping grid, pitfalls were deployed at relatively low densities without drift fences. As drift fences generally increases pitfall trap success (Kalko and Handley 1993), their omission may have underestimated pitfall trap success. Moreover, differences in vegetation type (dry versus wet prairie) also could conceivably affect the relative efficacy of pitfalls and other conventional trap types and therefore trap success across sites. Although there is no a priori reason to suspect that the relative efficacy of different trap types is likely to be affected by vegetation, it might be interesting in future studies to test for these effects.

Meadow vole capture rates were higher in large Sherman traps over both years of the study, whereas Longworth traps consistently captured lower numbers of voles, indicating that these traps were poor at capturing microtine rodents. Previous studies have shown that Longworths alone inadequately enumerate adult individuals in the population (Boonstra and Krebs 1978, Beacham and Krebs 1980,). Several biases have been recorded for Longworth traps (Boonstra and Krebs 1978), including variation in treadle sensitivity leading to a positive bias in prairie deer mice captures (Grant 1970) and a failure to capture larger, heavier voles (Boonstra and Rodd 1982). This positive bias in white-footed and prairie deer mouse captures, however, was not observed as these mice showed greater capture rates in Sherman traps in both years and a negative association with Longworth traps in the second year of the present study. Interestingly, western harvest mice, which are among the smallest mice, were captured more frequently in small Sherman traps than in either of the other trap alternatives, suggesting that the smaller size of these traps and their presumed greater sensitivity affected trap-type success. Finally, the negative bias observed in jumping mice toward Longworth traps is not at all surprising given the narrow entrance tunnel of Longworth traps. The differences in patterns of trap success between years could be attributable to a number of factors, the 2 most plausible being either: 1) differences among sites or environmental effects between years or 2) differences in the age and wear of the Sherman traps used. Sherman traps employed in the first year of the study had already been used for several seasons and were replaced by new traps in the second year of the study. Longworth traps by comparison were ~30 years of age so that any differences between years would have been negligible. While there were no differences in total number of animals captured between years, results indicated that long-tailed shrew capture success was much higher when new, small Sherman traps were deployed in the second year. Similarly, white-footed/prairie deer mouse captures were greater in large Sherman traps in the second but not first year of study, although small Sherman traps also captured more white-footed or prairie deer mice than other traps in the first round of study. Although comparison of trap-type effectiveness between years is necessarily limited by the fact that these comparisons were not carried out in parallel, the strong shift in capture rates between years suggests that trap age may be an important consideration and also can lead to potentially biased estimates of species capture rates. An additional caveat in our data set was that differences in the rate of recapture between trap types could conceivably differ from initial capture rates, as was observed for meadow voles in the second year of the study. Although the present study focused on differential capture rates for first-time captures only, it was possible that high rates of recapture in one trap type relative to another could influence trap type availability. Given the high numbers of traps used in this study and the small areas under study, this issue was likely to be a problem only in areas where animal abundance was very high.

Trap mortality rates also were clearly non-uniform between trap types, although mortality was heavily skewed toward shrews. Although community diversity estimates between trap types were largely comparable, community similarity indices indicated differences in overall species capture rates between trap types. Community similarity estimates were most dissimilar between Longworth and Sherman traps, indicating that these 2 trap types were non-interchangeable.

Conclusions

The following observations can be drawn from this study: 1) small Sherman traps captured the most animals and may be the most effective trap type for smaller-bodied animals; 2) in the absence of drift fencing, pitfall traps do not necessarily capture more shrews than conventional live traps; 3) Longworth and Sherman traps exhibited species-specific differences in capture rates and when used in combination are more likely to diminish overall bias; 4) trap age may affect relative capture rates; and 5) although species diversity indices are comparable between trap types, proportional abundance of each species may differ between trap types.

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