William C. McComb, Department of Forest Science, Oregon State University, Corvallis, Oregon 97331

Robert G. Anthony, Oregon Cooperative Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331

and

Kevin McGarigal, Department of Forest Science, Oregon State University, Corvallis, Oregon 97331

Differential Vulnerability of Small Mammals and Amphibians to Two Trap Types and Two Trap Baits in Pacific Northwest Forests

Abstract

A variety of sampling techniques are available to sample small mammals and amphibians, but an assessment of the least biased method to sample species assemblages is necessary to adequately describe community structure. We compared capture rates of small mammals and amphibians between pitfall and Museum Special traps in six mature forest stands in the central Oregon Coast Range in the spring, 1988. Fewer small mammal and amphibian species were caught with Museum Special traps than with pitfalls. Townsend's chipmunks (*Tamias townsendii*) and deer mice (*Peromyscus maniculatus*) were more vulnerable to capture in Museum Specials than in pitfalls. Pacific giant salamanders (*Dicamptodon ensatus*) and western red-backed salamanders (*Plethodon vehiculum*) were captured exclusively in pitfalls. Shrew-moles (*Neurotrichus gibbsii*), Pacific water shrews (*Sorex benderii*), Trowbridge's shrews (*S. trowbridgii*), and Pacific shrews (*S. pacificus*) were more vulnerable to pitfall than Museum Special capture. Western red-backed salamanders, shrew-moles, Trowbridge's shrews, and western jumping mice (*Zapus trinotatus*) were more vulnerable to capture in pitfalls with water present than to capture in dry pitfalls. Townsend's chipmunks were more vulnerable to capture by Museum Specials baited with peanut butter than baited with meat paste. Pitfalls partially filled with water and Museum Specials baited with peanut butter were the most effective methods tested.

Introduction

There are many established methods for trapping small mammals and amphibians. Comparisons of captures among pitfalls, snap traps, and live traps suggest that no one technique is appropriate for all species, and that results vary geographically (Bury and Corn 1987, Block *et al.* 1988, Szaro *et al.* 1988, Taylor *et al.* 1988). Several studies indicated that amphibians and Soricid mammals are more vulnerable to capture in pitfall traps than in Museum Special snap traps (Brown 1967, Williams and Braun 1983, Bury and Corn 1987, Taylor *et al.* 1988). Bury and Corn (1987) and Taylor *et al.* (1988) suggested that pitfalls were superior to Museum Specials in capturing many small mammal and amphibian species in forests of western Oregon and Washington. Bury and Corn (1987) suggested that a combination of pitfalls and Museum Specials were necessary to fully sample small mammal communities in these forests. However, Bury and Corn (1987) and Taylor *et al.* (1988) specifically excluded riparian areas from their study sites, and their comparison of Museum Specials with pitfalls was not paired in time nor space within each forest stand. Williams and Braun (1983) compared pitfalls with Museum Specials in riparian and upland areas of northern California, but their study was not replicated and their number of trap nights (TN) with Museum Specials was small (n = 500).

Pitfalls have been used in a variety of ways to capture and sample small mammals and amphibians. Williams and Braun (1983) and Bury and Corn (1987) tested several pitfall array designs and concluded that pitfalls without drift fences were as effective at sampling mammals as pitfalls with drift fences when three times as many single pitfalls were used. These authors and Pankowoski (1979) used pitfalls as kill traps (through adding water or accumulation of precipitation), whereas others (Brown 1967, Boonstra and Krebs 1978) have used dry pitfalls as live traps. The degree to which water in pitfalls influences captures of small mammals and amphibians and the comparative effectiveness of Museum Specials and pitfalls without drift fences has, to our knowledge, not been investigated in a replicated, experimental design.

Museum Specials have been criticized as being less effective than pitfalls for trapping Soricids. However, West (1985) demonstrated that the new model of Museum Special (with plastic treadles) was more effective at capturing Soricids than the old model. Thus, we wished to determine if pitfalls were more effective at capturing Soricids than the new Museum Special. Further, most previous investigators (e.g., Williams and Braun 1983, Taylor *et al.* 1988) used peanut butter and oats for bait. Soricids are carnivorous, so we compared the effectiveness of a bait made of meat paste with peanut butter.

Our null hypotheses were: 1) capture rates for small mammal and amphibian species would not differ between pitfalls and new Museum Specials; 2) capture rates for small mammal and amphibian species would not differ between pitfalls with water and pitfalls without water, and 3) capture rates for small mammal species would not differ between Museum Specials baited with peanut butter and Museum Specials baited with meat paste.

Methods

The study was located in the Drift Creek watershed, Lincoln County, Oregon (Figure 1). We sampled six unmanaged, mature forest stands which originated following extensive fires in the mid-1800's. Stands were characteristic of the western hemlock (*Tsuga heterophylla*) vegetation zone of the Oregon Coast Ranges (Franklin and Dyrness 1973). Overstory vegetation varied among sites but was dominated by Douglas-fir (*Pseudotsuga menziesii*) and red alder (*Alnus rubra*); other tree species included western hemlock, western redcedar (*Thuja plicata*), and bigleaf maple (*Acer macrophyllum*). Understory vegetation was patchily distributed and dominated by salmonberry (*Rubus spectabilis*), swordfern (*Polystichum munitum*), vine maple (*Acer circinatum*), salal (*Gaultheria shallon*), Oregon grape (*Berberis nervosa*), and huckleberries (*Vaccinium* spp.).

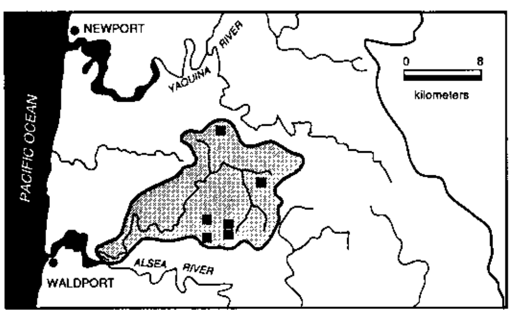

Figure 1. Location of study areas, Lincoln County, Oregon.

We established two 700-m transects in each stand: one along a second- or third-order stream and another 400 m upslope and parallel to the streamside transect. Two 400-m transriparian transects extended from the streamside transect to the upslope transect. We placed pitfall stations at 100-m intervals along the upslope and streamside transects and at 50-m intervals along the transriparian transects for a total of 30 stations per stand. At each station we subjectively located two pitfalls within 5 m of the station. Each pitfall was set level with the surface of the ground. Pitfalls were set adjacent to logs (63%), slope breaks (19%), in slash (11%) or adjacent to rocks (3%). Logs adjacent to pitfalls ranged from 1 to 20 m in length and were distributed among large (>49 cm, 46%), medium (20-49 cm, 32%), and small (<19 cm, 23%) diameters.

Pitfalls were made of two #10 tin cans (36 cm deep and 15 cm in diameter) held together with duct tape (Corn and Bury 1990). All pitfalls had 3-4 drainholes about 4 cm from the bottom to keep the traps from filling to the top with water which could allow animals to escape. Half of the pitfalls had a drain hole in the bottom to keep the trap free of water during sampling. One pitfall with a drain hole (dry pitfall) and one without a drain hole (wet pitfall) was set at each station. However, drain holes in the bottom of pitfalls were only marginally successful in keeping pitfalls dry. As a result, sampling intensity with wet pitfalls was consistently higher (1246-1704 TN/stand) among stands than dry pitfalls (96-554 TN/stand). Comparisons of community structure between the two types of pitfalls were not possible because of unequal sampling intensities. No bait was used in pitfalls.

We placed snap-trap stations at 20-m intervals along the upslope and riparian transects and at 10-m intervals along the transriparian transects for a total of 150 stations per stand. We subjectively located two Museum Special traps of the new design (with plastic treadles) within 2 m of each snap trap station. One Museum Special was baited with peanut butter and rolled oats and one was baited with meat paste and rolled oats. The meat paste consisted of a mixture of liverwurst and vegetable oil. Traps were set adjacent to or under some form of natural cover, typically along natural runways. Traps were set for 5 consecutive days in each stand and they were checked and rebaited daily.

We sampled stands between 24 April and 28 June 1988 in random order. Sampling was initiated in a new stand every seven days for a total of six weeks. Within each stand, we set and checked Museum Specials daily during the first five sampling days: the pitfalls were opened and checked weekly for 30 consecutive days. As a result of staggered sampling periods, Museum Special sampling was completed on 2 June (9,000 TN), while pitfall sampling was not completed until 28 June (10,800 TN). Precipitation data collected at Tidewater, OR, within 4-12 km of the study sites indicated that, over the 30-day sampling period in each stand, there was an average of 15 days with measurable rain per stand per 30 days (range = 10-19). Precipitation per stand per 30 days averaged 21 cm (range = 8-27 cm).

We calculated captures per 1,000 TN for each species by trap type within each stand. For each species, we compared capture rates between trap types, pitfalls with and without water, and snap trap baits with a Wilcoxon sign-rank test. Each stand was considered an independent observation (n = 6) and only species with >20 captures were included in statistical analyses.

To assess if logs, slope breaks, and rocks act as natural drift fences, we compared lengths of these features at pitfalls that captured a species with those that did not capture that species with Student's *t*-test. To determine if pitfalls adjacent to logs were more effective than pitfalls adjacent to other features, we compared captures along logs vs. along other features with Pearson's chi-square using Yates correction for small samples.

Because investigators often use trap results to compare community structure between or among habitats, we compared estimates of Shannon-Weaver species diversity ($H' = - p_i \log p_i$), equitability ($E = H'_{observed}/H'_{max}$), and richness (number of species) (Brower and Zar 1984) between pitfalls and Museum Specials using a Wilcoxon sign-rank test. We also calculated percent community similarity (PS) between sampling methods on each site to illustrate any biases in estimates of community composition between techniques. Percent similarity was defined as the sum over species of the lowest percentage of contribution of each species to either community (Brower and Zar 1984).

Results and Discussion

Pitfalls vs. Museum Specials

Pitfalls were more effective than Museum Specials in sampling amphibians (Table 1). Only one tailed frog (*Ascaphus truei*) and six rough-skinned newts (*Taricha granulosa*) were captured in Museum Specials. In contrast, 245 individuals representing eight species of amphibians were captured in pitfalls (Table 1). Most in low numbers, probably because sampling extended into late June when surface activity is reduced by lack of precipitation.

For most species of small mammals that were effectively sampled in this study (>20 captures), pitfalls were more effective than Museum Specials. Total number of individuals captured and species richness were greater in pitfalls than in Museum Specials (Table 1). Pacific shrews, Pacific water shrews, Trowbridge's shrews, and shrew-moles were captured more frequently in pitfalls than in Museum Specials. Despite the increased propensity for the new style of Museum Special to capture Soricids (West 1985), pitfalls were still more effective in sampling this group than the new style of Museum Specials. One dusky-footed woodrat (*Neotoma fuscipes*) was captured in a Museum Special. Deer mice and Townsend's chipmunks were also captured most frequently in Museum Specials. Estimates of small mammal species equitability was higher in the Museum Special sample than in the pitfall sample (Table 1), largely because of the reduced number of Soricids, especially Trowbridge's shrews, in the Museum Special sample. Pitfalls and Museum Specials produced dissimilar estimates of small-mammal community structure (PS = 42%) due to sampling bias in the two trap types.

Pacific jumping mice were less likely to be caught in pitfalls set along logs (observed = 53, expected = 67) than along rocks, slash, slope breaks or in the open (chi-square = 7.28, df = 1, p = 0.010). California red-backed voles (*Clethrionomys californicus*) were caught in pitfalls adjacent to features that were longer (5.0 m, SE = 0.4, n = 79) than features at pitfalls that did not capture them (3.8 m, SE = 0.3, n = 174, p = 0.015). Hence, the use of pitfalls to compare relative abundances of jumping mice and California red-backed voles among stand types should be standardized with respect to placement of pitfalls adjacent to logs. Other species were captured as expected in relation to forest floor features adjacent to traps.

Pitfalls With and Without Water

Pitfalls with water were more effective than dry pitfalls in sampling amphibians. Although total

TABLE 1. Average captures per 1,000 trap nights (TN) in pitfalls (10,800 TN) and Museum Specials (9,000 TN), in six sub-basins of the Drift Creek Basin, Lincoln County, Oregon, April-June 1988 (standard errors in parentheses).

Species	Pitfall (n = 6)	Museum Special (n = 6)	p[1]
Amphibians			
Ascaphus truei	3.6(0.7)	0.1(0.1)	0.036
Dicamptodon ensatus	1.9(0.3)	0.0(0.0)	0.036
Plethodon vehiculum	3.4(1.4)	0.0(0.0)	0.036
Number of individuals[2]	22.3(3.9)	0.8(0.5)	0.036
Number of species	6.3(0.4)	0.7(0.3)	0.036
Mammals			
Clethrionomys californicus	11.7(2.5)	11.2(2.2)	0.834
Microtus oregoni	1.0(0.6)	1.5(0.6)	1.000
Neurotrichus gibbsii	3.9(0.7)	0.1(0.1)	0.036
Peromyscus maniculatus	2.4(1.4)	21.9(7.8)	0.036
Sorex benderii	8.8(1.1)	1.1(0.4)	0.036
Sorex pacificus	17.2(2.2)	4.1(0.9)	0.036
Sorex trowbridgii	85.6(7.3)	10.2(1.9)	0.036
Tamias townsendii	0.0(0.0)	6.2(1.1)	0.036
Zapus trinotatus	10.0(2.3)	3.1(1.0)	0.059
Number of individuals[3]	247.3(27.7)	90.7(12.7)	0.036
Number of species	11.3(0.3)	8.8(0.3)	0.036
Diversity (H')	0.60(0.03)	0.73(0.05)	0.093
Equitability	0.57(0.02)	0.82(0.03)	0.036
Community similarity (%)	41.7(5.3)		

[1]Wilcoxon Sign-Rank test.

[2]Includes species captured in pitfalls (P), Museum Specials (M) or both (B): *Aneides ferreus* (P), *Ensatina eschscholtzi* (P), *Plethodon dunni* (P), *Rana aurora* (P), *Rhyacotriton olympicus* (P), and *Taricha granulosa* (B).

[3]Includes species captured in pitfalls (P), Museum Specials (M) or both (B): *Aplodontia rufum* (P), *Microtus longicaudus* (B), *Mustela erminea* (P), *Neotoma fuscipes* (M), *Phenacomys albipes* (B), *Phenacomys longicaudus* (P), *Scapanus orianus* (P), *S. townsendii* (P), *Sorex vagrans* (P), and *Thomomys mazama* (P).

number of individuals captured was slightly higher in wet than in dry pitfalls, we were able to detect statistically significant differences in capture rates between dry and wet pitfalls only for western red-backed salamanders (Table 2). Water in pitfalls may attract some amphibians, especially in upslope areas. Therefore, we compared capture rates between wet and dry pitfalls for three amphibian species at stations >200 m from permanent water. Tailed frogs were captured exclusively in wet pitfalls (2.9/1000 TN, SE = 0.7, p = 0.0360) on these upland sites. Pacific giant salamanders (wet = 2.7/1000 TN, SE = 0.9; dry = 0.9, SE = 0.9) and western red-backed salamanders (wet = 3.8/1000 TN, SE = 2.2; dry = 0.8/1000 TN, SE = 0.8) were captured more frequently in wet pitfalls on upland sites, but these differences were not significant (p = 0.180 and 0.090, respectively).

Overall capture rates for small mammals were higher in wet than in dry pitfalls; this difference was significant for shrew-moles, Trowbridge's shrews, and Pacific jumping mice (Table 2). Shrew-moles were caught exclusively in pitfalls with water. Only Oregon voles (*Microtus oregoni*) were captured more frequently in dry than in wet pitfalls, yet even dry pitfalls captured as many or more Soricids and jumping mice per 1000 TN as Museum Specials.

Water in pitfalls likely reduces the chances of escape for small mammals capable of leaping out of dry pitfalls, which may explain why jumping mice were captured less often in dry pitfalls. Dry pitfalls seem to have the potential for capturing most small mammal species alive and could serve as an effective live-trapping method. Shrew-moles may be missed in dry pitfall sampling and more pitfalls may be needed to compensate for reduced capture rates of other species.

Peanut Butter vs. Meat Paste

Overall, Museum Specials baited with peanut butter captured more individual mammals than traps baited with meat paste, although Townsend's chipmunk was the only species captured significantly more with peanut butter (Table 3). No species

TABLE 2. Average captures per 1,000 trap nights (TN) in pitfalls with (8,451 TN) and without (2,349 TN) water, in six sub-basins of the Drift Creek Basin, Lincoln County, Oregon, April-June 1988 (SE in parentheses).

Species	Water (n = 6)	Dry (n = 6)	p[1]
Amphibians			
Ascaphus truei	4.1(0.8)	1.8(1.0)	0.096
Dicamptodon ensatus	2.1(0.7)	2.5(1.6)	0.402
Plethodon vehiculum	3.7(1.4)	1.5(1.0)	0.036
Number of individuals[2]	13.5(2.4)	6.7(1.6)	0.094
Mammals			
Clethrionomys californicus	13.3(3.0)	7.4(3.0)	0.208
Microtus oregoni	0.7(0.6)	2.3(1.3)	0.201
Neurotrichus gibbsii	4.5(0.7)	0.0(0.0)	0.036
Peromyscus maniculatus	3.0(1.7)	2.6(1.8)	0.855
Sorex benderii	8.5(1.7)	4.8(2.7)	0.529
Sorex pacificus	17.4(2.7)	10.0(2.5)	0.142
Sorex trowbridgii	93.7(7.5)	41.8(10.3)	0.036
Zapus trinotatus	11.9(2.7)	2.9(1.7)	0.036
Number of individuals[2]	158.3(12.9)	74.1(10.2)	0.036

[1]Wilcoxon Sign-Rank test.

[2]Includes species captured in pitfalls (W), dry pitfalls (D), or both (B): *Aneides ferreus* (B), *Ensatina eschscholtzi* (W), *Plethodon dunni* (B), *Rana aurora* (W), *Rhyacotriton olympicus* (B), and *Taricha granulosa* (B).

[3]Includes species captured in pitfalls with water (W), dry pitfalls (D), or both (B): *Aplodontia rufum* (B), *Microtus longicaudus* (W), *Mustela erminea* (W), *Phenacomys albipes* (W), *Phenacomys longicaudus* (W), *Scapanus orianus* (B), *S. townsendii* (W), *Sorex vagrans* (B), and *Thomomys mazama* (W).

TABLE 3. Average captures per 1,000 trap nights (TN) in Museum Specials using peanut butter (4,500 TN) and meat paste (4,500 TN) as baits, in six sub-basins of the Drift Creek Basin, Lincoln County, Oregon, April-June 1988. (SE in parentheses).

Species	Peanut Butter (n = 6)	Meat Paste (n = 6)	p[1]
Sorex benderii	0.7(0.5)	0.9(0.4)	0.893
Sorex pacificus	1.8(0.6)	2.9(0.6)	0.182
Sorex trowbridgii	5.1(0.9)	4.4(1.7)	0.529
Clethrionomys californicus	5.8(1.9)	3.3(0.9)	0.225
Microtus oregoni	1.8(1.1)	0.7(0.3)	0.273
Peromyscus maniculatus	15.1(5.7)	7.5(4.4)	0.059
Tamias townsendii	5.8(1.3)	1.8(0.6)	0.036
Zapus trinotatus	3.1(1.3)	1.6(0.6)	0.215
Number of individuals[2]	57.2(6.3)	33.5(6.9)	0.036
Number of species	7.3(0.4)	7.5(0.3)	0.855
Diversity (H')	0.69(0.04)	0.71(0.04)	0.529
Equitability	0.80(0.04)	0.82(0.04)	0.675
Community similarity (%)	75.6(3.4)		

[1]Wilcoxon Sign-Rank test.

[2]Includes species captured with peanut butter (P) or both baits (B): *Phenacomys albipes* (B), *Microtus longicaudus* (B), and *Neotoma fuscipes* (P).

preferred the meat paste. Estimates of community structure were quite similar (PS = 75.6%) (Table 3). Differences in captures of mammals did not seem to be a result of the meat paste simply being washed away sooner during rainy periods. The average difference in captures of mammals per day between bait types (paired *t*) did not differ significantly between days with rain during the previous 24 hours (5.4, SE = 1.1, n = 17) and days without rain during the previous 24 hours (3.9, SE = 0.9, n = 15, p = 0.28). Further, the difference in captures of mammals per day between bait types was not associated (Pearson correlation) with the amount of precipitation during the previous 24 hours (r = 0.19, p = 0.30).

Conclusions

Our evidence suggests that a combination of techniques that include pitfall and Museum Special sampling would be most effective to estimate presence and abundance of most small mammal and amphibian species in mature forest including riparian areas. In this study, pitfalls were successful in capturing more species and more individuals of most species than were Museum Specials. Museum Specials are needed only because pitfalls do not effectively sample deer mice and Townsend's chipmunks, two common species (Fig. 2). If only one type of trap is used, then pitfall sampling would be most effective, particularly for the less common species (e.g., some of the Soricids). Also, pitfalls with water were more effective in capturing most small mammal and amphibian species than dry pitfalls; pitfalls with water should be considered the trap of choice for sampling amphibians, Soricids, and jumping mice. But pitfall placement was much more labor intensive than snap-trap placement and maintenance.

If snap trapping is the chosen sampling method, then Museum Specials baited with peanut butter and oats would be simpler, cheaper, and generally more effective than traps baited with meat paste and oats. Furthermore, peanut butter would be the preferred bait for sampling Townsend's chipmunks. Given West's (1985) finding that the new design of Museum Special may be less likely to capture chipmunks than the old design, then the old design baited with peanut butter may be the best option for sampling this species.

Not surprisingly, no trap type or trap bait adequately sampled all terrestrial small mammal and amphibian species present in this study. We suspect, for example, that Olympic salamanders (*Rhyacotriton olympicus*) and red-tree voles (*Phenacomys longicaudus*) were likely more common than our estimates indicated. All sampling methods were biased for or against some species, consequently estimates of community structure vary depending on the combination of techniques used. Based on our results, the use of pitfalls with water and Museum Specials baited with peanut butter, in combination with time-constrained searches and aquatic searches for more cryptic forms (e.g., Olympic salamanders) may provide the least biased estimate of terrestrial small-mammal and amphibian community structure. The combination of pitfalls with water and Museum Specials with peanut butter effectively sampled a broader range of small mammals than either technique individually (Fig. 2). The technique chosen obviously influences estimates of community structure because of inherent biases in any one technique. Indices to community structure are not comparable among data sets unless data sets can be combined in an unbiased and objective manner. Further, habitat relationships derived from different sampling techniques may vary among techniques (Taylor *et al.* 1988), so use of the most effective capture technique for each species is recommended to reduce this bias.

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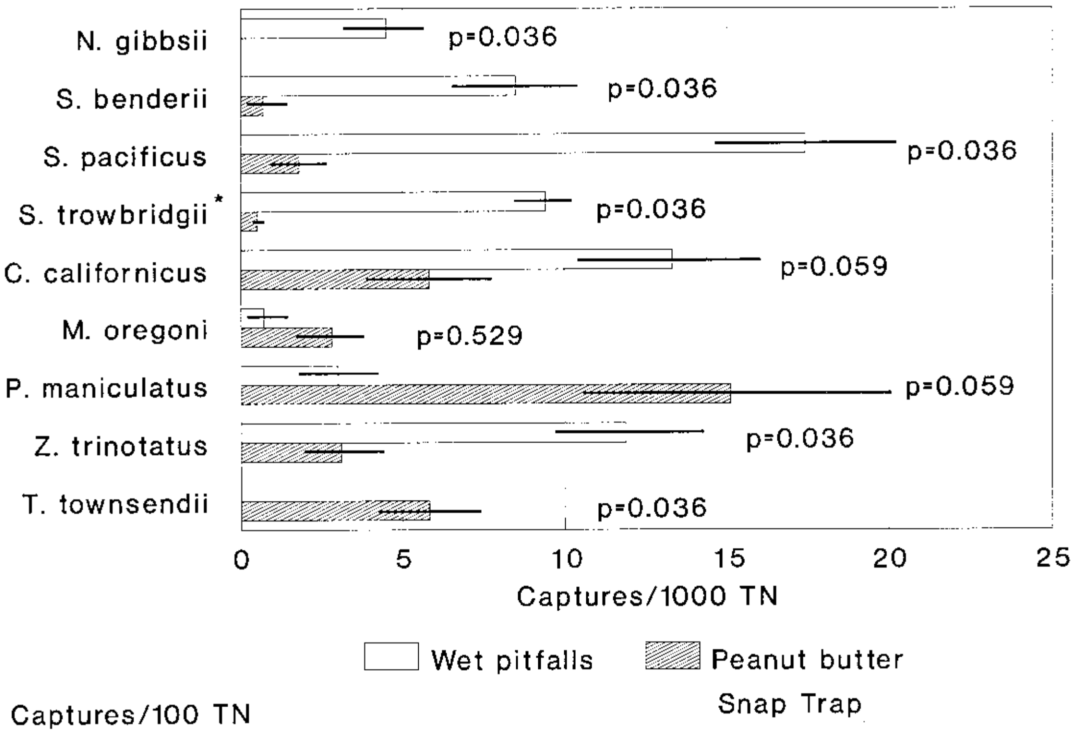

Figure 2. Captures/1000 trap nights of small mammals using pitfalls with water compared to Museum Specials baited with peanut butter in six sub-basins of the Drift Creek Basin, Lincoln County, Oregon, 1988. Standard errors indicated by bars. *S. trowbridgii* are in captures/100 trap nights. Probability values are associated with *a posteriori* comparisons using Wilcoxon Sign-Rank test.

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