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AN EVALUATION OF 2 ACTIVITY INDICATORS FOR USE IN MOUNTAIN BEAVER BURROW SYSTEMS

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Mountain beavers (*Aplodontia rufa*) cause extensive damage to coniferous seedlings and saplings in reforestation units. Currently, it is estimated that 121,500 ha are affected by mountain beaver damage (Campbell and Evans 1988). Mountain beavers are fossorial and usually solitary (Campbell and Evans 1984, Godin 1964). Their burrow systems are comprised of an extensive network of irregular tunnels just below the ground surface with many entrances and roof openings (Godin 1964). Although they do not repair roof openings, mountain beavers keep their tunnels clear by pushing material out of the openings (Godin 1964). Therefore, an index of activity for their burrow systems could have widespread applicability for research and evaluation of control programs, because the activity in a burrow system should reflect the activity (well being) of its occupant. Herein, we describe 2 indirect methods for assessing mountain beaver activity in their burrow systems.

METHODS

Construction and Placement of the Activity Indicators

We tested bundles of sword fern (*Polystichum munitum*) as indicators of mountain beaver activity in a burrow system. Mountain beavers use sword fern as food and nesting material (Godin 1964). Other mammals may occupy a mountain beaver's burrow; however, a search of the literature indicated that apparently none use sword fern. Three freshly gathered sword fern tips 15–20 cm in length were bundled together with plastic flagging ribbon (2.5-cm-wide blue polyethelene). The plastic flagging distinguished the activity indicator from naturally occurring piles of sword fern found in mountain beaver burrows or elsewhere. The sword fern bundles were kept cool and used within 3 or 4 days. For testing purposes, 1 bundle was placed at the entrance of each burrow, with the basal end of each bundle placed inward toward the burrow's interior. We considered a missing sword fern bundle to indicate activity in the burrow.

A second activity indicator, hereafter termed a "knockdown," was constructed by stapling a 5- × 9-cm waterproof paper tab to a 0.5- × 15-cm plastic twist-tie. The twist-tie was then stapled in line to a wooden popsicle or craft stick (length = 11 cm). The knockdown was installed in the middle of a burrow entrance by forcing the entire popsicle stick into the burrow floor, exposing only the twist-tie and attached paper tab. The tab was then positioned upright to block the center of the burrow. We considered a knocked down or missing tab to indicate activity in the burrow. To use both indicators simultaneously in the same burrow, we positioned a knockdown and then placed the sword fern beside the tab of the knockdown.

We located and marked 5 well-spaced (>1 m apart) and apparently active (indicated by clean entrances, relatively free of debris and spider webs) mountain beaver burrows in a burrow system (geographically clustered and interconnected burrows). To be included in the study, each set of 5 burrows had to be within a 0.027-ha circular plot (radius = 9.3 m). All such systems were separated by a minimum of 60 m. Activity indicators were placed in each burrow 5–7 nights and then read for activity. If activity was recorded by activity indicators in ≥1 burrow within a system, then the complete burrow system was designated as active.

Measuring the Adequacy of the Activity Indicators

Although we know of no other animal that would remove bundles of sword fern in the burrows, it is possible that other animals which use mountain beaver burrows could indicate activity with the knockdowns. To numerically describe the adequacy of our activity indicators, we collected data and calculated 3 measures commonly used to describe medical tests (Galen and Gambino 1975, Fleiss 1981) because activity indicators can be considered diagnostic tests for mountain beaver activity. First, we calculated sensitivity, the proportion of burrow systems inhabited by a live mountain beaver that resulted in a positive reading using the activity indicator. We also calculated specificity, the proportion of unoccupied burrow systems that resulted in a negative reading by the activity indicator. And lastly we calculated efficiency, the proportion of correct results for occupied and unoccupied burrow systems combined.

We conducted 4 experiments in southwest Washington in winter and spring of 1988 to provide information on the sensitivity, specificity, and efficiency of sword fern as an indicator of mountain beaver activity. Knockdowns also were evaluated in the final 2 of these experiments. Because mountain beavers were monitored with radiotelemetry (with mortality signals) during these experiments, our data also provided a qualitative comparison of sensitivity of the activity indicators with that of radiotelemetry for assessing mountain beaver activity.

Experiment 1.—This experiment (Jan–Feb 1988) examined the sensitivity of sword fern. Twenty mountain beavers were livetrapped, fitted with radio collars, and released back into their burrow systems. During the time the animals were monitored telemetrically, the burrow systems were evaluated for activity using sword fern bundles.

Experiment 2.—In this experiment (Jan–Feb 1988) we examined both sensitivity and specificity of sword fern as an activity indicator. Twenty-five mountain beavers were livetrapped, fitted with radio collars, and returned to their burrow systems. The activity of the animals was monitored by radiotelemetry for at least 1 week, during which time bundles of sword fern were placed in burrow entrances. Mountain beavers were then baited using 0.29% strychnine paste on sword fern as bait, and activity was monitored by radiotelemetry and with sword fern.

Experiment 3.—Thirty-one mountain beavers were livetrapped (Mar–Apr 1988), fitted with radio collars, and their subsequent activity was simultaneously assessed using sword fern and knockdown activity indicators, thereby permitting evaluation of the sensitivity of both indicators.

Experiment 4.—Twenty-seven inactive burrow systems, not previously used in this study, were tested for activity using both indicators (Mar–Apr 1988). Each system originally was occupied by a mountain beaver that had been fitted with a radio collar. Of these, 18 were killed using strychnine baits, 3 were killed by other causes such as predators, 4 vacated their systems after having their nests destroyed, and the other 2 vacated their systems for unknown reasons.

RESULTS

Experiment 1.—Each of the 20 tested burrow systems with a live mountain beaver had a positive activity reading using the sword fern activity indicator. Thus, sensitivity of sword fern as an activity indicator was 100% for this sample.

Experiment 2.—The sword fern correctly indicated activity in 24 of 24 burrow systems prior to strychnine treatment, again providing a sensitivity of 100%. Data from 1 burrow system was excluded because the fate of its occupant could not be verified. One other system was vacated by its occupant, but invaded by the nearest neighbor (not radio-collared). We included this system in our analysis, and removed the individual by trapping during the strychnine treatment period.

After treatment with strychnine baits, 21 of the animals with radio collars died (including 1 killed by a coyote and the trapped animal) and 3 others vacated the area. The sword fern indicated no activity in 22 of the systems, but indicated positive activity in the other 2. For these 2 systems, we found that even though the original occupants were killed, the systems were rapidly reinvaded by other mountain beavers (which were later trapped). Thus, the sword fern correctly identified the status of all 24 systems. The specificity for this sample was thus 100% (22/22), as was the sensitivity (2/2).

Experiment 3.—Each of the 31 active burrow systems was correctly identified as such by both the sword fern and knockdown activity indicators (100% sensitivity).

Experiment 4.—Of the 27 burrow systems from which the radio-collared occupant had been removed, 1 was reinvaded. Thus, 26 burrow systems were available for testing specificity. For the 26 burrow systems without mountain beaver, the sword fern correctly indicated that all 26 were inactive (100% specificity), but the knockdown indicated inactivity for only 23 of the 26 systems (88% specificity). Both the sword fern and knockdown indicators correctly identified the reinvaded system as active.

In each of the 3 burrow systems where the knockdown indicated activity (presumably due to another species of animal in the system), only 1 of the 5 knockdowns was down. In contrast, 3 or more knockdowns usually were affected in a system containing mountain beavers. When another species passes through a mountain beaver burrow system, it usually affects only 1 knockdown. However, a mountain beaver will also affect only 1 knockdown in an active system 6% of the time (based on all of our data).

Combined Results.—We combined the results of the 4 experiments to get an overview of the sensitivity and specificity, and to estimate efficiency for the sword fern activity indicator. We did the same for the knockdown device using the information from experiments 3 and 4.

The sword fern correctly indicated an active burrow system in 78 of 78 trials. In 48 of 48 trials it correctly indicated inactivity. Thus, over the 4 experiments the sword fern had 100% sensitivity, specificity, and efficiency.

In experiments 3 and 4, the knockdown correctly indicated activity in 32 of 32 trials, and it correctly indicated activity in 23 of 26 trials. Thus, it gave the correct result in a total of 55 of 58 trials. The resulting sensitivity, specificity, and efficiency were, respectively, 100%, 88%, and 95%.

DISCUSSION

Sword fern is a highly reliable indicator of activity of mountain beavers. The sword fern bundles were invariably moved by a mountain beaver, resulting in an extremely accurate assessment of activity (high sensitivity). We have found a number of other species that use mountain beaver burrow systems, the most common of which are long-tailed weasel (*Mustela frenata*) and mink (*Mustela vison*). On rare occasions we find snowshoe hare (*Lepus americanus*) in mountain beaver burrows. We also have found incidents where opossum (*Didelphis virginiana*) and spotted skunk (*Spilogale putorius*) have been in burrows. However, we found neither information in the literature nor evidence from our field and pen tests suggesting that any of these species that use mountain beaver burrows also use sword fern. This may explain the accurate negative readings for sword fern (high specificity) that we obtained. It also adds confidence to the specificity results from experiment 2, because the toxic baits used for mountain beaver (using strychnine on sword fern as bait) are unlikely to have removed any other species that would use the burrow systems.

Sword fern appears excellently suited as an activity indicator. In pen and field tests, we have never noticed a time of year when fresh fronds were not readily accepted by mountain beaver, nor when they would be less palatable. Additionally, by attaching miniature radio transmitters to the bundles, it is possible to track transportation of materials and to locate mountain beaver nests or food caches (Campbell and Evans 1988). The only potential limitation of the technique is that fresh sword fern may not always be available during a 2–3-week period in April or May when new fronds are being formed.

Knockdowns also were highly reliable when they indicated inactivity. However, in a small percentage of cases, positive results were caused by another species that uses mountain beaver burrows. We currently are trying to develop a knockdown device that also serves as a hair collector. A sticky substance applied to the tab of the knockdown could collect hair from the animal that knocks it down. Identification of the hair collected by the knockdown would increase the specificity of the device, because we would then know if it was a mountain beaver causing the positive reading.

The sensitivities of the sword fern and the knockdown device for testing an active burrow system are both superior to that of radiotelemetry. Although mountain beavers are usually solitary, rapid reinvasion of an occupied burrow system could occur (and did in our studies). Therefore, a burrow system with a radio-collared mountain beaver from which a mortality signal is emitted may have remained active through reinvasion. Both activity indicators can detect this, but radiotelemetry may not. Telemetry works well for following the movements and fate of individual animals, whereas the activity indicators are superior for assessing whether burrow systems are occupied.

Activity indicators should be valuable tools for evaluating the efficacy of control programs. They should be applied immediately after the control program would be expected to have maximal effect, thus avoiding the possible biasing effects from rapid reinvasion. If there is a great potential for immediate reinvasion (high populations in adjacent areas) and the poison is slow or highly variable in the time it takes effect, then radiotelemetry of individual animals should be used to corroborate the results from activity indicators.

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