UTILIZING BEHAVIORAL BIOPHYSICS TO MITIGATE MORTALITY OF SNARED ENDANGERED NEWFOUNDLAND MARTEN

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In 2000, the Committee on the Status of Endangered Species in Canada (COSEWIC) identified the Newfoundland marten (*Martes americana atrata*) as an endangered species. The Newfoundland marten is a genetically distinct subpopulation of the American marten (Kyle and Strobeck 2003) that has experienced a dramatic population decline over the twentieth century. The decline of the Newfoundland marten population has been attributed to the loss of forested habitat through fire, damage by herbivorous insects, and logging; historical overtrapping; current accidental snaring and trapping mortality; disease; and combinations of these perturbations. A National Recovery Plan (Forsey et al. 1995) was created that aimed to establish 2 discrete populations on the island of Newfoundland with a minimum size of 350 animals each, with 100 satellite animals. This plan also required curtailment of anthropogenic mortality, including snaring-related, accidental mortality (Forsey et al. 1995).

Although marten trapping in Newfoundland was banned in 1934, there are approximately 26.4 million snare nights per year set for snowshoe hare (*Lepus americanus*; W. Barney, Newfoundland and Labrador Inland Fish and Wildlife Division [IFWD], unpublished data). Accidental mortality of Newfoundland marten in snares set for snowshoe hares is a serious concern, with a reported 48 marten killed since 1970. This averages to 1.45 marten killed each year, out of an estimated population of approximately 300 animals, though the unreported kill could be higher (W. Barney, IFWD, unpublished data).

To address this source of mortality as required by the National Recovery Plan, a modified hare snare mechanism was developed (Proulx et al. 1994). This modified snare design capitalized on behavioral differences between hare and marten; hare tend to pull against a snare, whereas marten tend to twist along their own longitudinal axis. The modified snare employs an anchored coil with a standard 25-gauge stainless-steel snare wire looped around the coil. When tested in a controlled setting, the modified snare was successful in retaining 100% of hares and releasing 100% of marten tested (Proulx et al. 1994). With the development of this modified snare, Modified Snare Zones were established in Newfoundland at Northwest Grand Lake, Red Indian Lake, Terra Nova, and the Charlottetown enclave. The establishment of Modified Snare Zones was intended to allow culturally important hare snaring activity to continue, while mitigating endangered marten bycatch.

The modified coil snares are believed to have mitigated some marten mortality, but some limitations exist. The modified snare requires skill and training to properly set. Many snares are improperly set, thus reducing their effectiveness at releasing marten (W. Barney, IFWD, unpublished data). Education and training programs underway in Newfoundland have increased adherence to modified snare regulations and improved correct setting rates. However, alternative approaches that are cost-comparable to standard stainless-steel wire, with similarly simple setting requirements, are necessary.

We investigated the possibility of identifying a wire with physical and metallurgical properties that would capitalize on biophysical differences

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between snowshoe hare and marten that result from species-specific behaviors and morphology. As an animal pulls against a snare, it produces tension; as an animal rotates along its own longitudinal axis within a snare, it produces torque. We hypothesized that if the tension and torque exerted by each species on a snare wire differed, a wire could be identified that would release marten but retain snowshoe hares. This would allow an important subsistence harvest to continue, while facilitating endangered species recovery. We quantified the tension and torque exerted by each of these species and tested for statistical differences between the 2, and we then tested potential wires for their ability to retain hares and release marten. We asked 2 questions: (1) Do the tension and torque generated by snared animals differ significantly between species? (2) If so, is there a wire available with sufficient ductility and tensile strength to capitalize on this difference so that ≥75% of hares captured are retained and ≥90% of marten captured are released?

Study Area

We tested snares at the Trap Effectiveness Testing Compound at the Alberta Research Council (ARC), Vegreville, Alberta. The test pen consisted of a chain link enclosure approximately 10 m × 15 m in size that contained trees, coarse woody debris, and vegetation to emulate a natural parkland/boreal environment. We live trapped snowshoe hares near Vegreville using Tomahawk® Live Traps (Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA); we live trapped marten near Robb, Alberta, using Havahart® Live Traps. To our knowledge there was no heterogeneity in trappability (Jolly and Dickson 1983) that may have biased our sample such that it was unrepresentative of the respective populations.

Methods

We used 3/64-inch 1 × 7 strand aircraft cable as the experimental snare wire. Unlike traditional snaring wires, aircraft cable does not readily deform; thus, it reliably transmitted force to the sensor. We fitted snares with a slim lock (i.e., a thin rectangular metal loop through which the snare wire was fed) to prevent the snare from opening once pulled tight. Traditional stainless-steel snowshoe hare snares are not equipped with a slim lock, but aircraft cable cannot form a snare loop; hence, a slim lock was required to facilitate capture in our experiment. We connected the snare wire to a torque/tension sensor (AMTI Force/Torque Sensor Model MC3A-1-100[FZ]-50[MZ]), fitted with a Calex Bridge Amplifier (model no. 347) to modify the excitation voltage. We bolted the sensor to the side of the test pen. It was protected with a metal shield, and we placed small logs beside the sensor/shield assembly to prevent the animal from back-torquing the snare wire. We used a Campbell Scientific CR-10× data logger to record voltage data. We videotaped all snaring events via remote camera.

We transferred snowshoe hare from holding pens to the test pen 3–4 at a time to allow individuals time (6–24 hr) to acclimate. We then set the experimental snare, and once a hare was snared, we remotely video-monitored it to ensure it did not become entangled, which would confound transmission of the force data. We recorded force and torque data from the point the snare was set until the termination of the snaring event. We terminated the experiment once the hare entered respiratory distress and movement ceased, and we then released the hare from the snare. We repeated this procedure until 10 snowshoe hares, of random gender and mass, were snared. All animal use followed Canadian Council on Animal Care Guidelines (1984, 1993, 2003).

We placed marten in the test pen one at a time. To capitalize on their exploratory behavior, we did not acclimate marten to the test pen, and we started the experiment upon their release. Termination occurred under the same criteria described for snowshoe hares. We snared 9 marten of random gender and mass.

We identified several candidate wires of differing diameter and alloy composition, based on the results of the force testing, as having potentially appropriate tensile strength and ductility to achieve our set criteria of ≥75% hare retention and ≥90% marten release. We tested hare retention in the subboreal forest of Newfoundland. We conducted 44–957 trap nights for each snare wire between October and December 2003, using solid anchor sets.

Two wires met our snowshoe hare retention criteria of ≥75%. The 6-strand wire was composed of 6 braided strands of low-carbon, steel galvanized of diameter 0.26 mm +/–0.01 mm. The 22-gauge brass wire was standard brass alloy 0.71 mm in diameter (Microwire Products, Ontario, Canada). We tested marten in each wire under simulated conditions, using the same experimental protocols as in force testing, to assess release rates and capture duration. We monitored marten for a minimum of 10 days, and a maximum of 1 month, for signs of permanent physiological damage from the snare.

Table 1. Statistical analysis of tension and torque by exerted snared marten ($n = 9$) and snowshoe hares ($n = 10$) at Vegreville, Alberta, Canada. Tests consisted of independent samples *t*-tests except where otherwise noted; results were considered significant at the $P = 0.05$ level.

Variable	Hare		Marten		Test significance
	Mean	SD	Mean	SD	(*P* value)
Average tension (kg)	0.100	0.024	0.286	0.082	<0.001
Maximum tension (kg)	1.284	0.481	2.254	0.735	0.003
Average torque (Newton meters)	0.026	0.047	0.025	0.023	0.939
Maximum torque (Newton meters)	0.078	0.113	0.134	0.168	0.034*
Mean cumulative torque (Newton meters / second)	6.236	5.466	14.173	7.140	0.014

*Mann-Whitney U test.

We applied a conversion equation developed by the force sensor manufacturer (AMTI) to convert voltage data to tension (i.e., the stress caused by a force or forces operating to extend or stretch a material, measured in kilograms [kg]) and torque (i.e., a measure of the force applied to produce rotational motion, measured in Newton-metres [N.m]). These measures were time-independent and quantified only force associated with a motion, either longitudinal (tension) or rotational (torque).

In some cases, null tension or torque data were not centered around a mean of zero as we expected, but drifted to negative linearly throughout time, possibly due to cold temperatures (<–30°C) acting on the force sensor. We calculated a linear correction factor and applied this to datasets that exhibited this anomalous drift. After these corrections, null data were centered around zero +/–0.005 kg (tension) or 0.001 Newton m (torque). We then only analyzed data from the second the animal entered the snare to the time it ceased struggling. Data possessed positive or negative tension and torque values depending on axis of travel of the wire; we converted these to absolute values to provide direction-independent force data. We calculated maximum tension (kg), average tension (kg), maximum torque (N.m), and average torque (N.m) for each animal, and we contrasted these parameters across species using independent samples *t*-tests.

Results

There were significant differences in force exerted between species. Mean tension exerted by hares was 0.1000 kg; mean tension exerted by marten was 0.2858 kg; these were significantly different ($n = 10,9$; $P < 0.001$; Table 1). Mean maximum tension exerted by hares was 1.284 kg, whereas mean maximum tension exerted by marten was 2.254 kg; these differed significantly between species ($P = 0.003$; Table 1).

Differences in torque exerted by each species were more difficult to detect. A *t*-test comparing mean maximum torques across marten and hares did not detect a significant difference ($P = 0.402$). However, mean maximum torque exerted by marten was approximately twice that of hares (0.1343 vs. 0.0783 Newton m). We believed that large variability in the datasets (Table 1), combined with low sample size, rendered the test inappropriate. Therefore, we used the nonparametric Mann-Whitney U test to detect differences in mean maximum torques. Results of this test suggested that maximum torques were significantly different between marten and hares ($P = 0.035$; Table 1).

Average torque exerted did not differ significantly across species (*t*-test; $P = 0.939$; Table 1). However, there were marked differences in observed behavior; hares tended to pull more and roll less, whereas marten exhibited heavy and sustained rolling behavior. We concluded that the 3/64-inch 1 × 7 strand aircraft cable looped back on itself when torqued and prevented accurate measurement of cumulative torque. We compensated for this by adding each absolute torque value, by second, to previous values, thus calculating effective cumulative torque. We standardized for different capture durations by dividing cumulative torque by capture time for each animal. The resultant mean cumulative torque was significantly different across species (*t*-test; $P = 0.014$; Table 1). Mean cumulative torque exerted by hares was 6.263 Newton m/sec; marten exerted 14.172 Newton m/sec, over twice the value for hares.

In the wire-testing experiments, the 6-strand wire retained 32 of 38 captured hares (84.2%); the 22 gauge brass retained 31 of 35 captured hares (88.6%). The 6-strand wire released 12 of 12 marten captured (100%). Two of these were abdominal captures; the remainder were neck captures. The 22 brass released 10 of 11 marten captured (90.9%). One of these was an abdominal capture; this animal was not able to release itself, and we terminated the experiment after 4 hours 8 minutes. One marten was captured by the thorax and did release. The remainder were neck captures. Visual inspection of marten indicated that all animals shed snare wires immediately after release or within 24 hours.

Mean time to escape for marten in the 6-strand snare was 844 seconds (SD = 721; n = 12); mean time to escape from the 22-gauge snare was 2,116 seconds (SD = 3,132; n = 10). The difference between these times was significant (t-test; n = 10,12; $P = 0.008$), indicating that the 6-strand wire released marten significantly faster than did the 22-gauge wire.

Discussion

Statistically significant differences in the amount of force exerted by snared marten and hares mirrored behavioral observations noted by Proulx et al. (1994); marten pulled harder and rolled longer when snared than did snowshoe hares, resulting in greater tension and cumulative torque exerted by marten on the snare wire. Though both wires met the criteria for ≥75% hare retention and ≥90% marten release, the 6-strand wire was most effective at quickly releasing marten, but also released a larger percentage of hares than did 22-gauge brass wire. We did not notice any external signs of damage or distress in any of the marten we tested, and all of the marten shed the wires within 24 hours of self-releasing, suggesting these snares would be suitable for releasing marten unharmed under field conditions. These snare wires are set in the same manner as traditional stainless-steel snares, and they are easier to set than are Proulx's coil-style modified snares (W. Barney, IFWD, unpublished data). They are cost-comparable to stainless steel wire (Microwire Products, Ontario, Canada), which represents considerably less expense than the approximately $0.50/unit coil device. Based on these criteria, both wires we tested could achieve the conservation objective of curtailing snaring mortality of endangered Newfoundland marten, while still permitting an effective snowshoe hare subsistence harvest.

Management Implications.—We demonstrated that in the case of snared endangered Newfoundland marten, conflicts between endangered species management and traditionally held harvest rights can be overcome—snare-induced mortality of marten can be mitigated using 22-gauge brass or 6-strand picture wire. The low cost, ease of use, and reliability suggest that these wires are more likely to be effectively used by the snaring public than current mitigation methods, thus releasing animals and reducing incidental mortality of endangered Newfoundland marten in snares set for snowshoe hares.

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