Field immobilization and use of radiocollars on long-tailed weasels

Thomas M. Gehring and Robert K. Swihart

Abstract Using radiocollars to conduct relatively long-term studies of weasels (*Mustela* spp.) is problematic because individuals shed collars frequently and because collars may induce behavioral changes. During 1998–1999, we immobilized 16 free-ranging long-tailed weasels (*Mustela frenata*) using 25-mg/kg ketamine hydrochloride and 2-mg/kg xylazine hydrochloride. Mean induction time was 2 minutes and time to first arousal averaged 26 minutes. We fitted 9 male and 6 female weasels with 6.5-g and 3.2-g tuned-loop radiocollars, respectively. Of these, we observed 5 males and 2 females in captivity under semi-natural conditions. Radiocollars did not appear to influence weasel use of burrows and coarse woody debris or compromise their ability to kill prey. In the field, 8 of 9 males and all females retained collars more than one week. Males were tracked for a mean of 62 days (range=5–158 days), whereas females were tracked for a mean of 51 days (range=8–108 days). Radiocollars did not appear to adversely affect foraging or reproduction of tagged weasels.

Key words anesthesia, handling, immobilization, ketamine hydrochloride, long-tailed weasel, *Mustela frenata,* radiotelemetry, xylazine hydrochloride

Relatively little is known of the ecology of weasels (*Mustela* spp.) as compared to other North American furbearers (Fagerstone 1987) and quantitative assessments of habitat selection and movements are lacking (DeVan 1982, King 1989). The dearth of ecological information on weasels is due partly to the difficulty in radiotagging these animals for extended periods of time. Weasels have been radiocollared by several researchers (Erlinge 1977, 1979; Pounds 1981; DeVan 1982; Erlinge and Sandell 1986; Sandell 1986; Sleeman 1987; Murphy and Dowding 1994, 1995; Jedrzejewski et al. 1995; Samson and Raymond 1998). However, radiocollared weasels in these studies were tracked for short time periods ($\bar{x}$= 15 days, range=1-91 days), mainly due to failed or shed collars.

Collar and harness transmitter attachments can be generally problematic with mustelids (Melquist and Hornocker 1979, Eagle et al. 1984, Murphy and Dowding 1995) due to their long necks and small heads (Murphy and Dowding 1994). These attachment methods can result in shed transmitters and neck abrasions or may influence the behavior of marked animals (Delattre et al. 1985). However, radiocollars have been used successfully with black-footed ferrets (*Mustela nigripes,* Biggins et al. 1985, Fagerstone et al. 1985). Melquist et al. (1981) and Eagle et al. (1984) implanted radiotransmitters in the peritoneum of mink (*M. vison*) to try to reduce transmitter loss and neck irritation. Eagle et al. (1984) suggested that implanted transmitters did not interfere with reproduction or result in excessive mortality in mink. However, transmitters implanted intraperitoneally often have a ≥50% reduction in transmitter range and require invasive, potentially stressful surgery (Anderka 1987). Animal Care and Use Committees also may restrict the implantation procedures (Anderka 1987), such as holding animals in captivity for 2-10 days following surgery.

Attaching collars or harnesses to weasels requires immobilization to ensure safety of the animal and the researcher. Weasels have been immobilized with ether (Lockie and Day 1963, King and Edgar 1977, Nams 1981, DeVan 1982, Jedrzejewski et al. 1995, Samson and Raymond 1998), phencyclidine hydrochloride (HCl) and promazine (Seal and

Authors' address: Department of Forestry & Natural Resources, Purdue University, West Lafayette, IN, 47907-1159, USA; e-mail for Gehring: tgehring@fnr.purdue.edu.

Erickson 1969, Seal et al. 1970), and ketamine HCl (Jessup 1982, Belant 1992). Ether is carcinogenic and flammable (American Society of Mammalogists 1998) and therefore an unacceptable immobilizing agent. Ketamine HCl has a wide safety margin (Jessup 1982), but can cause muscle rigidity, slight tremoring, and seizures (Seal and Kreeger 1987). Using xylazine HCl combined with ketamine HCl provides muscle relaxation (Moreland and Glaser 1985). Seal and Kreeger (1987) recommended 10-15 mg/kg of ketamine HCl in combination with one mg/kg of promazine, 0.5 mg/kg of diazepam, or 0.5 mg/kg of xylazine HCl to immobilize long-tailed weasels (*M. frenata*). Moreland and Glaser (1985) cautioned against using ketamine HCl alone or ketamine-diazepam in ferrets (*M. putorius*) due to incomplete analgesia and muscle rigidity. A dose of 25 mg/kg of ketamine HCl and 2 mg/kg of xylazine HCl provided suitable muscle relaxation and smooth recovery (Moreland and Glaser 1985).

We know of only one radiotelemetry study conducted on long-tailed weasels and it collared and tracked only 5 male long-tailed weasels for a mean of 9 days (DeVan 1982). Here, we describe immobilization of long-tailed weasels using ketamine HCl and xylazine HCl and techniques we have developed for fitting radiocollars used in the field with male and female long-tailed weasels.

Methods

During 1998-1999, we conducted research in the Indian Pine Study Area (IPSA) located in Benton, Tippecanoe, and Warren counties, west-central Indiana. Approximately 82% of the IPSA was in agricultural production (corn and soybeans are the dominant crops). Forested lands comprised approximately 16% of the area, with 11% represented as riparian and 89% identified as forest patches (Sheperd 1994). Fencerows and drainage ditches bisected agricultural fields and provided varying levels of connectivity between forest patches.

We live-trapped long-tailed weasels within woodlots, grassland patches, fencerows, and drainage ditches using Edgar live traps (King and Edgar 1977, King 1989). We used fresh, dead domestic mice and commercial lures for bait. To reduce trap-related mortality, we checked traps daily and closed trap lines during extreme cold and wet periods (i.e., $\leq 0°C$ with rain showers). Furthermore, we covered traps with woody material or vegetation and provided poly-fiber-bedding material in traps during all seasons except summer. We did not use the nest box attachment for the Edgar trap as suggested by King and Edgar (1977). We restrained captured weasels in a canvas and mesh handling bag and immobilized them via an intramuscular (IM) injection (25-gauge × 16-mm needle) of ketamine HCl and xylazine HCl. We used the dosage recommended for ferrets of 25-mg/kg ketamine HCl and 2-mg/kg xylazine HCl (Moreland and Glaser 1985). We recorded age, sex, mass (g), and body measurements (mm) for immobilized weasels and attached uniquely numbered ear tags (size 1 Monel tag, National Band and Tag Co., Newport, Ky.).

We fitted males with 6.5-g and females with 3.2-g radiocollars (SOM-2190M and SOM-2070 models, Wildlife Materials, Inc., Carbondale, Ill.). Radiocollars consisted of a 0.5-cm-wide brass collar, which served as a tuned-loop antenna. Collars were covered with heat-shrink tubing to reduce rubbing and neck irritation. Collars were secured with 2 hexagonal nuts. We used an index card folded 2 times (i.e., 4 layers or approximately 2 mm)

Radiocollars used on female (left) and male (right) long-tailed weasels.

Female long-tailed weasel with radiocollar attached.

A "slow release" method using a nest box aided in the recovery of immobilized weasels.

and approximately 0.6 cm wide to check collar fit. We obtained a proper fit when: 1) the radiocollar could be rotated around the neck, 2) the collar gap equaled the index card thickness, 3) the collar was seated in the mid-region of the neck with the transmitter positioned on the ventral surface, and 4) the radiocollar did not move freely up and down the neck.

Initially, we held a sample ($n=7$) of weasels in captivity for 5 days to observe foraging and behavioral patterns of radiocollared individuals. We held these weasels in cages (150 × 90 × 90 cm) containing a soil substrate, underground tunnels 38 mm in diameter, coarse woody debris, and a nest box with an opening 40 mm in diameter. We fed each weasel 2-5 live domestic mice twice daily and videotaped and observed each weasel for one hour daily to monitor effects of the radiocollar on its use of burrows and coarse woody debris, and on behaviors related to prey capture and handling. We defined the time to kill from the point of prey release by us to each predation event. We defined the time to subdue prey from the point when a weasel perceived the prey item through the time it needed to handle and dispatch the prey.

Prior to release, we allowed all immobilized weasels to recover in a wooden nest box (30 × 30 × 15 cm) provisioned with 2-3 dead domestic mice. Nest boxes contained ventilation holes and a sliding door. We released weasels from the nest box 2-3 hours after handling procedures by opening the sliding door. In the field, we monitored newly collared weasels via telemetry twice daily for 7 days to index the well being of animals and to quickly locate shed collars. After 7 days, we retrieved the nest box from the release site. We chose these procedures so that radiocollared weasels would have a secure environment in which to recover from anesthesia and time to acclimate to the radiocollar. Subsequently, we located radiotagged weasels daily via triangulation (Heezen and Tester 1967), using a vehicle-mounted 3-element Yagi antenna and hand-held antenna. All handling methods were conducted in accordance with Purdue Animal Care and Use Committee (PACUC) guidelines (PACUC# 98-006).

Results

We captured 16 weasels (6 adult male, 3 juvenile male, and 7 adult female) during 1998-1999. Mean mass of adult and juvenile males was 195 g (SE=8 g) and 162 g (SE=9 g), respectively, and differed significantly ($t_7=2.56$, $P=0.04$). The average mass of adult females was 111 g (SE=5 g) and was significantly less than adult males ($t_{11}=9.44$, $P<0.001$) and juvenile males ($t_8=5.60$, $P=0.001$). We did not observe any evidence of canine or facial injuries with the Edgar live traps. We observed 7 weasels (5 male, 2 female) in captivity for 5 days during 1998 (Table 1). Weasels readily occupied the nest box as a surrogate den. Radiocollars did not appear to hinder weasel use of the nest box, burrows, or coarse woody debris. Additionally, radiocollared weasels were efficient in capturing and handling prey (Table 1). Once weasels detected mice, they typically required <2 seconds to subdue mice and they cached prey in the nest box before foraging again. Weasels were not visibly compromised by the radiocollar while foraging in burrows or coarse woody debris. While in captivity, male and female weasels consumed an average 28.4% (SE=2.3%) and 37.5% (SE=2.5%) of their body mass/day, respectively.

Mean induction time for weasels ($n=16$) was 2 minutes with a range of 1-5 minutes. Time to first arousal ranged from 13-45 minutes with a mean of 26 minutes. Typically, we completed handling procedures within 20-25 minutes; thus, booster injections generally were not necessary. We allowed all weasels to recover completely in nest boxes. When released 2-3 hours after immobilization, all weasels were fully recovered. Following release, radiocollared weasels remained in the nest box or in the immediate vicinity for 1-4 days before resuming movements within their home range.

Table 1. Foraging behaviors and related activities of radiocollared long-tailed weasels (*Mustela frenata*) observed in captive trials conducted in west-central Indiana during 1998. One-hour observation trials were conducted daily over a 5-day period. All response variables are presented as means (with standard errors in parentheses) of the one-hour trials.

Weasel #	Sex	Frequency of burrow use[a] (number/hour)	Use of coarse woody debris[a] (number/hour)	Number of prey killed/ released	Time to kill[b] (minutes)	Percentage time active[c]
1M	male	7 (1)	10 (3)	3/3 (0/0)	1.3 (0.4)	38 (19)
2F	female	2 (1)	1 (1)	1/3 (1/1)	7.5 (6.5)	2 (1)
3M	male	8 (3)	5 (3)	4/4 (0/0)	1.6 (0.7)	22 (15)
4M	male	3 (1)	2 (1)	2/4 (1/1)	4.9 (2.4)	17 (12)
6F	female	5 (1)	2 (1)	2/3 (0/1)	7.6 (3.1)	8 (3)
7M	male	5 (4)	2 (1)	2/4 (1/1)	1.4 (0.4)	12 (6)
8M	male	4 (3)	2 (1)	3/4 (2/1)	0.9 (0.4)	3 (2)

[a] Recorded as number of times weasel entered burrow or coarse woody debris (CWD).

[b] The time to kill was measured for each predation event.

[c] Activity was characterized by active foraging and exploratory movements. Weasels were considered inactive when they remained in the nest box or in CWD.

flaw was remedied for subsequent collars. Females were tracked for a mean of 51 days (range=8-108 days, Table 2), whereas males were tracked for a mean of 62 days (range=5-158 days, Table 3). Transmitter range was 400-800 m for females and 800-1,600 m for males using a vehicle-mounted antenna system.

Our trapping data suggested that radiocollars did not compromise the health of free-ranging weasels. No neck chafing or irritation was observed in 5 radiocollared weasels we recaptured 14-34 days after their initial capture. Of these recaptures, 4 weasels exhibited no change in body mass and one weasel gained 30 g. Our field observations on weasel movements and behavior also suggested that radiocollars did not adversely affect foraging or reproduction in tagged weasels. We documented den use (coarse woody debris and subterranean) by 11 radiocollared weasels (5 females and 6 males). Mean diameter of den entrances was 30 mm (SE=1.3 mm) and 40 mm (SE=2.5 mm) for females and males, respectively. Ad-ditionally, during the breeding season, a radiocollared female maintained a den and 2 males exhibited nomadic movements with localized activity in female home ranges (T. M. Gehring, unpublished data).

One female died from exposure, due to wet conditions, following capture and handling (Table 2). Following this mortality, we modified our handling protocol to maintain potentially hypothermic weasels in captivity. We provided weasels with extra bedding and 3-5 mice in the live trap and moved the trap to a heated location for 6-8 hours before they were immobilized. No additional capture-related moratlities were noted following this modification. Two long-tailed weasels were killed by predators during the study period (Table 3).

Eight of 9 males and all females retained radiocollars more than one week, whereas 5 of 8 males and 4 of 6 females retained collars >5 weeks (Tables 2 and 3). Additionally, 2 radiocollars expired prematurely due to a manufacturing flaw that allowed moisture to permeate the transmitter. This

Table 2. History and fate of female long-tailed weasels (*Mustela frenata*) radio-tracked in west-central Indiana from 1998 to 1999.

Weasel #	Age[a]	Weight (g)	Dates	Number of days tracked	Fate
2F	Adult	115	19 August–24 September 1998	37	Collar expired
5F	Adult	115	18 October 1998	0	Capture mortality[b]
6F	Adult	100	21–28 October 1998	8	Collar malfunction
11F	Adult	105	21 February–8 June 1999	108	Collar expired
12F	Adult	135	30 June–5 October 1999	98	Collar expired
13F	Adult	110	8–16 July 1999	9	Shed collar
14F	Adult	100	12 July–24 August 1999	44	Collar malfunction
				$\bar{x}$=51 (SE=18)	

[a] Determined by presence of nipples (Wright 1948, King 1989).

[b] Not included in calculation of mean number of radio days

Discussion

Chemical immobilization of weasels with ketamine HCl and xylazine HCl was characterized by short induction times. Belant (1992) reported slight tremoring in short-tailed weasels (*M. erminea*) immobilized with ketamine HCl. However, our combined dose of 25 mg/kg ketamine HCl and 2 mg/kg xylazine HCl produced no visible seizures

Table 3. History and fate of male long-tailed weasels (*Mustela frenata*) radio-tracked in west-central Indiana from 1998 to 1999.

Weasel #	Age[a]	Weight (g)	Dates	Number of days tracked	Fate
1M	Adult	230	13–21 July 1998	9	Shed collar
3M	Adult	200	20 August–13 September 1998	25	Killed by mustelid
4M	Adult	190	6 October 1998–12 March 1999	158	Killed by raptor
7M	Adult	195	22–26 October 1998	5	Shed collar
8M	Juvenile	175	28 October–2 December 1998	36	Collar malfunction
9M	Adult	175	26 January–10 June 1999	136	Collar expired
10M	Adult	180	19 February–6 May 1999	77	Unknown
15M	Juvenile	145	9 November 1999–14 February 2000	98	Collar still functioning
16M	Juvenile	165	30 January–14 February 2000	16	Collar still functioning
				$\bar{x}$=62 (SE=19)	

[a] Determined by scrotal size (Wright 1948, King 1989).

or muscle rigidity and provided approximately 25 minutes for safe handling. Recovery from anesthesia likely was aided by use of a nest box, which provided a dark, secure environment.

We did not maintain a control group of uncollared weasels in captivity with which to compare our radiocollared sample. However, our observations on the foraging behavior of captive and free-ranging radiocollared weasels provided several indirect measures of the effects of radiocollars. Radiocollars might influence the foraging behavior of weasels if the collar and transmitter package interferes with a weasel's ability to: 1) use tunnels, 2) capture and subdue prey, and 3) consume food.

Simms (1979) documented minimal passable tunnel diameters for female (n=9) and male (n=9) long-tailed weasels based on captive experiments with uncollared individuals. He reported a mean minimal tunnel diameter of 27.1 mm (range=26–30 mm) and 35.6 mm (range=32–40 mm) for females and males, respectively (Simms 1979). Radiocollared weasels in our study successfully accessed dens with entrance diameters similar to those reported by Simms (1979). Captive radiocollared weasels in our study were proficient in capturing and subduing live domestic mice and displayed stereotypic killing techniques, such as nape biting, throat biting, and pulling prey from cover prior to a nape bite (Glover 1943, Heidt 1972, Byrne et al. 1978, King 1989). Although mean time from prey release to kill varied (see Table 1), once weasels perceived a prey item they quickly attacked and killed it. Food consumption rates for our captive radiocollared weasels were similar to those reported by DeVan (1982). He found that uncollared male (n=5) and female (n=4) long-tailed weasels consumed an average 25.5% (SE=1.4%) and 35.8% (SE = 2.0%) of their body mass/day during the first 15 days in captivity when provided with live domestic mice (DeVan 1982). Thus, the foraging behavior of weasels did not appear to be substantially modified by radiocollars.

Delattre et al. (1985) reported changes in movement behaviors of radiocollared common weasels (*M. nivalis*) compared to trapping data obtained prior to radiotagging. However, Delattre et al. (1985) collared only 2 male weasels and obtained telemetry data for a 10-day period. Radiocollared animals often spend several days becoming acclimated to collars (White and Garrot 1990). We found that long-tailed weasels often remained fairly sedentary for 1–4 days after radiocollaring and release. Thus, results of Delattre et al. (1985) may demonstrate temporary changes in movement behavior during this acclimation period.

DeVan (1982) radiotracked 5 male long-tailed weasels for 1–34 days. The mean weight of transmitter packages was 12.6 g or 6.3% of body weight. He suggested that the transmitter package did not interfere with normal movements (DeVan 1982). DeVan (1982) did not radiotag female long-tailed weasels, but suggested that a 6-g transmitter would be suitable. We used a 6.5-g transmitter for males (3.4% of body weight) and a 3.2-g transmitter for females (2.9% of body weight), which conforms with recommendations that transmitter packages should be ≤5% of body weight (Cochran 1980, Anderka 1987, American Society of Mammalogists 1998). We believe that this smaller and lighter collar design resulted in a relatively short acclimation period and was less of a burden for foraging weasels.

Transmitter range was adequate given the road network in our study area and we often searched <30 minutes for the initial location of radiocollared individuals using a vehicle-mounted antenna system. A 50% reduction in range (e.g., as commonly reported for radio implants) would have increased amount of search time and likely limited number of locations obtained. Eagle et al. (1984) reported that the surgical procedure for intraperitoneal implants in mink was simple and relatively quick. However, for long-tailed weasels, we suggest that radiocollaring would be a simpler, less invasive, and less time-consuming process, especially when replacing expired transmitters.

Recommendations

The immobilization and radiocollaring techniques that we used for long-tailed weasels provided efficient and safe handling of most weasels we captured. We believe that our modified protocol to handle potentially hypothermic animals and using Edgar live traps reduced risk of capture mortality and injuries substantially. Similarly, the "slow release" system we used with a nest box allowed immobilized weasels to recover adequately in a secure environment. The criteria we used to radiocollar weasels were necessary to determine collar fit and we suggest that researchers should use and improve them in future weasel studies. Researchers should strive to use the lightest and most streamlined radiocollar design available while maintaining adequate battery life and transmitter range.

King and Edgar (1977) suggested that a nest box attachment should be used with the Edgar live trap to ensure the health and safe immobilization of weasels. Although we did not use this attachment, we concur with them in the potential advantages of a nest box attachment relative to the well being and handling of captured weasels. A nest box attachment (with bedding) would provide a secure environment for potentially hypothermic individuals, thereby possibly reducing the need to hold these individuals for 6-8 hours. Furthermore, it might provide an effective immobilization chamber. Isoflurane or an equivalent inhalant anesthetic administered by a portable regulator could be used as the initial immobilizing agent to remove weasels from the nest box. Subsequently, an intramuscular injection of 25-mg/kg ketamine HCl and 2-mg/kg xylazine HCl would provide effective immobilization for radiocollaring. We believe that this modification to the handling protocol would significantly reduce the handling stress to weasels. We believe that future researchers would benefit by using these techniques with all weasels (*Mustela* spp.).

Acknowledgments. We thank the American Society of Mammalogists, Furbearers Unlimited, and Purdue University for funding. D. E. Biggins, S. Erlinge, C. M. King, R. A. Powell, and L. Thomasma provided valuable advice during the initial stages of this study. We thank C. M. King, H. P. Weeks, Jr., and an anonymous reviewer for providing comments that improved the manuscript. We are grateful to S. Peachey, R. Becker, J. Osbourne, and T. Preuss for field assistance. We thank the numerous private landowners for allowing us to conduct this research on their lands.

Literature cited

ANDERKA, F. W. 1987. Radiotelemetry techniques for furbearers. Pages 216-227 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Toronto, Canada.

AMERICAN SOCIETY OF MAMMALOGISTS. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. Journal of Mammalogy 79:1416-1431.

BELANT, J. L. 1992. Field immobilization of American martens (*Martes americana*) and short-tailed weasels (*Mustela erminea*). Journal of Wildlife Diseases 28:662-665.

BIGGINS, D. E., M. SCHROEDER, S. FORREST, AND L. RICHARDSON. 1985. Movements and habitat relationships of radio-tagged black-footed ferrets. Pages 11.1-11.17 *in* S. H. Anderson and D. B. Inkley, editors. Black-footed ferret workshop proceedings. Wyoming Game and Fish Department, Cheyenne, USA.

BYRNE, A., L. L. STEBBINS, AND L. DELUDE. 1978. A new killing technique of the long-tailed weasel. Acta Theriologica 23:127-143.

COCHRAN, W. W. 1980. Wildlife telemetry. Pages 507-520 *in* S. D. Schemnitz, editor. Wildlife management techniques manual. Fourth edition. The Wildlife Society, Washington, D.C., USA.

DELATTRE, P., J. M. ANGIBAULT, AND S. POSER. 1985. Influences du port d'un collier émetteur sur les déplacements et le rythme d'activité de la belette (*Mustela nivalis*). Gibier Faune Sauvage 2:5-13.

DEVAN, R. 1982. The ecology and life history of the long-tailed weasel (*Mustela frenata*). Dissertation, University of Cincinnati, Cincinnati, Ohio, USA.

EAGLE, T. C., J. CHOROMANSKI-NORRIS, AND V. B. KUECHLE. 1984. Implanting radio transmitters in mink and Franklin's ground squirrels. Wildlife Society Bulletin 12:180-184.

ERLINGE, S. 1977. Spacing strategy in stoat *Mustela erminea*. Oikos 28:32-42.

ERLINGE, S. 1979. Movements and daily activity pattern of radio tracked male stoats, *Mustela erminea*. Pages 703-710 *in* C. L. Amlaner and D. W. Macdonald, editors. A handbook on biotelemetry and radio tracking. Pergamon, New York, New York, USA.

ERLINGE, S., AND M. SANDELL. 1986. Seasonal changes in the social organization of male stoats, *Mustela erminea*: an effect of shifts between two decisive resources. Oikos 47:57-62.

FAGERSTONE, K. A. 1987. Black-footed ferret, long-tailed weasel, short-tailed weasel, and least weasel. Pages 549-573, *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Toronto, Canada.

Fagerstone, K. A., D. E. Biggins, and T. M. Campbell III. 1985. Marking and radiotagging of black-footed ferrets (*Mustela nigripes*). Pages 10.1-10.10 *in* S. H. Anderson and D. B. Inkley, editors. Black-footed ferret workshop proceedings. Wyoming Game and Fish Department, Cheyenne, USA.

Glover, F. A. 1943. Killing techniques of the New York weasel. Pennsylvania Game News 13:11-23.

Heezen, K. L., and J. R. Tester. 1967. Evaluation of radio tracking by triangulation with special reference to deer movements. Journal of Wildlife Management 31:124-141.

Heidt, G. A. 1972. Anatomical and behavioral aspects of killing and feeding by the least weasel, *Mustela nivalis* L. Arkansas Academy of Science Proceedings 26:53-54.

Jedrzejewski, W., B. Jedrzejewska, and L. Szymura. 1995. Weasel population response, home range, and predation on rodents in a deciduous forest in Poland. Ecology 76:179-195.

Jessup, D. A. 1982. Restraint and chemical immobilization of carnivores and furbearers. Pages 227-244 *in* L. Nielsen, J. C. Haigh, and M. E. Fowler, editors. Chemical immobilization of North American wildlife. Wisconsin Humane Society, Milwaukee, USA.

King, C. 1989. The natural history of weasels and stoats. Comstock, Ithaca, New York, USA.

King, C. M., and R. L. Edgar. 1977. Techniques for trapping and tracking stoats (*Mustela erminea*); a review, and a new system. New Zealand Journal of Zoology 4:193-212.

Lockie, J. D., and M. G. Day. 1963. The use of anesthetics in the handling of stoats and weasels. Pages 187-189 *in* O. G. Jones, editor. Symposium on small mammal anesthesia. Pergamon, Oxford, United Kingdom.

Melquist, W. E., and M. G. Hornocker. 1979. Development and use of a telemetry technique for studying river otter. Proceedings of the International Conference on Wildlife Biotelemetry, 2: 104–114.

Melquist, W. E., J. S. Whitman, and M. G. Hornocker. 1981. Resource partitioning and coexistence of sympatric mink and river otter populations. Pages 187-220 *in* J. A. Chapman and D. Pursley, editors. Proceedings of the Worldwide Furbearer Conference. Frostburg, Maryland, USA.

Moreland, A. F., and C. Glaser. 1985. Evaluation of ketamine, ketamine-xylazine and ketamine-diazepam anesthesia in the ferret. Laboratory Animal Science 35:287-290.

Murphy, E. C., and J. E. Dowding. 1994. Range and diet of stoats (*Mustela erminea*) in a New Zealand beech forest. New Zealand Journal of Ecology 18:11-18.

Murphy, E. C., and J. E. Dowding. 1995. Ecology of the stoat in *Nothofagus* forest: home range, habitat use and diet at different stages of the beech mast cycle. New Zealand Journal of Ecology 19:97-109.

Nams, V. O. 1981. Prey selection mechanisms of the ermine (*Mustela erminea*). Pages 861-882 *in* J. A. Chapman and D. Pursley, editors. Proceedings of the Worldwide Furbearer Conference. Frostburg, Maryland, USA.

Pounds, C. J. 1981. Niche overlap in sympatric populations of stoats (*Mustela erminea*) and weasels (*Mustela nivalis*) in northeast Scotland. Dissertation, University of Aberdeen, Aberdeen, Scotland.

Samson, C., and M. Raymond. 1998. Movement and habitat preference of radio tracked stoats, *Mustela erminea*, during summer in southern Quebec. Mammalia 62:165-174.

Sandell, M. 1986. Movement patterns of male stoats *Mustela erminea* during the mating season: differences in relation to social status. Oikos 47:63-70.

Seal, U. S., and A. W. Erickson. 1969. Immobilization of Carnivora and other mammals with phencyclidine and promazine. Federation Proceedings 28:1410-1419

Seal, U. S., and T. J. Kreeger. 1987. Chemical immobilization of furbearers. Pages 191-215 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Toronto, Canada.

Seal, U. S., A. W. Erickson, and J. G. Mayo. 1970. Drug immobilization of the Carnivora. International Zoo Yearbook 10:157-170.

Sheperd, B. F. 1994. Ecology and spatial dynamics of fox squirrels (*Sciurus niger*) in fragmented landscapes. Thesis, Purdue University, West Lafayette, Indiana, USA.

Simms, D. A. 1979. North American weasels: resource utilization and distribution. Canadian Journal of Zoology 57:504-520.

Sleeman, P. 1987. The ecology of the Irish stoat. Dissertation, National University of Ireland.

White, G. C., and R. A. Garrot. 1990. Analysis of wildlife radio-tracking data. Academic, San Diego, California, USA.

Wright, P. L. 1948. Breeding habits of captive long-tailed weasels. American Midland Naturalist 39:338-344.

Thomas M. (Tom) Gehring (right) is a Ph.D. candidate in wildlife in the Department of Forestry & Natural Resources at Purdue University. He obtained B.S. and M.S. degrees in biology and wildlife from University of Wisconsin-Stevens Point. His research interests are related to carnivore ecology and conservation. His previous research has examined the spatial ecology of wolves and the management of wolf-caused depredations in the Great Lakes region. He currently serves on the Conservation of Land Mammals Committee of the American Society of Mammalogists. ***Robert K. (Rob) Swihart*** (left) is a professor of wildlife ecology in the Department of Forestry & Natural Resources at Purdue University. He obtained a B.S. in wildlife from Purdue, an M.S. in wildlife from University of Minnesota, and a Ph.D. in ecology from University of Kansas. His research focuses on the spatial ecology of mammals. He teaches courses in mammalogy, vertebrate population dynamics, and quantitative methods and is a member of the university's committee on animal care and use.

Associate editor: *Miller*