

HOME RANGE AND MOVEMENTS OF LONG-TAILED WEASELS IN A LANDSCAPE FRAGMENTED BY AGRICULTURE

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Quantitative assessments of home-range dynamics and movements of long-tailed weasels (*Mustela frenata*) are lacking, in spite of the importance of these data to understanding how habitat fragmentation influences behavior, ecology, and interspecific interactions. During autumn to late winter 1998–2000, we monitored 11 long-tailed weasels (7 male, 4 female) via radiotelemetry to examine home-range dynamics and movement rates in an Indiana landscape fragmented by agriculture. Mean (\pm SE) 95% adaptive kernel contour area for adult females and adult males was 51.8 ± 8.1 ha and 180.3 ± 60.3 ha, respectively, and differed significantly. Hourly rate of movement for male long-tailed weasels (130.5 ± 12.7 m) was greater than that of females (79.2 ± 13.5 m). Weasels demonstrated greater hourly rates of movement during the fallow season (138.2 ± 12.8 m) compared with the preharvest season (63.0 ± 11.2 m). Mean hourly rates of movement were lower in corridors, forest patches, and grassland patches compared to crop fields. Mean hourly rate of movement was positively related with home-range size ($P < 0.001$) with the greatest rates of movement in the largest home ranges. Mean hourly rate of movement varied inversely with prey biomass ($P = 0.07$). Our results are consistent with the notion that long-tailed weasels may be sensitive to agriculturally induced fragmentation of habitat and the importance of maintaining landscape connectivity for species conservation.

Key words: habitat fragmentation, home range, long-tailed weasel, *Mustela frenata*, movements, radiotelemetry, spatial elements

Habitat fragmentation can result in 1st-order effects on vertebrates via modification of the physical environment (Saunders et al. 1991), which changes the distribution, abundance, and behavioral ecology of a species (Lima and Zollner 1996; Noss and Csuti 1997; Yahner and Mahan 1997). In particular, changes in the behavioral ecology of mammalian predators can have important ramifications for the abundance and distribution of prey species (Brown and Litvaitis 1995; Gehring and Swihart 2003; Oehler and Litvaitis 1996; Yahner and Mahan 1997). Habitat fragmentation leads to reductions in the size of remnant patches of habitat, higher ratios of edge to interior habitat, increased isolation of patches, and variation in the degree of connectivity of patches (reviewed in Saunders et al. 1991). As such, fragmentation can alter the spatial structure of vertebrate populations (Noss and Csuti 1997; Saunders et al. 1991). Furthermore, populations restricted to smaller,

isolated habitat patches (e.g., due to reduced mobility) can exhibit higher extinction probabilities due to demographic or environmental stochasticity (Lande 1993) and inbreeding depression (Frankel and Soulé 1981; Mills and Smouse 1994).

The sensitivity of mammals to fragmentation is related to their ability to move through the landscape, and this ability is related to body size and behavioral responses to varied habitat types (Gehring and Swihart 2003; Laurance 1995; Nupp and Swihart 2000; Wolff 1999). In agricultural landscapes, generalist predators with home ranges encompassing several habitat patches often must travel between patches during normal foraging movements. Travel time and predation risk can vary among individuals and species, depending on the ease with which predators can traverse and/or forage in the crop-field matrix surrounding habitat patches, and the availability of corridors that facilitate movement between foraging patches (or serve as foraging patches themselves). Thus, fragmentation may influence home-range size and rate of movement among habitat types in a home range.

The behavioral ecology of long-tailed weasels (*Mustela frenata*) is poorly understood (Fagerstone 1987; Sheffield and Thomas 1997). Quantitative assessments of home-range

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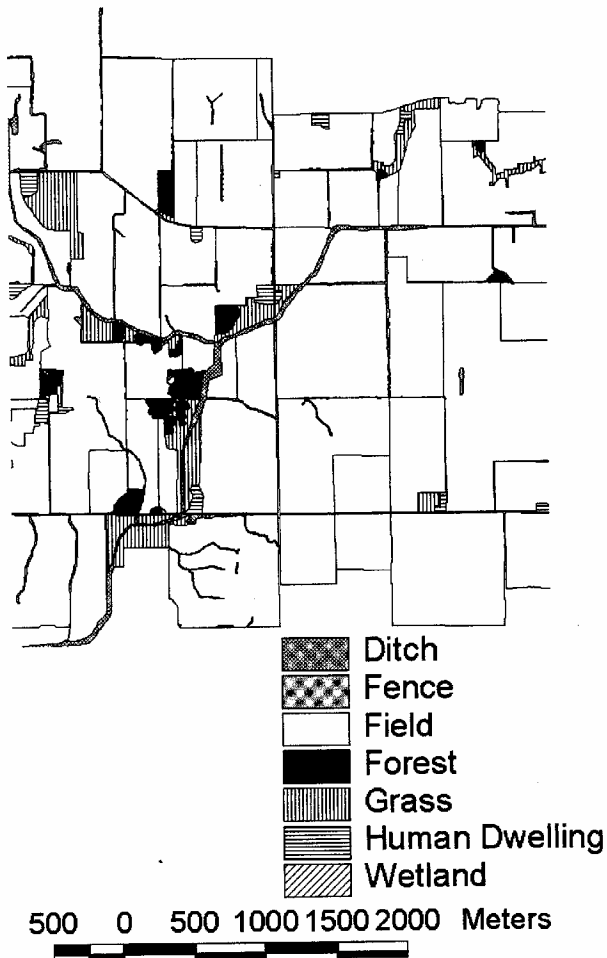


FIG. 1.—Representative portion of study area in west-central Indiana showing fragmented nature of the habitat where long-tailed weasels were monitored. Forests, grasslands, and corridors comprised only 11%, 4%, and 2% of the area, respectively.

dynamics and movements are lacking and have been based principally on snow tracking or mark-recapture techniques rather than radiotelemetry (DeVan 1982). Fagerstone (1987) suggested that long-tailed weasels might be sensitive to intensive agricultural practices because of reductions in available habitat and prey and additional factors associated with agriculture, such as additive mortality from interspecific predation and trapping pressure. If agricultural expansion is linked to declines in long-tailed weasel populations, populations also likely have declined in the midwestern United States where agricultural practices have resulted in large-scale deforestation and fragmentation of habitat (Warner 1994).

To our knowledge, the present study is only the 2nd (and is the largest) radiotelemetry study of long-tailed weasels (Gehring and Swihart 2000). The lack of documentation of the effects of habitat fragmentation on home-range size and movements by weasels is troubling given the declining pop-

ulations in agricultural landscapes of Canada (Fagerstone 1987). Movement data are fundamental to understanding the functional role of weasels in communities and implementing management strategies for ameliorating the potential negative effects of habitat fragmentation on weasels, small mammals, and birds in agricultural landscapes (Manly et al. 1993).

Our objectives were to quantify home-range size and rates of movement by long-tailed weasels in a landscape fragmented by agriculture, and we determined the effects of sex, season, prey, type of spatial element, and time of day on the rate of movement within weasel home ranges. Because body size often confers increased mobility (Swihart et al. 1988), we predicted that male long-tailed weasels would be more mobile than females. We predicted that rate of movement by weasels would be lower in areas with greater prey biomass and abundance compared to areas with a depauperate prey base. Because more overhead cover was available in crop fields during the growing and preharvest seasons compared to the fallow season (Gehring 2000), we predicted rates of movement by long-tailed weasels would be lower during the growing and preharvest seasons. We also predicted that weasels would be more mobile during nocturnal hours because of the reduced risk of predation at night. Additionally, we predicted that rates of movement by weasels within forests, grassland patches, and corridors would be lower than those in crop fields because the former habitat types offer greater cover and more abundant prey than crop fields.

MATERIALS AND METHODS

Study area.—During February–March and August–November 1998–2000, we conducted a radiotelemetry study on long-tailed weasels within a 200-km² study area in Benton, Tippecanoe, and Warren counties of west-central Indiana (40°25'50"N, 86°55'05"W). We defined the study area as the area in which we livetrapped weasels, plus a 1-km buffer surrounding the outermost locations of traps as a maximal measure of the radius of weasel home ranges (reviewed in Fagerstone 1987). We digitized all habitat types in the study area from 1998 digital ortho quadrangles using ArcView (ESRI, Redlands, California) and converted these data into shape files with 1-m resolution for use in ArcView. We identified 5 habitat types in the study area: forest, corridor (fencerows and drainage ditches), grassland, crop field, and human dwellings (Fig. 1). We defined seasons as growing season, preharvest season, and fallow season.

Human land use dominated the study area, with approximately 76% in agricultural production, principally corn and soybeans. The agricultural matrix consisted of relatively short (<1 m) crop vegetation with high ground cover during the growing season (May to August). Before fall harvest (August to mid-October), the matrix was characterized by dense and tall vegetation (1–3 m); however, ground cover was reduced due to drying conditions and crop senescence. The matrix was nearly barren during the fallow season (late October to April), with vegetative cover absent from fields.

Habitat types differed in the relative abundance and biomass of small mammals (white-footed mice and deer mice, *Peromyscus*; meadow voles, *Microtus pennsylvanicus*; pine voles, *M. pinetorum*; prairie voles, *M. ochrogaster*; short-tailed shrews, *Blarina brevicauda*; eastern chipmunks, *Tamias striatus*) and eastern cottontails (*Sylvilagus floridanus*). In general, fencerow corridors were characterized by a more abundant and diverse prey base and greater relative biomass compared to ditches, grassland patches and fields. Additionally, forest

TABLE 1.—Relative abundance and relative biomass of prey as number and mass (g) of small mammal captures per 100 trap nights, respectively, within habitat types of weasel home ranges in west-central Indiana, 1998–2000, as reported in Gehring (2000). Eastern cottontail (*Sylvilagus floridanus*) pellet groups were counted within 1 m on each side of alternating sections of small-mammal trapping grid and transect lines (i.e., a 180-m² area).

Habitat	Relative abundance of small mammals ^a	Species richness ^a	Relative biomass of small mammals ^a	Number of rabbit pellet groups ^b
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Forest	5.78 ± 4.08	1.29 ± 0.36	125.37 ± 68.33	4.14 ± 2.73
Field	5.04 ± 1.76	0.91 ± 0.09	91.72 ± 31.82	0
Grass	4.33 ± 1.42	1.00 ± 0.32	78.55 ± 22.88	0
Fencerow	17.66 ± 5.12	2.33 ± 0.21	402.47 ± 126.18	3.00 ± 0.68
Ditch	2.56 ± 1.53	1.67 ± 0.67	57.50 ± 35.59	0.67 ± 0.67

^a Fencerow > Field, Grass, Ditch.

^b Fencerow and Forest > Field, Grass, Ditch.

patches and fencerows contained greater numbers of rabbits than other habitat types (Table 1). A complete description of the study area is provided elsewhere (Gehring 2000).

Radio telemetry.—We livetrapped long-tailed weasels using a modified (enlarged) Edgar live trap (King and Edgar 1977). Fresh, dead domestic mice and commercial lures were used for bait. Traps were spaced 200–400 m apart to provide adequate trapping effort over the study area (King 1994). Weasels were restrained in a handling bag and immobilized via an intramuscular injection of 25 mg/kg of ketamine hydrochloride and 2 mg/kg xylazine hydrochloride (Gehring and Swihart 2000). At capture, we categorized age of weasels into 2 classes, juvenile (immature) or adult, based on weight and reproductive condition (King 1989). We fitted males and females with 6.5-g and 3.2-g radio collars (SOM-2190M and SOM-2070 models, Wildlife Materials, Inc., Carbondale, Illinois), respectively, and allowed individuals to recover in a nest box before release (Gehring and Swihart 2000). All handling methods were conducted in accordance with Purdue Animal Care and Use Committee (PACUC) guidelines and ASM animal care and use guidelines (American Society of Mammalogists 1998).

We relocated radiocollared weasels via triangulation (Heezen and Tester 1967) using a vehicle-mounted, 3-element Yagi directional antenna and electronic compass (Lovallo et al. 1994), and via ground-based homing using a hand-held, 3-element Yagi antenna. We attempted to obtain radio locations daily during randomly determined times to provide a representative sample of weasel movements. Additionally, we determined the hourly rate of movement from successive relocation at 1-h intervals over extended crepuscular, diurnal, and nocturnal periods (4–12 h).

We obtained 3–5 bearings as quickly as possible (within 5–8 min) to reduce telemetry error (White and Garrott 1990). The road system in the study area allowed us to establish known telemetry stations at ≤1 km of radiotagged animals. We tested telemetry precision and accuracy by locating radio collars placed at geo-referenced positions using established telemetry stations. Radiocollars were attached to a small vial containing saline solution (Hupp and Ratti 1983) and placed within 3 cm of the ground surface. True bearings ($n = 51$) from each station were calculated after White and Garrott (1990). The standard deviation of bearing error (Lee et al. 1985) was used to calculate 95% confidence ellipses in the microcomputer program LOCATE II (Nams 1990). Locations were determined using the maximum likelihood estimator (Lenth 1981) available in LOCATE II software.

Approximately 68% of locations were obtained during daylight conditions, including dawn and dusk hours. Fencerows and drainage ditches were the narrowest habitat types in the study area, with an

average width of approximately 15 m. Therefore, given the area of the average error ellipse (i.e., 30 × 30 m pixel), a location centered in a linear habitat was within a 7.5-m buffer on either side of a typical 15-m wide corridor. We believe that this level of accuracy was sufficient in delineating weasel use of corridor habitat. Mean number (± SE) of locations for females was 41 (±11), whereas mean number of locations for males was 56 (±15). Females were radiotracked for a mean of 51 (±18) days, and males were monitored for a mean of 62 (±19) days (Gehring and Swihart 2000).

We estimated 95% home-range contours for weasels using the adaptive kernel method (Worton 1989) in software program CALHOME (Kie et al. 1996). All weasel relocations were used for home-range estimation because kernel estimators are robust to violations of independence (Swihart and Slade 1997). Simulation studies (Swihart and Slade 1985a, 1997) and field studies (Anderson and Rongstad 1989; Gese et al. 1990) suggest that moderately autocorrelated observations do not invalidate the use of adaptive kernel or minimum convex polygon (Mohr 1947) estimators of home-range size. For comparison to published accounts of home-range size of long-tailed weasels, we estimated 100% minimum convex polygon home ranges using daily weasel locations and the Animal Movement Extension for ArcView (Hooge et al. 1999). We determined the minimum number of radio locations at which home-range size stabilized at the asymptote of accumulation curves (i.e., plot of number of locations and home-range size—White and Garrott 1990). We also used the Animal Movement Extension for ArcView to calculate the distance between successive locations in each monitoring session. Locations recorded during the breeding season were excluded because they may have represented extraterritorial movements (Erlinge and Sandell 1986; Sandell 1986).

For determination of rates of movement within home ranges, we sequentially relocated weasels during 25 monitoring sessions (151 h; males = 99 h; females = 52 h) that ranged from 4 to 12 h (mean = 6.1 h, SE = 0.6 h). Four males and 2 females were monitored during the fallow season (February, early March, and November), and 2 males and 1 female were located sequentially during the preharvest season (late August, September, and mid-October). Sequential locations were distributed among crepuscular (22%), diurnal (60%), and nocturnal (18%) hours. We found no significant serial correlation between successive locations at different lag-times (range in $r = -0.04$ to -0.32 , $P = 0.10$ to 0.71), thus we treated hourly locations as independent observations and an index of rate of home-range use (Swihart and Slade 1985b).

Statistical Analysis.—We used the Wilcoxon rank-sum test (Zar 1996) for examining differences in home-range size of males and females, and differences between juveniles and adults. We also

TABLE 2.—Results for the general linear model (PROC GLM; SAS Institute 1994) of factors determining hourly rate of movement for long-tailed weasels monitored in west-central Indiana, 1998–2000. Main effects and significant interactions are shown.

Source	F-value	P-value
Sex	17.5	<0.001
Time of Day	2.9	0.061
Season	19.8	<0.001
Type of Element	11.4	<0.001
Home-range Size	48.2	<0.001
Prey Biomass	8.2	0.006
Number of Pellet Groups rabbits	0.2	0.665
Sex*Season	7.1	0.010
Sex*Element	2.1	0.054
Time of Day*Element	3.4	0.001
Time of Day*Prey Biomass	4.2	0.018
Home Range Size*Element	2.7	0.019
Prey Biomass*Element	3.5	0.004
Home Range Size*Prey Biomass	9.4	0.003

examined differences in home-range size during the preharvest and fallow seasons. Because of the potential for autocorrelation between locations in sequential monitoring sessions, we examined the influence of time on comparisons of rates of movement to determine if inclusion of a time component was necessary for further analyses. Initially, we standardized rates of movement by computing z-scores (time-zero z-scores) for each monitoring session and each weasel. We then computed product-moment correlations between time-zero z-scores and z-scores at time lags of 1, 2, and 3 hours. Similarly, we standardized prey biomass by computing z-scores for the biomass of small mammals and rabbit abundance for all weasels combined and for separate sexes. We also computed a composite biomass index by summing z-scores. We then computed product-moment correlations between home-range size, biomass of small mammals, rabbit abundance, and a composite biomass index. We used a general linear model approach (PROC GLM, SAS Institute 1994), blocking for individuals, to determine the effects of biomass of small mammals, number of rabbit pellet groups, sex, season, home-range size, type of spatial element, and time of day on the rate of movement within weasel home ranges. We used Tukey's means comparison test (Zar 1996) to determine significant differences in rates of movement. Our data met or deviated only slightly from assumptions of the GLM approach of normality and homogeneity of variance. However, Zar (1996) indicated that analysis of variance ANOVA procedures are robust even with considerable heterogeneity of variances as long as sample sizes in cells are nearly equal.

We classified the type of habitat as the pair of habitat types a weasel moved to and from based on hourly locations, resulting in 10 paired combinations of the 4 habitat types. We defined time of day as crepuscular (i.e., 1 h before and after sunrise or sunset), diurnal, and nocturnal. We classified hourly locations into 1 of these classes by referencing Eastern Standard Time Zone times provided in United States Naval Observatory sunrise/sunset tables for Lafayette, Indiana (United States Naval Observatory 2001, http://aa.usno.navy.mil/data/docs/RS_OneYear.html web page accessed in January 2001) for each individual weasel. We used a more liberal significance level ($\alpha = 0.10$) in significance tests because of our small sample of individual weasels captured. Values are presented as mean \pm SE.

RESULTS

We captured 17 long-tailed weasels (6 adult male, 3 juvenile male, 8 female) 22 times over 4,256 trap nights during 1998–2000 (i.e., 0.5 captures per 100 trap nights). Of these, 11 individuals (4 adult males, 3 juvenile males, 4 females) were radiotracked for time periods sufficient to provide reasonable estimates of home-range size. A portion of the sample of weasels used for home-range analysis (9 individuals, including 6 males and 3 females) was monitored via sequential relocations to determine rates of movement within home ranges. Eight of the 11 weasels were radiotracked during late winter to early spring (prior to denning), whereas 3 of 11 were monitored during late summer to autumn (i.e., after late August).

For determination of home-range size, we collected 555 radiolocations with an average 95% error ellipse of 0.09 ± 0.02 ha. The mean bearing error was estimated at 2.4° , and precision was 2.7° ($n = 51$ bearings). Home-range size stabilized at 20–24 radiolocations per weasel. Home-range size was not related to biomass of small mammals ($r = -0.35$, $df = 8$, $P = 0.15$), but size of weasel home ranges was negatively correlated with the composite index of biomass (small mammals and rabbits; $r = -0.49$, $df = 8$, $P = 0.06$). In general, larger home ranges were characterized by lower prey biomass. Biomass of rabbits was related to home-range size for males ($r = -0.74$, $df = 5$, $P = 0.08$) but not for females ($r = -0.09$, $df = 2$, $P > 0.25$). Home-range size and biomass of small mammals were not related for either males ($r = -0.51$, $df = 5$, $P > 0.25$) or females ($r = -0.47$, $df = 2$, $P > 0.25$).

The 95% adaptive kernel contour area for adult females and adult males was 51.8 ± 8.1 ha and 180.3 ± 60.3 ha, respectively, and differed significantly ($Z = -1.88$, $P = 0.03$). Minimum convex polygon home ranges for adult females and adult males were 38.8 ± 9.8 ha and 136.7 ± 38.3 ha, respectively. The 95% adaptive kernel contour area for adult males was significantly larger than that of juvenile males (22.1 ± 4.9 ha; $Z = -1.62$, $P = 0.05$). Minimum convex polygon home range for juvenile males was 17.2 ± 2.0 ha. We found no seasonal difference in home-range size for adaptive kernel ($Z = 1.12$, $P = 0.13$) or minimum convex polygon contours ($Z = 0.92$, $P = 0.18$) estimated for the preharvest and fallow seasons.

Hourly rate of movement was influenced by prey biomass, sex, season, home-range size, and type of habitat ($F = 4.44$; $df = 73,77$; $P < 0.001$). Hourly rate of movement was lowest in areas with the greatest prey biomass ($r = -0.15$, $df = 8$, $P = 0.07$), although prey biomass did not explain much variability in rate of movement compared to other factors. Hourly rate of movement for males (130.5 ± 12.7 m) was greater than that of females (79.2 ± 13.5 m). Weasels demonstrated greater hourly rates of movement during the fallow season (138.2 ± 12.8 m) than in the preharvest season (63.0 ± 11.2 m). The significant interaction of sex and season is explained by males and females moving at similar rates (62.9 ± 5.9 m and 63.0 ± 17.1 m, respectively) during the preharvest season, but males moving faster than females (145.5 ± 15.0 m and 107.1 ± 21.0 m, respectively; Table 2)

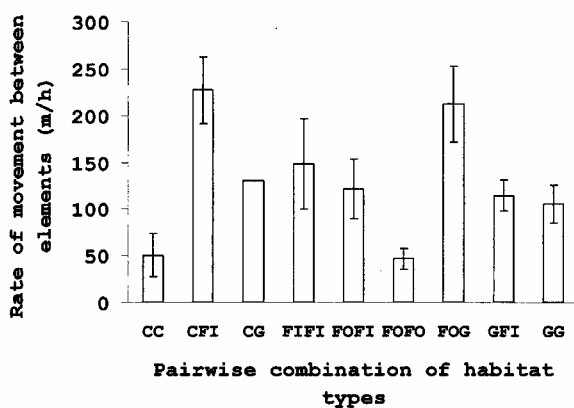


FIG. 2.—Rate of movement between habitat elements, shown as mean hourly rate (\pm SE) between 1 type of element and another. Rates estimated from 25 sequential monitoring sessions of 9 long-tailed weasels during 1998–2000 in west-central Indiana. Abbreviations: CC = corridor–corridor; CFI = corridor–crop field; CG = corridor–grassland; FIFI = crop field–crop field; FOFI = forest–crop field; FOFO = forest–forest; FOG = forest–grassland; GFI = grassland–crop field; and GG = grassland–grassland. No movements between corridors and forest patches were observed.

during the fallow season. Hourly rate of movement was related positively to home-range size ($r = 0.29$, $d.f. = 8$, $P < 0.001$). Mean hourly rates of movement were lower in corridors and forest patches compared to crop fields. Weasels moved between different habitat types at greater speeds than within corridors and forests, particularly when crossing corridor–crop field or forest–grassland edges (Fig. 2). Type of habitat and prey biomass interacted significantly, with crop field characterized by the lowest prey biomass and highest hourly rate of movement. Forest patches and corridors contained the highest prey biomass and lowest hourly rate of movement.

Time of day was marginally related to hourly rates of movement, whereas number of rabbit pellet groups was not related (Table 2). Time of day and prey biomass interacted significantly, with diurnal hours characterized by higher rates of movement and lower prey biomass compared to nocturnal or crepuscular periods when low rates of movement corresponded to high prey biomass.

Along forest–crop field edges and within forest patches, mean rates of movement increased to the highest level during the nocturnal period. Conversely, time of day did not appear to influence mean rate of movement within grassland patches (Fig. 3). During crepuscular hours, weasels exhibited the lowest mean rates of movement along forest–crop field edges and within forest patches, whereas mean rates of movement were highest along corridor–crop field edges and within crop fields. During the diurnal period, mean rates of movement were highest along forest–grassland and corridor–crop field edges and lowest within forest patches (Fig. 3).

We were unable to gather sequential locations during the growing season due to the lack of tagged weasels throughout

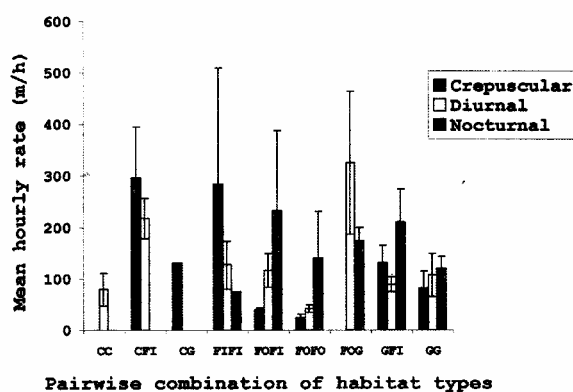


FIG. 3.—Rate of movement for interaction of time of day and type of element for 9 long-tailed weasels located during tracking periods in 1998–2000 in west-central Indiana. Bars indicate mean \pm SE for 3 times of day. Abbreviations as in Fig. 2.

this season. However, during early to mid-May, 2 males that were monitored from February to late May abandoned their winter home ranges and moved extensively on forays ranging 1–3 km from their winter home ranges. One male was relocated on 2 occasions within the nest den (which contained an unknown number of 6–8 week old weasels) of a radio-tagged female.

DISCUSSION

The size of weasel home ranges is related primarily to prey availability, body size (sex), and season (Erlinge and Sandell 1986; King 1989). Home-range size of long-tailed weasels appears to be explained by differences in prey availability with size inversely related to prey availability (DeVan 1982; Fagerstone 1987; King 1975, 1989; Sheffield and Thomas 1997). In our study, larger home ranges were characterized by lower prey biomass. Our correlation between home-range size and the biomass of small mammals was rather weak, perhaps because long-tailed weasels have a greater diet breadth than other smaller weasels and can prey upon small mammals and rabbits (King 1989). Inclusion of rabbits in our index of prey biomass yielded a strong inverse relationship between the size of home ranges and prey biomass for males, but not females. Male long-tailed weasels are more proficient at including rabbits in their diet compared to females (King 1989). Additionally, weasels moved at the slowest speeds while foraging in forest and grassland patches and corridors that were characterized by the greatest prey biomass. Data from scent stations also indicated that long-tailed weasels made concentrated use of fencerows and forest patches within home ranges, presumably because these habitat types offered the greatest biomass of prey (Gehring and Swihart 2003). Similarly, least weasels (*Mustela nivalis*) and stoats (*M. erminea*) tend to decrease mobility when prey density is high (Klemola et al. 1999).

Strong intersexual differences were evident in home-range size and hourly rates of movement. Our estimates of mean

home-range size are similar to those reported in the literature. Our data showed adult home ranges of 39 ha and 137 ha for females and males, respectively. Snow-tracking studies of long-tailed weasels have revealed home ranges of 32–160 ha (Quick 1944, 1951). Svendsen (1982) indicated that summer home ranges of long-tailed weasels ranged from 12 to 16 ha. In Kentucky farmland, DeVan (1982) reported male home ranges of 10–24 ha based on a mark-recapture and radiotelemetry study, whereas King (1989—citing C. Vispo, pers. comm.) reported a 41-ha home range for 1 female long-tailed weasel radiotracked in Indiana. Our data corroborate past research on long-tailed weasels that has reported larger home ranges for males compared to females (Fagerstone 1987; Sheffield and Thomas 1997).

Past studies have used snow tracking to determine average nightly distance traveled rather than hourly rates of movement. Glover (1943) found that the average distance that males ($n = 11$) and females ($n = 10$) traveled in 1 winter night was 214 m and 105 m, respectively. However, these estimates may represent minimum nightly distances moved as weasels appear to travel shorter distances in winter compared to summer to reduce energy loss from exposure to cold (DeVan 1982; Samson and Raymond 1998). In our study, males moved at nearly twice the rate of females, as Glover (1943) found for nightly distances moved by long-tailed weasels in Pennsylvania. Samson and Raymond (1998) found no difference between the rate of movement for male and female stoats in Quebec; however, their sample included only 3 males and 1 female.

In Europe, stoats experience 2 biological seasons: nonbreeding and breeding (Erlinge 1977 and Erlinge and Sandell 1986). During the nonbreeding season, availability of prey dictates home-range dynamics and movements of males and females. Conversely, during the breeding season, males largely abandon their home ranges and become nomadic in an attempt to locate females in estrus, whereas females maintain a relatively stable home range (Erlinge 1977; Erlinge and Sandell 1986; Sandell 1986). Our observations during the breeding season lend support to the idea that male long-tailed weasels may increase the size of their home ranges (Sheffield and Thomas 1997) or become nomadic in a fashion similar to that reported for stoats and weasels.

Based on the seasonal pattern in stoats, we expected the rate of movement for males to be greater during the late breeding season compared to the nonbreeding season. Further, we expected movements would be reduced during the winter period (i.e., fallow season) because of increased energetic demands associated with cold temperatures. However, long-tailed weasels traveled at a greater rate of movement during the fallow season (winter) compared to the preharvest (summer to early autumn) season in our study area. We suggest that this change in rate of movement between the fallow and preharvest season corresponded with changes in the crop matrix. Weasels attempting to traverse the row-crop matrix during the fallow season would likely be more prone to a higher risk of predation (raptors and carnivores) compared to their risk of predation

in native habitats. For example, Gehring and Swihart (2003) found that coyotes effectively traversed and used crop fields regardless of season. Individuals also might be more susceptible to cold exposure in winter fields because snow accumulation in Indiana crop fields is sparse due to high wind speeds.

Habitat type was important in determining the rate of movement for long-tailed weasels. Weasels moved at slower rates through corridors and forest patches compared to crop fields presumably because the latter offered few prey resources and a high risk of predation (Gehring and Swihart 2003). Weasels moved across edge habitats, especially edges with greater productivity gradients (e.g., corridor-field and forest-grassland edges), at greater speeds than within corridor, forest, and grassland habitats. Glover (1943) reported that weasels moved farther per excursion through open timberlands compared to brushland and dense forest.

Evidence about the activity patterns of long-tailed weasels is contradictory relative to time of day. Fagerstone (1987) suggested that long-tailed weasels can be active during the day but are primarily nocturnal. Conversely, others have reported that long-tailed weasels generally are active within several hours of the crepuscular period (see Svendsen 1982). In our study, weasels moved at greater rates along forest-grassland and corridor-crop field edges during diurnal hours, presumably using these habitats as both foraging patches and relatively safe travel conduits (i.e., corridors) between habitat patches. During crepuscular hours, weasels moved at greater rates across crop fields potentially because of the increased risk of predation from owls and mesocarnivores.

Our results, taken together with results of our studies of habitat selection in agricultural landscapes (Gehring 2000), suggest that long-tailed weasels may be sensitive to agriculturally induced fragmentation of habitat (Fagerstone 1987). Female long-tailed weasels may be particularly sensitive to habitat fragmentation because of their reduced mobility relative to males. Conversely, the distribution of male long-tailed weasels likely is influenced by the spatial arrangement of females, prey, and habitat types in the landscape.

Our data demonstrate that the orientation of habitat types can strongly affect the ability of species to move among and between elements. Our study area was a high-production agricultural region that has been dominated by humans for nearly a century (Warner 1994). As such, restoration of most habitats that have been converted to row crops will not occur in the foreseeable future. However, our results suggest that the removal of extensive corridor systems in agricultural landscapes can be detrimental, as these habitats serve as important travel and foraging patches for long-tailed weasels (see also Gehring 2000; Gehring and Swihart 2003) and therefore should be maintained. Species that persist in this landscape, including generalist predators such as long-tailed weasels, must contend with the constraints imposed by the spatial distribution of habitat resulting from fragmentation that can alter their behavioral ecology.

ACKNOWLEDGMENTS

We thank J. B. Dunning, Jr. and an anonymous reviewer for providing comments that improved the manuscript. D. E. Biggins, S. Erlinge, C. M. King, R. A. Powell, and L. Thomasma provided valuable advice. We are grateful to J. Osbourne, T. Preuss, S. Peachey, R. Becker, A. Bishop, L. Burgess, B. Miller, and B. Willson for field assistance, and numerous landowners for permission to use their lands. We thank the American Museum of Natural History (Theodore Roosevelt Memorial Fund), American Society of Mammalogists (Grants-In-Aid Award), Furbearers Unlimited, and Purdue University for funding.

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Submitted 3 October 2001. Accepted 3 March 2003.

Associate Editor was Ronald E. Barry.