Habitat use by the European polecat Mustela putorius at low density in a fragmented landscape

Authors: Baghli, Adil, Walzberg, Claudio, and Verhagen, Ron

Source: Wildlife Biology, 11(4) : 331-339

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/0909-6396(2005)11[331:HUBTEP]2.0.CO;2

Habitat use by the European polecat *Mustela putorius* at low density in a fragmented landscape

Adil Baghli, Claudio Walzberg & Ron Verhagen

Baghli, A., Walzberg, C. & Verhagen, R. 2005: Habitat use by the European polecat *Mustela putorius* at low density in a fragmented landscape. - Wildl. Biol. 11: 331-339.

We studied habitat use and selection, seasonal variation in the use of different habitats, and the factors possibly influencing their utilisation in six male and four female polecats *Mustela putorius* monitored in a fragmented area in Luxembourg. Deciduous forests appeared to be the most used habitat in summer, whereas grassland and pastures were more often used in winter and spring. Human settlements were frequently used in winter, likely because they provide both food and insulation. The influence of climatic conditions on habitat use was assessed; both rain and temperatures seemed to affect habitat use by polecats. Food habits also showed a seasonal variation with small rodents as the main food item in all seasons, but with amphibians becoming an important prey in spring and summer. Our results suggest that habitat use is influenced by trophic factors and climatic conditions, which confirms the opportunistic feeding behaviour of the polecat.

Key words: climatic factor effects, feeding habits, habitat use, Luxembourg, Mustela putorius

Adil Baghli, Scientific Research Center, National Museum of Natural History, 25 rue Münster, L-2160 Luxembourg, Grand Duchy of Luxembourg - e-mail: adil.baghli@mnhn.lu
Claudio Walzberg, Geodata, 27, rue de Dippach, L-8055 Bertrange, Grand-Duchy of Luxembourg - e-mail: walzberg@pt.lu
Ron Verhagen, Evolutionary Biology Group, Department of Biology, University of Antwerp (RUCA), 171 Groenenborgerlaan, B-2020 Antwerp, Belgium - e-mail: ron.verhagen@ua.ac.be

Corresponding author: Adil Baghli

Received 5 August 2003, accepted 17 September 2004

Associate Editor: Piero Genovesi

Habitat selection by animal species depends on several elements that need to be fulfilled; food availability, presence of thermophilic shelters, areas with low predation risk and presence of mates (Buskirk & Powell 1994).

During the past century, increased human activities (i.e. agricultural and industrial development, forest management, road construction and urbanisation) in Western Europe led to broad-scale habitat changes. The most obvious impacts of such changes are the loss and/or the fragmentation of habitats into isolated and small patches (Gilpin & Hanski 1991, Harrisson & Fahrig 1995). These alterations affect life history parameters of several animal species (e.g. dispersal, rate of growth, mortality and carrying capacity) and the final result is, in some cases, a reduction in likelihood of population survival (i.e. Beier 1993, Gaona et al. 1998).

The polecat *Mustela putorius* occurs throughout the Western Palearctic and the species is known to occupy a variety of habitat types from lowlands to mountains: woodland, forest, marsh, riverbanks and farmland (see Blandford 1987 for a review).

Different studies on the food habits of the polecat (see review in Lodé 1997) have shown that different food items can dominate in the species' diet, e.g. amphibians

(Weber 1989a, Jędrzejewski et al. 1993, Sidorovich & Pikulik 1997), rodents (Libois 1984, Lodé 1994, De Marinis & Agnelli 1996) and rabbits *Oryctolagus cuniculus* (Brugge 1977, Roger 1991, Birks & Kitchener 1999). Lodé (1997) suggested that predation on woodland rodents and amphibians make the polecat a generalist predator well adapted to the central European region.

Data on habitat use by polecats are scarce; Weber (1989b), Lodé (1994) and Birks & Kitchener (1999) have provided the only quantitative examinations of polecat habitat use by radio tracking. However, most of these studies were applied on medium-high density populations and do not provide the information needed to identify key habitat parameters for endangered populations living at low density (Baghli & Verhagen 2003).

The objective of our study was thus to describe habitat use by polecats in a fragmented landscape in Luxembourg, where the species occurs at very low densities and is considered threatened (Baghli et al. 1998, Baghli & Verhagen 2003). Investigations made by Schröpfer et al. (2000) in Germany showed a correlation between meteorological conditions and the availability of rabbits, which were considered as the main food resource of the polecat in that area. We thus tested for an indirect influence of weather conditions on habitat use. We also tested the effects of the polecat's feeding habits on habitat use.

Material and methods

Study area

The study was performed in the Gutland region (southern part of the Grand-Duchy) around Luxembourg City (49°36'N, 06°12'E; altitude 376 m a.s.l.). Human population density was approximately 170/km^2 and road density about 1.10 km/km^2 (Statec 2001). Agriculture occupies 49% of the land in Luxembourg, of which 51.2% consist of pasture and grassland, whereas the remaining area is covered by various crops such as cereals and fodder plants (Statec 2001). Woods cover about 34% of the country. In Gutland, only land unsuitable for farming is still covered by forest. Large areas were cleared to make room for agricultural land and the major types of forest are high beech *Fagus* sp. forests with sparse undergrowth in the drier areas, oak *Quercus* sp. - hornbeam *Carpinus betulus* forests in the more humid areas and spruce *Picea* sp. plantations (Schley 2000). Several rivers flow through the region, the Alzette and the Syre being the most important ones. The mean annual temperature is about 9°C and varies between 0.8°C in January and 17.5°C in July. Average annual rainfall is 782 mm, and the number of days with frost range within 60-80. Hereafter, we will refer to the study area as the part of the territory delimited by the minimum convex polygon encompassing all fixes of polecats in the studied population.

Trapping and radio-tracking

We trapped 10 polecats using 60 × 17 × 17 cm live traps (model 203, Tomahawk Live Trap Co., Wisconsin USA) covered with local vegetation to protect the animals from rain, cold temperatures and light. As trapping is not allowed in Luxembourg, a license (n° 03/11/1997) for using this kind of trap was obtained from the Ministry of the Environment. Traps were baited with fresh eggs. Polecats were anaesthetised with Ketamine hydrochloride and weighed and sexed. Age class was estimated based on physical measurements and date of capture. Two classes were distinguished: subadults (< 1 year old) and adults (> 1 year old). However, ageing polecats in winter may lead to errors, which is why we did not compare activity rates of adults vs subadults. Sex was determined together with reproductive condition.

Polecats were radio-tracked between February 1999 and March 2001, using a Televilt receiver (RX 900, Lindesberg, Sweden), and neck-collar transmitters from Biotrack Ltd. (model TW3, Wareham, UK). Approximate locations of the radio-tracked polecats were obtained by triangulation. Precision was initially tested by trials on hidden collars (accepted error < 50 m; see Baghli & Verhagen 2004).

Radio-tracking was carried out during continuous 4-12 hour sessions per day during which fixes were taken every 15 minutes. For each fix, we recorded the activity of the animal and the habitat. Beginning and cessation of movements were recorded. For all the monitored polecats, the start of activity was determined as the time of first movement outside the resting site, whereas cessation of activity was considered as the time when they returned to their resting site. After that tracking was stopped. Polecats are known to be essentially nocturnal (Blandford 1987), and thus, both beginning and cessation of their activity were related to official sunrise and sunset times. Most locations were recorded at night, when polecats were active, but at least one fix per animal was collected during daytime. Only active fixes were taken into account for habitat use analyses, and activity was defined by significant variations in radio-signal strength (Kenward 2001). The occurrence of rainfall at the moment of radio location was recorded for each fix in order to test for possible effects on habitat use and activity. Analyses were conducted at the individual level according to recommendations of Thomas & Taylor (1990) and Palomares & Delibes (1992).

Habitat use

Home ranges were estimated using the minimum convex polygon MCP (Mohr 1947) and the fixed Kernel method (Worton 1989). Home range is defined as the area traversed by an animal in its normal activities during a specified time period (Hansteen et al. 1997). The fixed Kernel method (KE) is known to be the most accurate technique currently available for describing home ranges (Seaman & Powell 1996). We used the MCP method because of its simplicity, ease of plotting and because it allows comparison with other studies (Harris et al. 1990). As we found no significant difference between home ranges sizes estimated using the MCP or KE method ($t = 0.528$, $df = 18$, $P > 0.05$), we used the MCP method for habitat use analyses.

Habitat use by an animal population is selective when the resources are used disproportionately to their availability (Johnson 1980). Habitat selection was evaluated at two levels: first the proportion of each habitat within each home range was compared to its availability in a reference area represented by the polygonal area encompassing the home ranges of all radio-tracked polecats (second-order selection according to Johnson 1980); second, the use as proportion of active fixes in each habitat was compared to the availability of each habitat within the home range (third-order selection of Johnson 1980). This method assumes that habitat availability is measured without error (Alldredge & Ratti 1992). We considered this assumption fulfilled as we used accurate techniques for habitat measurements (GIS on digitised map). The distribution of habitats in the study area was defined using the OBS digitised map based on aerial photographic (Cartographie de l'Occupation Biophysique du Sol, Ministère de l'Environnement, Luxembourg; grid scale 1:5000; Table 1). Home ranges (KE 95 and MCP 100), the proportion of fixes in each habitat, and the extent of different habitats in the study area and in each home range were calculated using the Animal Movement analyse extension (Version 2.1; Hooge & Eichenlaub 2000) in the ArcView GIS 3.2 program (ESRI, Ca., USA).

Autocorrelated data sets have often been assumed to underestimate home range size. However, this conventional principle has been strongly challenged in recent years, and is now refuted by several studies (Reynolds & Laundre 1990, Rooney et al. 1998, De Solla et al. 1999, Otis & White 1999, Blundell et al. 2001, Vaughan & Ormerod 2003) showing that eliminating autocorrelation prior to analysis by restrictive sampling may be unwise because it involves getting rid of biologically significant data. Autocorrelation should not introduce unnecessary bias to home range estimates if the time interval between successive fixes is relatively constant (De Solla et al. 1999). Moreover, autocorrelation is a highly artificial concept when applied to animals, since their behaviour by its nature is non-independent, decision making being influenced by previous experience (Powell 1987, Goodrich & Buskirk 1998) such as movements following daily routine, travelling to seasonal breeding grounds or to high resource concentration areas, and annual migrations. The sampling scheme we used (continuous location at 15-minute interval) ensures constant time interval and thus avoids autocorrelation biases.

Food habits

Feeding habits of polecats were investigated using scat analysis according to standard techniques (for more details: see Baghli et al. 2002). We collected a total of 121 scats (56 in winter: October-February, and 65 in summer: March-September) throughout the study area (covering 55 km^2 in Gutland). Prey determination was performed by microscope on the basis of feather, bone and hair characteristics using published guides (Day 1966, Debrot et al. 1982). Diet composition was estimated as frequencies of occurrence. Prey items were pooled in five categories: mammals, amphibians, birds, invertebrates and carrion.

Data analysis

The most widely used statistical technique for testing habitat selection is a χ^2 goodness-of-fit test of whether the observed habitat use differs significantly from the expected use (White & Garrott 1990). This method, however, does not identify which habitats are avoided or preferred. We thus used the method proposed by Neu et al. (1974) and Rice (1989), that calculates confidence inter-

Table 1. Habitat types and their characteristics within polecat home ranges.

Habitat types	Description
C/O: Crops/Orchards	Cultivated fields, vineyards and fruit trees
CF: Coniferous forests	Mainly Norway spruce *Picea abies*, pine *Pinus sylvestris* and Douglas fir *Pseudotsuga menziesii*
DF: Deciduous forests	Mainly beech and oak
G/P: Grassland/Pasture	All open lands for cattle breeding and fallow
RH: Riparian habitats	Wetlands, marshlands and banks of water courses
HS: Human settlements	Urban areas, agricultural premises, roads and former quarries
T: Thickets	Thorny thickets on sunny slopes and forest cuts vegetation

Table 2. Characteristics and home range sizes (in ha) of 10 radio-tracked polecats. F = female, M = males.

					Home range	
Animal ID	Age	Weight (g)	Survey period	Number of fixes	MCP 100	KE 95
F4	Adult	880	04.02.99-18.03.99	165	63	100
F5	Adult	890	12.04.00-26.04.00	297	93	121
F6	Subadult	500	24.07.00-12.08.00	264	52	72
F7	Adult	620	21.02.01-29.03.01	495	65	42
M4	Adult	1100	15.01.99-27.04.99	627	276	428
M5	Subadult	600	26.07.99-02.09.99	462	153	107
M6	Adult	1300	26.02.00-20.04.00	363	319	287
M7	Adult	1200	06.03.00-21.03.00	198	131	254
M8	Adult	1160	26.04.00-02.08.00	726	155	160
M9	Adult	1400	22.12.00-20.01.01	396	249	240

vals for each habitat based on the Bonferroni z-statistic. We tested for seasonal differences in habitat use during the three seasons: winter, spring and summer, using the Wilcoxon W-test. Influence of weather conditions within individuals was examined using ANOVA with the General Linear Model Procedure (SPSS 10 software) using the habitat-use index as the response variable and rain and negative temperatures as factors. The same procedure (ANOVA) was used to test the sex effect on habitat selection with sex as the fixed factor and the habitat-use index as the response variable.

Trophic niche breadth was calculated using the standardised Levins index applied to the proportion of occurrence: $B = 1 \Big/ \sum_{i}^{n} p_i^{\,2}$ where n is the total number of food categories and p_i is a food category proportion according to Colwell & Futuyma (1971).

Results

Trapping and home range size

From February 1999 to March 2001, 10 polecats (six males and four females) were trapped and radio-tracked, and a total of 3,993 fixes were recorded (Table 2). Home range size was not correlated with the number of fixes ($r = 0.379$, $N = 10$, $P = 0.280$). Consequently we considered the sample size of locations sufficient for correctly estimating individual home ranges. Home range sizes of male polecats varied from 153 to 304 ha (mean = 226.2, N = 6, SD = 64.9), while those of females varied from 63 to 98 ha (mean = 79.7, N = 4, SD = 18.3). Male ranges were therefore significantly larger than female ranges ($t = -5.23$, $df = 6$, $P < 0.01$).

Habitat composition and habitat use

The study area is characterised by a large proportion of grassland and pastures (35%), followed by deciduous forests (27%), crops/orchards (25%), human settlements (7%), coniferous forests (3%) and thickets (2%), whereas riparian habitats occupy < 1% of the area.

Within the home ranges of the radio-tracked polecats, grassland and pastures represented 45% of the area, crops and orchards 20% and deciduous forest 18% (Table 3). Human settlements covered 12%, and the rest of the habitats accounted for small proportions of coniferous forests (2%), thickets (2%) and riparian habitats (1%; see Table 3).

Grassland and pastures appeared to be the most used habitat (39%) among radio-tracked polecats. Deciduous forests (21%) and human settlements (15%) were also used more frequently than the other habitats (Fig. 1).

Individual comparisons show that grassland and pastures were significantly selected (F4, F7, M7, M9) or used as available (rest of the tested polecats; Table 4). Crops/orchards in the home ranges were avoided (F4,

Table 3. Percentages of the seven habitat types within the total home ranges (MCP 100) of the 10 radio-tracked polecats. See Table 1 for abbreviation of the habitat types. F = female, M = male.

	Habitattype						
Animal ID	C/O	CF	DF	G/P	RH	HS	T
F4	3.17	0.00	0.00	69.08	1.79	24.65	1.32
F5	50.06	1.01	8.58	25.81	0.00	3.90	10.64
F6	1.21	6.34	37.55	36.69	4.81	12.71	6.90
F7	12.50	1.91	11.86	62.09	0.00	11.63	0.00
M4	29.62	4.21	20.74	31.87	0.17	11.83	1.55
M5	21.60	3.70	22.6	23.76	1.13	26.98	0.23
M6	25.63	1.84	24.28	40.99	0.26	5.85	1.14
M7	32.45	0.00	1.78	56.73	1.41	5.73	1.90
M8	7.17	2.31	45.72	34.32	0.22	0.21	10.04
M9	6.78	0.65	5.19	66.88	0.60	19.40	0.51
Average	19.84	2.19	18.49	44.34	0.80	11.84	2.49

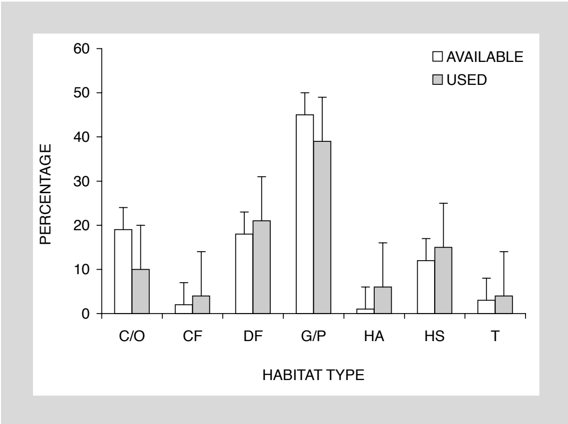

Figure 1. Proportional habitat use by the 10 polecats at two levels: % habitat composition of home range (available) and % active fixes in each habitat type (used). Error bar represent ± 1 SE. See Table 1 for abbreviations of the habitat types.

F6, M8, M9) or used as available (F7, M4, M5, M6, M7). Only one polecat (F5) used a significantly higher proportion of this habitat. Deciduous forests in the home ranges were avoided by four tested animals (F4, F5, F7, M9) and were selected by only one individual (M8). Human settlements were also selected in the ranges of two tested polecats (F4, M5). The proportion of use of other habitats did not differ from availability except for thickets, which were selected in the range of F5 (see Table 4).

Habitat selection differed among individuals ($F = 3.16$, $df = 9$, $P < 0.05$). With the exception of M8, habitats were used by the radio-tracked polecats disproportionately to their availability in the home ranges (see Table 4). Five of the polecats (F5, F7, M4, M5, M6) avoided crops and orchards. On the other hand, polecats tended to select riparian habitats (F4, F6, M9; see Table 4). The use of other habitats by polecats varied highly among individuals. Only thickets were used in proportion to their availability in the home ranges.

Significant seasonal variations in habitat use were observed (Table 5). In winter, grassland and pastures were of highest importance with a mean of 45.7% (SD = 9.0) of utilisation followed by human settlements (21.5%, SD = 12.4). In contrast, the use of grassland decreased in summer (22.0%, SD = 6.1), while deciduous forests were more used (41.7%, SD = 3.1). In spring, grassland and pastures were used intensively (44.6%, SD = 10.0) followed by deciduous forests (28.6%, SD = 17.1).

When analysing seasonal variations in habitat use, no significant seasonal variation was found in the use of crops and orchards, coniferous forests, riparian habitats and thickets (Wilcoxon test: $P > 0.05$). Human settlements were used more intensively in winter than in spring (Wilcoxon test: $W = 19$, $N_1 = 6$, $N_2 = 5$, $P = 0.04$). Conversely, grassland and pastures were used significantly less often in summer than in winter (Wilcoxon test: $W = 6$, $N_1 = 3$, $N_2 = 6$, $P = 0.02$) and in spring (Wilcoxon test: $W = 6$, $N_1 = 3$, $N_2 = 5$, $P < 0.05$). Deciduous forests were used significantly more in summer than in winter (Wilcoxon W-test: $W = 21$, $N_1 = 3$, $N_2 = 6$, $P < 0.05$).

Table 4. Habitat use by the 10 polecats in relation to habitat availability in the study area and in the home range. Habitats used significantly (P < 0.01, Bonferroni confidence intervals) more or less than expected are marked with + or -, respectively. F = female, M = male; N = number of fixes. See Table 1 for abbreviations of the habitat types.

	Habitat							
Animal ID	C/O	CF	DF	G/P	RH	HS	T	N
Habitat proportion in home ranges compared to proportion in the study area								
Study area	0.25	0.03	0.27	0.35	< 0.01	0.07	0.02	
F4	0.03-	0.00	0.00-	0.69+	0.02	0.25+	0.01	165
F5	0.49+	0.01	0.09-	0.26	0.00	0.04	0.11+	297
F6	0.01-	0.06	0.37	0.37	0.05	0.13	0.01	264
F7	0.12	0.02	0.12-	0.62+	0.00	0.12	0.00	495
M4	0.30	0.04	0.21	0.31	< 0.01	0.12	0.02	627
M5	0.22	0.04	0.23	0.24	0.01	0.26+	< 0.01	462
M6	0.26	0.02	0.24	0.41	< 0.01	0.06	0.01	363
M7	0.32	0.00	0.02	0.57+	0.01	0.06	0.02	198
M8	0.07-	0.02	0.47+	0.34	< 0.01	< 0.01	0.10	726
M9	0.07-	0.01	0.05-	0.66+	0.01	0.19	0.01	396
Average	0.19	0.02	0.18	0.45	0.01	0.12	0.03	
Proportion of active fixes compared to proportion in home range								
F4	0.05	0.00	0.00	0.54	0.14+	0.27	0.00	78
F5	0.22-	0.00	0.00-	0.48+	0.00	0.20+	0.10	143
F6	0.00	0.19+	0.45	0.18-	0.17+	0.00-	0.00	163
F7	0.00-	0.07	0.14	0.46	0.00	0.33+	0.00	182
M4	0.13-	0.05	0.25	0.34	0.00	0.14	0.08	353
M5	0.08-	0.04	0.41+	0.19	0.08	0.20	0.00	281
M6	0.05-	0.00	0.30	0.50	0.07	0.08	0.00	223
M7	0.33	0.00	0.11+	0.45	0.00	0.10	0.00	106
M8	0.07	0.02	0.40	0.31	0.05	0.00	0.15	382
M9	0.07	0.06	0.05	0.46-	0.11+	0.18	0.07	229
Average	0.10	0.04	0.21	0.39	0.06	0.15	0.04	

Table 5. Seasonal variation in winter, spring and summer habitat use by the 10 polecats. See Table 1 for abbreviations of the habitat types.

	Habitat type						
Animal ID	C/O	CF	DF	G/P	RH	HS	T
Winter							
F4	0.05	0.00	0.00	0.54	0.14	0.27	0.00
F5							
F6							
F7	0.00	0.07	0.06	0.42	0.00	0.44	0.00
M4	0.16	0.06	0.24	0.31	0.00	0.17	0.04
M5							
M6	0.07	0.00	0.20	0.56	0.04	0.13	0.00
M7	0.33	0.00	0.11	0.45	0.00	0.10	0.00
M8							
M9	0.07	0.06	0.05	0.46	0.11	0.18	0.07
Spring							
F4							
F5	0.22	0.00	0.00	0.48	0.00	0.20	0.10
F6							
F7	0.00	0.06	0.35	0.59	0.00	0.00	0.00
M4	0.07	0.03	0.26	0.40	0.00	0.08	0.16
M5							
M6	0.04	0.00	0.41	0.44	0.09	0.02	0.00
M7							
M8	0.09	0.03	0.41	0.32	0.05	0.00	0.10
M9							
Summer							
F4							
F5							
F6	0.00	0.19	0.45	0.18	0.17	0.00	0.00
F7							
M4							
M5	0.08	0.04	0.41	0.19	0.08	0.20	0.00
M6							
M7							
M8	0.04	0.01	0.39	0.29	0.05	0.00	0.23
M9							

We found a significant difference in habitat selection between males and females (F = 7.47, df = 1, P < 0.01). Males seem to select deciduous forests more than females (see Table 4). Weather conditions (rain and negative temperatures) significantly influenced habitat selection (F = 9.81, df = 2, P < 0.01). When it was raining, polecats significantly avoided grassland and pastures (F = 24.17, df = 1, P < 0.001), deciduous forests (F = 6.83, df = 1, P < 0.05) and riparian habitats (F = 6.17, df = 1, P < 0.05). When temperatures dropped below 0°C, polecats significantly selected more human settlements (F = 10.19, df = 1, P < 0.01). No interaction was detected between individual habitat selection and weather factors (F = 1.01, df = 12, P > 0.05).

Table 6. Percentage occurrence (and number of items, N, in parentheses) of the different food categories used by polecats in the study area.

Food categories	Summer (N)	Winter (N)
Apodemus sp.	-	2.7 (2)
Arvicola terrestris	-	5.5 (4)
Clethrionomys glareolus	11.9 (7)	26.0 (19)
Crocidura russula	6.8	1.4 (1)
Micromys minutus	6.8 (4)	2.7 (2)
Microtus sp.	15.2 (9)	20.6 (15)
Neomys fodiens	5.0 (3)	12.3 (9)
Rattus norvegicus	-	2.7 (2)
Sorex sp.	6.8 (4)	8.2 (6)
Total mammals	52.5 (31)	82.1 (60)
Amphibians	37.3 (22)	15.1 (11)
Birds	3.4 (2)	-
Invertebrates	6.8 (4)	-
Carrion	-	2.7 (2)
Number of identified prey	59	73
Number of scats	56	65
Niche breadth	2.38	1.43

Food habits

Overall, the 121 scats contained a wide variety of prey species (Table 6). The main food of polecats consisted of small mammals (mainly rodents), which represented 69% of the prey items. Amphibians (frogs and toads) made up 25% of total prey items. However, a clear seasonal variation was observed. Small mammals were by far the most frequent food type (82%) during the winter period, while the proportion of amphibians increased in summer (37% of the total items). Birds and invertebrates were only present in summer, and carcasses were recorded in winter only. The trophic niche breadth increased from winter (B = 1.43) to summer (B = 2.38).

Discussion

In our study, polecats living in a fragmented rural landscape used home ranges containing a high proportion of grassland and pastures, crops and orchards and deciduous forests habitats, with some areas of human settlements. Other habitats, such as coniferous forests, thickets and riparian habitats, were present in very small proportions. Grassland and pastures were significantly selected within home ranges, while crops and orchards were avoided. Consistently with the results of previous studies (Walton 1968, Danilov & Rusakov 1969, Libois 1984, Jędrzejewski et al. 1993), riparian habitats were significantly selected by polecats.

In mustelid species such as badger *Meles meles* (Brøseth et al. 1997), pine marten *Martes martes* (Stier 2000), American marten *M. americana* (Thompson & Harestad 1994), polecat (Lodé 1994), American mink *Mustela vison* (Arnold & Fritzell 1990), weasel *M. nivalis* and stoat *M. erminea* (King 1989) habitat use is correlated to prey availability and protective cover. The importance of wetlands (Blandford 1987, Weber 1989c, Brzezinski et al. 1992, Lodé 1994, Birks & Kitchener 1999) and forests (Weber 1989c) to polecats was explained by higher prey density around shelters (Lodé 1997, Baghli et al. 2002).

In Switzerland, polecats established home ranges mostly in the northern Prealps and adjacent mountainous areas where their preferred prey (amphibians) was more common (Weber 1989a). However, Weber (1989b) emphasised that, in this context, the survival of polecats during the cold season was linked to food and insulation provided by human settlements. In western France, polecats used different habitats depending on season. Marshes were most used in spring, forests in autumn and winter and meadows in summer and winter (Lodé 1994). In England, polecats preferred forest edges (defined as the peripheral five metres of any woodland or plantation) and agricultural premises with high concentrations of rabbits and rabbit warrens (Birks & Kitchener 1999).

In our study area, polecats showed flexible and individually variable strategies for the selection of their habitats. They tended to use human settlements more intensively in winter. This is probably related to the need of suitable resting sites in the coldest period and to the availability of food resources in the vicinity of human settlement, i.e. rodents in farm building, domestic animals and industrial cat food (Baghli et al. 2002). Unfortunately, this behaviour may increase vulnerability of polecats to non-selective hunting in human settlements, which is intended to control beech marten *Martes foina* populations. Moreover, there is evidence that secondary rodenticide contamination is common in polecats during their winter occupation in human settlements (Shore et al. 1996, Birks 1998).

In spring, polecats shift their habitat exploitation to areas supplying amphibians, and this behaviour was observed in all animals tracked during this period, when grassland and pastures were used intensively. Deciduous forests were the most used habitat in summer, when prey is abundant.

Our results indicate a selection for deciduous forest, which is in accordance with results obtained in France (Lodé 1994) and Switzerland (Weber 1989b). Direct observation of the use of grassland and pastures by polecats suggests that the use of this habitat generally occurred in association with hay structures or small riparian vegetation adjacent to water courses.

Inter-individual differences in habitat use were detected in our study and have not been examined previously. Moreover, our results document the influence of weather conditions on habitat use, e.g. on rainy days, polecats avoided grassland and pastures, deciduous forests and riparian habitats. Moreover, when temperatures were below 0°C, polecats selected human settlements.

Human settlements provided the only places where food and suitable resting sites (thermal cover) remained available during days with cold temperatures. Therefore, in agreement with Weber (1989b), change in habitat use from deciduous forests to human settlements appears to be an adaptation to cold winter conditions.

Polecats are generalist feeders, but may specialise locally on one major resource such as rodents, amphibians or rabbits (Lodé 1997). Basically, polecats in our study fed both on rodents and amphibians, and the exploitation of these prey types was probably related to their seasonal availability (Baghli et al. 2002). The trophic niche breadth increases in spring when amphibians become more accessible. Consequently, the importance of grassland and pastures to the feeding behaviour of polecats may explain the overrepresentation of this habitat category in their home ranges. Our data are consistent with those of Lodé (1994), who reported the generalist and opportunist character of the polecat and its adaptation to the environmental conditions for its habitat use and exploitation.

Acknowledgements - funding for this study was provided by a grant from the Ministry of Culture and Scientific Research (Bourse Formation-Recherche BFR 97/003), by the Forest Administration (Services: Conservation de la Nature, Chasse et Pêche) and by the National Museum of Natural History of Luxembourg. We thank P. Genovesi, L. Schley and two anonymous referees for their helpful comments on the manuscript.

References

Alldredge, J.R. & Ratti, J.T. 1992: Further comparison of some statistical techniques for analysis of resource selection. - Journal of Wildlife Management 56: 1-9.

Arnold, T.W. & Fritzell, E.K. 1990: Habitat use by male mink in relation to wetland characteristics and avian prey abundances. - Canadian Journal of Zoology 68: 2205-2208.

Baghli, A., Engel, E. & Verhagen, R. 1998: Premières données sur la répartition et le statut des mustélidés en général et du putois (Mustela putorius L.) en particulier au Luxembourg. - Bulletin de la Société des Naturalistes luxembourgeois 99: 87-93. (In French with an English summary).

Baghli, A., Engel, E. & Verhagen, R. 2002: Feeding habits and trophic niche overlap of two sympatric Mustelidae, the polecat Mustela putorius and the beech marten Martes foina. - Zeitschrift für Jagdwissenschaft 48: 217-225.

Baghli, A. & Verhagen, R. 2003: The distribution and status of the Polecat Mustela putorius L. in Luxembourg. - Mammal Review 33: 57-68.

Baghli, A. & Verhagen, R. 2004: Home ranges and movement patterns in a vulnerable polecat Mustela putorius population. - Acta Theriologica 49: 247-258.

Beier, P. 1993: Determining minimum habitat areas and habitat corridors for cougars. - Conservation Biology 7: 94-108.

Birks, J.D.S. 1998: Secondary rodenticide poisoning risk arising from winter farmyard use by the European polecat Mustela putorius. - Biological Conservation 85: 233-240.

Birks, J.D.S. & Kitchener, A.C. 1999: Ecology of the Polecat in Lowland England. - In: Birks, J.D.S. & Kitchener, A.C. (Eds.); The distribution and status of the polecat Mustela

putorius in Britain in the 1990s. The Vincent Wildlife Trust, London, Great Britain, pp. 111-130.
Blandford, P.R.S. 1987: Biology of the Polecat Mustela putorius: a literature review. - Mammal Review 17: 155-198.
Blundell, G.M., Maier, J.A. & Debevec, E.M. 2001: Linear home ranges: effects of smoothing, sample size, and autocorrelation on kernel estimates. - Ecological Monographs 71: 469-489.
Brøseth, H., Knutsen, B. & Bevanger, K. 1997: Spatial organisation and habitat utilization of badgers Meles meles: effects of food patch dispersion in the boreal forest of central Norway. - Zeitschrift für Säugetierkunde 62: 12-22.
Brugge, T. 1977: Prooidierkeuze van wezel, hermelijn en bunzing in relatie tot geslacht en lichaamsgrootte. - Lutra 19: 39-49. (In Dutch).
Brzezinski, M., Jędrzejewski, W. & Jędrzejewska, B. 1992: Winter home ranges of polecats Mustela putorius in Bialowieza primeval forest, Poland. - Acta Theriologica 37: 181-191.
Buskirk, S.W. & Powell, R.A. 1994: Habitat ecology of Fishers and American martens. - In: Buskirk, S.W., Harestad, A.S., Raphael, M.G. & Powell R.A. (Eds); Martens, sables and fishes: biology and conservation. Cornell University Press, Ithaca, New York, USA, pp. 283-296.
Colwell, R.R. & Futuyma, D.J. 1971: On the measurement of niche breadth and overlap. - Ecology 52: 567-576.
Danilov, P.I. & Rusakov, O.S. 1969: ОСОБЕННОСТИЭКО ЛОГИИЧЕРНОГО ХОРЯ (Mustela putorius) ВСЕВЕРО-ЗАЛАДНЫХ ЕВРОЛЕЙСКОЙ ЧАСТИ СССР. (In Russian with an English summary: Peculiarities of the ecology of Mustela putorius in northwest districts of the European part of the USSR). - Zoologicheskii Zhurnal 48: 1383-1394.
Day, M.G. 1966: Identification of hair and feather remains in the gut and faeces of stoats and weasels. - Journal of Zoology (London) 148: 201-217.
Debrot, S., Fivaz, G., Mermod, C. & Weber, J.M. 1982: Atlas des poils de mammifères d'Europe. - Université de Neuchâtel, Switzerland, 208 pp. (In French).
De Marinis, A.M. & Agnelli, P. 1996: First data on the winter diet of the polecat, Mustela putorius, (Carnivora, Mustelidae) in Italy. - Mammalia 60: 144-146.
De Solla, S.R., Bonduriansky, R. & Brooks, R.J. 1999: Eliminating autocorrelation reduces biological relevance of home range estimates. - Journal of Animal Ecology 68: 221-234.
Gaona, P., Ferreras, P. & Delibes, M. 1998: Dynamics and viability of a metapopulation of the endangered Iberian Lynx (Lynx pardinus). - Ecological Monographs 68: 349-370.
Gilpin, M.E. & Hanski, I. 1991: Metapopulation Dynamics: Empirical and Theoretical Investigations. - Academic Press, London, 336 pp.
Goodrich, J.M. & Buskirk, S.W. 1998: Spacing and ecology of North American badgers (Taxidea taxus) in a prairie-dog (Cynomys leucurus) complex. - Journal of Mammalogy 79: 171-179.
Hansteen, T.L., Andreassen, H.P. & Ims, R.A. 1997: Effects of spatiotemporal scale on autocorrelation and home range estimators. - Journal of Wildlife Management 61: 280-290.
Harris, S., Cresswell, W.J., Forde, P.G., Trewhella, W.J., Woollard, T. & Wray, S. 1990: Home-range analysis using radio-tracking data - a review of problems and techniques particularly as applied to the study of mammals. - Mammal Review 20: 97-123.
Harrisson, S. & Fahrig L. 1995: Landscape pattern and population conservation. - In: Hansson, L., Fahrig, L. & Merriam, G. (Eds.); Mosaic Landscapes and Ecological Processes. Chapman and Hall, London, pp. 293-308.
Hooge, P.N. & Eichenlaub, B. 2000: Animal movement extension to ArcView. Version 2.1. - Alaska Biological Science Center, U.S. Geographical Survey, Anchorage, Alaska, USA. Available at http://www.absc.usgs.gov/glba/gistools/
Jędrzejewski, W., Jędrzejewska, B. & Brzezinski, M. 1993: Winter habitat selection and feeding habits of polecats (Mustela putorius) in the Białowieża National Park, Poland. - Zeitschrift für Säugetierkunde 58: 75-83.
Johnson, D.H. 1980: The comparison of usage and availability measurements for evaluating resource preference. - Ecology 61: 65-71.
Kenward, R.E. 2001: A manual for wildlife radio tagging. - Academic Press London, 311 pp.
King, C.M. 1989: The natural history of weasels and stoats. - Christopher Helm, London, Great Britain, 271 pp.
Libois, R.M. 1984 : Atlas des mammifères sauvages de Wallonie. Le genre Mustela en Belgique. - Cahiers d'Ethologie Appliquée 4: 279-314. (In French).
Lodé, T. 1994: Environmental factors influencing habitat exploitation by the polecat Mustela putorius in western France. - Journal of Zoology (London) 234: 75-88.
Lodé, T. 1997: Trophic status and feeding habits of the European Polecat Mustela putorius L. 1758. - Mammal Review 27: 177-184.
Mohr, C.O. 1947: Table of equivalent populations of North American small mammals. - American Midland Naturalist 37: 223-249.
Neu, C.W., Byers, C.R. & Peek, J.M. 1974: A technique for analysis of utilization-availability data. - Journal of Wildlife Management 38: 541-545.
Otis, D.L. & White, G.C. 1999: Autocorrelation of location estimates and the analysis of radio tracking data. - Journal of Wildlife Management 63: 1039-1044.
Palomares, F. & Delibes, M. 1992: Data analysis design and potential bias in radio-tracking studies of animal habitat use. - Acta Oecologica 13: 221-226.
Powell, R.A. 1987: Black bear home range overlap in North Carolina and the concept of home range as applied to black bears. - International Conference on Bear Research and Management 7: 235-242.
Reynolds, T.D. & Laundre, J.L. 1990: Time intervals for estimating pronghorn and coyote home ranges and daily movements. - Journal of Wildlife Management 54: 319-322.

Rice, W.R. 1989: Analyzing tables of statistical tests. - Evolution 43: 223-225.

Roger, M. 1991: Régime et disponibilités alimentaires chez le putois (Mustela putorius L.). - Revue d'Ecologie (Terre Vie) 46: 245-261. (In French).

Rooney, S.M., Wolfe, A. & Hayden, T.J. 1998: Autocorrelated data in telemetry studies: time to independence and the problem of behavioural effects. - Mammal Review 28: 89-98.

Schley, L. 2000: The Badger Meles meles and the Wild Boar Sus scrofa: Distribution and damage to agricultural crops in Luxembourg. - PhD dissertation, University of Sussex, Great Britain, 162 pp.

Schröpfer, R., Bodenstein, C. & Seebass, C. 2000: Der Räuber-Beute-Zusammenhang zwischen dem Iltis Mustela putorius L., 1758 und dem Wildkaninchen Oryctolagus cuniculus (L., 1758). (In German with an English summary: A predator-prey-correlation between the European polecat Mustela putorius L., 1758 and the wild rabbit Oryctolagus cuniculus (L., 1758)). - Zeitschrift für Jagdwissenschaft 46: 1-13.

Seaman, D.E. & Powell, R.A. 1996: An evaluation of the accuracy of kernel density estimators for home range analysis. - Ecology 77: 2075-2085.

Shore, R.F., Birks, J.D.S., Freestone, P. & Kitchener, A.C. 1996: Second-generation rodenticides and polecats (Mustela putorius) in Britain. - Environmental Pollution 91: 279-282.

Sidorovich, V.E. & Pikulik, M. 1997: Toads Bufo spp. in the diets of mustelids predators in Belarus. - Acta Theriologica 42: 105-108.

Statec 2001: Le recensement agricole. - Bulletin du Statec 3: 125-127. (In French).

Stier, N. 2000: Habitat use of the pine marten Martes martes in small-scale woodlands of Mecklenbourg (Germany). - Lutra 43: 185-203.

Thomas, D.L. & Taylor, E.J. 1990: Study designs and tests for comparing resource use and availability. - Journal of Wildlife Management 54: 322-330.

Thompson, I. & Harestad, A. 1994: Effects of logging on American martens, and models for habitat management. - In: Buskirk, S.W., Harestad, A.S., Raphael, M.G. & Powell R.A. (Eds); Martens, sables and fishes: biology and conservation. Cornell University Press, Ithaca, New York, USA, pp. 355-367.

Vaughan, I.P. & Ormerod, S.J. 2003: Improving the quality of distribution models for conservation by addressing shortcomings in the field collection of training data. - Conservation Biology 17: 1601-1611.

Walton, K.C. 1968: The distribution of the polecat, Putorius putorius in Great Britain, 1963-1967. - Journal of Zoology (London) 155: 237-240.

Weber, D. 1989a: The diet of polecats (Mustela putorius L.) in Switzerland. - Zeitschrift für Säugetierkunde 54: 157-171.

Weber, D. 1989b: The ecological significance of resting sites and the seasonal habitat change in polecats (Mustela putorius). - Journal of Zoology (London) 217: 629-638.

Weber, D. 1989c: Foraging in polecats (Mustela putorius L.) of Switzerland: The case of a specialist anuran predator. - Zeitschrift für Säugetierkunde 54: 377-392.

White, G.C. & Garrott, R.A. 1990: Analysis of wildlife radio-tracking data. - Academic Press, San Diego, California, USA, 383 pp.

Worton, B.J. 1989: Kernel methods for estimating the utilisation distribution in home-range studies. - Ecology 70: 164-168.