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## Home ranges of Eurasian lynx *Lynx lynx* in the Polish Carpathian Mountains

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Home-range size of Eurasian lynx *Lynx lynx* was studied in two different mountain ranges of the Polish Carpathians during 1999-2004. We live-trapped and radio-collared five adult lynx (two males and three females). One female was probably killed only 10 days after being radio-collared. Home-range size of radio-collared individuals calculated for the whole period of radio-tracking (MCP with 100% observations) was 164 km<sup>2</sup> for male M1 from the Beskid Sądecki Mountains, and it was 124 and 190 km<sup>2</sup>, respectively, for the two females F1 and F2 and 199 km<sup>2</sup> for male M2 in the Bieszczady Mountains.

*Key words:* Carpathians, Eurasian lynx, home range, *Lynx lynx*

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The Eurasian lynx *Lynx lynx* once existed throughout Europe, but at present its distribution is continuous only in Scandinavia and Russia. In central, western and southern Europe its distribution has broken into small and scattered populations. The Carpathian Mountains harbour the largest lynx population in Europe, and this population is completely isolated from the contiguous population in

northern Europe (Breitenmoser et al. 2000). The Carpathian lynx is morphologically quite distinct from their northern conspecifics and has been described as a distinct subspecies (Stollman 1963). Recent genetic studies confirmed the separate status of the Carpathian lynx (Breitenmoser-Würsten & Obexer-Ruff 2003). Additionally, this is the only region so far where the species has been found to

exhibit such behaviours as intense scavenging (H. Okarma, S. Śnieżko & W. Śmietana, unpubl. data) and catching of prey in trees (Červený & Okarma 2002).

The biology and ecology of lynx reintroduced from Slovakia have been studied intensively since the early 1970s in Switzerland and France (Haller & Breitenmoser 1986, Herrenschmidt et al. 1986). In the northern part of the species' range, similar research on native lynx populations was conducted in the Białowieża Primeval Forest, Poland (Schmidt et al. 1997) and in Scandinavia (Linnell et al. 2001). As a result, a considerable body of knowledge on spatial requirements, intraspecific relations and predation by lynx has been gathered (Breitenmoser & Haller 1993, Breitenmoser et al. 1993, Okarma et al. 1997, Schmidt et al. 1997, Linnell et al. 2001, Jędrzejewski et al. 2002). Unfortunately, similar research has not been conducted in native lynx populations in the Carpathians.

Our objective in this paper is to present data on home-range size of Eurasian lynx from the Polish Carpathian Mountains and to compare them with data collected elsewhere using the same methodology, i.e. radio-telemetry.

## Methods

### Study area

Our study was conducted in the Polish part of the Carpathian Mountains (southeastern Poland), i.e. in the Beskid Sądecki Mountains, Gorce Mountains and Bieszczady Mountains during 1999-2004 (Figs. 1-4). The area is characterised by considerable differences in relative altitudes. The highest hills reach 1,300 m a.s.l. The larger part of the area is primarily covered by mixed deciduous-coniferous forest composed of beech *Fagus sylvatica*, spruce *Picea abies* and fir *Abies alba*. The primary species of wild ungulates are red deer *Cervus elaphus*, roe deer *Capreolus capreolus*, and wild boar *Sus scrofa*. Other large carnivores besides the lynx are the wolf *Canis lupus* and brown bear *Ursus arctos*. The area is sparsely populated and the small human population is concentrated along rivers and streams high up into the mountains (Staszkievicz & Witkowski 1986, Zarzycki & Głowaciński 1986).

### Data collection and analysis

Lynx were live-trapped using footsnare traps (Schmidt et al. 1997) at fresh kills or when scaveng-

ing on ungulate carcasses (Table 1), immobilised with 2.5-3.0 ml 'Domitor' (medetomidine; Pfizer GmbH, Germany) and fitted with VHF radio-collars (Andreas Wagener, Köln, Germany and ATS, Minnesota, USA). After the collars were fitted, lynx received 1.2-1.5 ml 'Antisedan' (atipamezole; Pfizer GmbH) as a reversal agent. We live-trapped and radio-collared five adult lynx in different parts of the Polish Carpathians (see Table 1). Female F3 from the Gorce Mountains was probably killed illegally 10 days after being radio-collared.

Animals were located by triangulation with a minimum of two bearings from the ground using a portable receiver (K. Wagener, Köln, Germany) and a 3-element Yagi antenna at least once a week. Additionally, we conducted 24-hour sessions of continuous radio-tracking (with radio-locations taken at 30-minute intervals) 1-3 times every month. Tracking accuracy was within 500 m due to lack of roads and rough mountain terrain. We succeeded in finding radio-collared lynx in 75-92% of our searching attempts. Telemetry locations were plotted on 1:25,000 maps. The minimum-convex-polygon (MCP) method (with 100% of locations included) was used to estimate the size of home ranges (White & Garrott 1990) which were calculated using the program TRACKER (A. Angerbjörn, Radio Location Systems, Sweden). When calculating total home-range size and home-range seasonal and year-to-year changes only one radio-location per day (chosen randomly) was used for a given animal.

## Results and discussion

The home range (Schmidt et al. 1997) of male M1 in the Beskid Sądecki Mountains was 164 km<sup>2</sup> (N = 1,816 radio-locations) calculated for the entire 23-month period during which he was radio-tracked (see Table 1). The home range of this individual covered the whole mountain range of Radziejowa in the Beskid Sądecki Mountains and part of the neighbouring mountain group, the Pieniny Hills (see Fig. 1). During two years of radio-tracking, a considerable shift in the home range of this individual was observed (see Fig. 1). During the first period (8 March 1999 - 15 February 2000), the male occupied the northwestern part of his life-time home range (138 km<sup>2</sup>) which was nearly the entire Radziejowa mountain range (see Fig. 1) and rarely crossed the border into Slovakia. In the second year



Figure 1. Home range of the male lynx M1 in the Beskid Sądecki Mountains in the Polish Carpathians. The area delineated by the solid line (1) shows his home range during March 1999 - February 2000, and the area delineated by the dashed line (2) shows his home range during March 2000 - February 2001. Forested areas (■) and the national border to Slovakia (---) are shown.

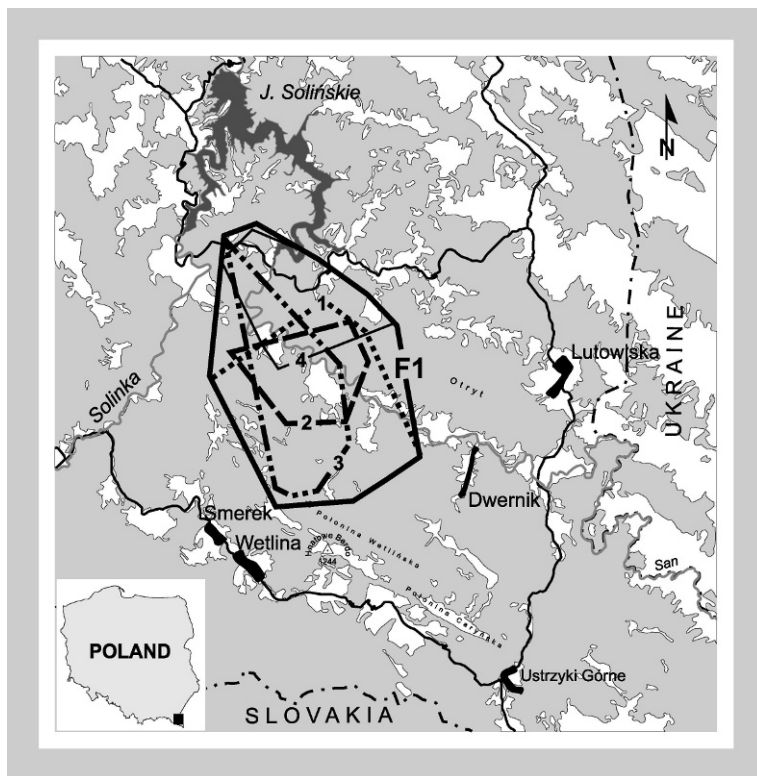


Figure 2. Home ranges utilised by the female lynx F1 in the Bieszczady Mountains in the Polish Carpathians during the entire 45-month period of radio-tracking (1999-2002). Area 1 shows her home range during March 1999 - February 2000, area 2 her home range during March 2000 - February 2001, area 3 her home range during March 2001 - February 2002, and area 4 her home range during March 2002 - November 2002. Forested areas (■) and the national borders to Slovakia and the Ukraine (---) are shown.

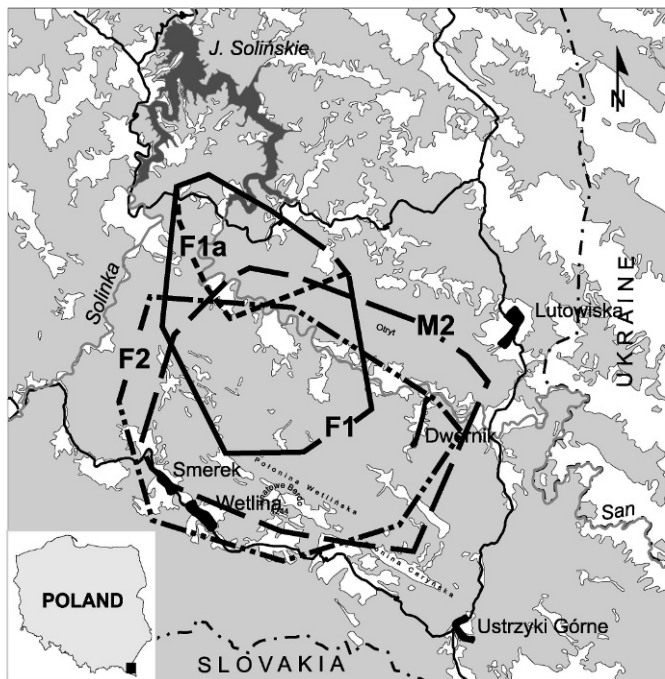


Figure 3. Home ranges of the two female lynx F1 and F2 and the male lynx M2 in the Bieszczady Mountains in the Polish Carpathians. The area 'F1' shows the home range of the female F1 over the entire 45-month period of radio-tracking (1999-2002), and the area 'F1a' shows the home range of female F1 in March-November 2002 (see explanation in the text). Forested areas (■) and the national borders to Slovakia and the Ukraine (---) are shown.

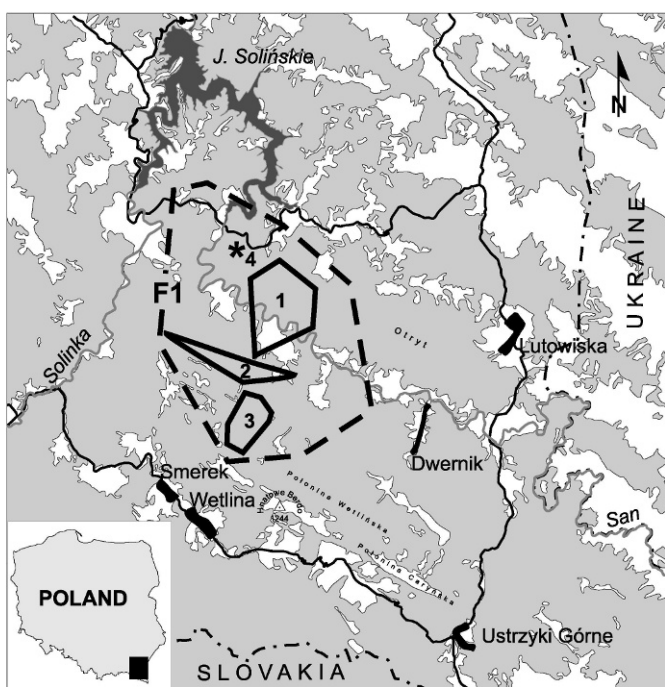


Figure 4. Home range utilised by the female F1 in the Bieszczady Mountains in the Polish Carpathians during the entire 45-month period of radio-tracking (1999-2002) and the parts of her home range utilised during the three months (May-July) following parturition in three consecutive years: 1999 (1), 2000 (2), 2001 (3). The asterisk (4) shows the location of a den found in May 2002. Forested areas (■) and the national borders to Slovakia and the Ukraine (---) are shown.

Table 1. Mountain range, period of radio-tracking, number of locations (N) taken for home-range calculation, and home-range size (in km<sup>2</sup>; MCP 100%) for two male (M) and three female (F) lynx in the Polish Carpathians during 1999-2004.

Individual	Mountain range	Period of radio-tracking	N	Home-range size (km <sup>2</sup> )	Comments
M1	Beskid Sadecki	08.03.1999-15.02.2001	354	164	Live-trapped when scavenging
M2	Bieszczady Mountains	15.02.2002-13.03.2004	240	199	Live-trapped when scavenging
F1	Bieszczady Mountains	17.03.1999-19.11.2002	228	124	Live-trapped at its own kill
F2	Bieszczady Mountains	07.03.2002-13.03.2004	177	190	Live-trapped when scavenging
F3	Gorce Mountains	08.02.2000-16.02.2000	5	-	Live-trapped at its own kill

(16 February 2000 - 15 February 2001) this individual inhabited mainly the southeastern portion of his home range (104 km<sup>2</sup>) including the Pieniny Hills on the Slovakian side, and visited the northern part only sporadically. We confirmed by snow-tracking that another adult male lynx appeared in the mountain range of Radziejowa in winter 2000/01. Thus, the shift in the home range of the radio-collared lynx we observed might have been a result of the presence of the second male in the northern part of its original home range.

The home range of female F1 in the Bieszczady Mountains calculated for the 45-month period of radio-tracking was 124 km<sup>2</sup> (N = 228 locations; see Table 1). The home range of this individual covered the mountain range of Otryt and a fragment of the San river valley (see Fig. 2.). During the first three years of study, we observed a continuous decrease in F1's home-range size, from 79 km<sup>2</sup> (N = 70 locations) during March 1999 - February 2000 to 31 km<sup>2</sup> (N = 54) during March 2000 - February 2001, and 28 km<sup>2</sup> (N = 78) during March 2001 - February 2002. In the fourth year of study (March 2002 - November 2002), even though we did not manage to follow the animal for 12 months, its home range expanded considerably to 41 km<sup>2</sup> (N = 28) and additionally, a pronounced shift in her home range to the north was observed (see Fig. 2). We do not know if this shift was caused by the appearance of female F2 within a central part of F1's home range, because F1 and F2 were radio-tracked simultaneously for only nine months beginning in March 2002.

The home range of female F2 in the Bieszczady Mountains was 190 km<sup>2</sup> (N = 177 locations) during 25 months of radio-tracking (see Table 1). The home range of this individual covered the mountain range of Połonina Wetlińska (see Fig. 3). We did not observe annual or seasonal shifts in this individual's home range.

The home range of male M2 in the Bieszczady Mountains was 124 km<sup>2</sup> (N = 228 locations) during 24 months of radio-tracking (see Table 1). The home range of this individual covered two moun-

tain ranges: Połonina Wetlińska and Otryt (see Fig. 3) and no annual or seasonal shifts in home-range size were observed.

We were not able to describe well enough the spacing pattern in the lynx population in the Carpathians, because we simultaneously followed only three adult lynx (F1, F2 and M2) for nine months (March-November 2002). However, our findings were similar to those reported from other studies, in that home ranges of adult females radio-tracked simultaneously overlapped to a very small extent, and adult males tended to have at least one female within their home ranges (see Fig. 3; Breitenmoser et al. 1993, Schmidt et al. 1997, Linnell et al. 2001).

In other studies, home ranges of female lynx were considerably smaller than those of males (Breitenmoser et al. 1993, Schmidt et al. 1997, Linnell et al. 2001). Our study did not confirm these findings. Although we only followed two adult females and two adult males, the period of radio-tracking was long enough to exclude the influence of too small a sample size (see Table 1).

The home ranges of male lynx in the Polish Carpathians appeared to be much smaller (164 and 199 km<sup>2</sup>) than those estimated in other studies. The mean annual home ranges of males ranged within 190-343 km<sup>2</sup> in a lowland population in Poland (Białowieża Primeval Forest; Schmidt et al. 1997), within 275-450 km<sup>2</sup> in the Swiss Alps, and within 304-465 km<sup>2</sup> in the Jura Mountains (Breitenmoser et al. 1993). In Scandinavia, the observed home ranges were several times larger than home ranges reported elsewhere, ranging within 600-1,400 km<sup>2</sup> for resident males (Linnell et al. 2001).

Home-range sizes of the two female lynx in the Polish Carpathians (i.e. 124 and 190 km<sup>2</sup>) fell well within the range of home-range sizes observed elsewhere: 74-147 km<sup>2</sup> in the Białowieża Primeval Forest, Poland (Schmidt et al. 1997), 96-135 km<sup>2</sup> in the Alps and 98-337 km<sup>2</sup> in the Jura Mountains, both in Switzerland (Breitenmoser et al. 1993), and 300-800 km<sup>2</sup> in Scandinavia (Linnell et al. 2001). Preliminary data from radio-tracking of two female

lynx in Romania gave home-range estimates of 42 and 129 km<sup>2</sup> (Promberger-Fürpass et al. 2002).

Parturition has a great influence on the pattern of home-range utilisation by female lynx (Schmidt 1998). Most of this time females spend at the den taking care of their cubs. However, they can change the location of the den a few times. After July each year, females with older cubs expand the area used, which reaches its maximum size at the end of winter (Schmidt 1998). The behaviour of females F1 and F2 was similar to that of females in a lowland lynx population in the Białowieża Forest, Poland (Schmidt et al. 1997, Schmidt 1998). The female F1, which was followed during four breeding seasons, utilised only very small areas (see Fig. 4) during the first three months after parturition (May-July). Home-range sizes in that period were 13 km<sup>2</sup> (N = 30 radio-locations) in 1999, 5 km<sup>2</sup> (N = 18) in 2000, and 4 km<sup>2</sup> (N = 38) in 2001. After July, F1 expanded her home range to encompass 79 km<sup>2</sup> (N = 96 locations), 38 km<sup>2</sup> (N = 67), and 27 km<sup>2</sup> (N = 46), respectively, by the end of April the next year. In 2002, due to irregular radio-collar functioning, we were not able to estimate her May-July home range. However, we managed to confirm that F1 was breeding, because we found her den and cubs. Additionally, F1 gave birth in different locations within her home range in consecutive years (see Fig. 4).

Female F2 was followed during two breeding seasons and revealed different patterns of home-range utilisation. In 2002, her May-July home range was relatively large with 39 km<sup>2</sup> (N = 30 locations), and by the end of April 2003 it had expanded to 153 km<sup>2</sup> (N = 128). We assume that F2 lost her cubs relatively soon after parturition in 2002. Although we found her den with two cubs in early May 2002, we did not find any signs of young when snow-tracking this female in winter 2002/03. In 2003, the pattern of home-range utilisation by F2 was typical for nursing females in that her home range was only 18 km<sup>2</sup> (N = 23) in May-July, but by the end of the winter season it had expanded to 117 km<sup>2</sup> (N = 49).

The results of our study suggest that the spatial requirements of males in the native lynx population in the Carpathians are lower than in other populations. The question is, to what extent the observed differences are caused by density of prey, the composition of the prey community, and/or lynx population dynamics.

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