# The first density estimation of an isolated Eurasian lynx population in southwest Asia

Authors: Avgan, Batur, Zimmermann, Fridolin, Güntert, Marcel, Arıkan, Fehmi, and Breitenmoser, Urs

Source: Wildlife Biology, 20(4) : 217-221

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/wlb.00025

**Wildlife Biology 20: 217–221, 2014**
doi: 10.2981/wlb.00025

Subject Editor: Peter Sunde. Accepted 16 May 2014

# The first density estimation of an isolated Eurasian lynx population in southwest Asia

**Batur Avgan, Fridolin Zimmermann, Marcel Güntert, Fehmi Arıkan and Urs Breitenmoser**

*B. Avgan (baturoo@yahoo.com), PK121 Turgutreis, TR-48961 Muğla, Turkey. – F. Zimmermann, Thunstrasse 31, CH-3074 Muri, Switzerland. – M. Güntert, Natural History Museum Bern, Bernastrasse 15, CH-3005 Bern, Switzerland. – F. Arıkan, Ministry of Forestry and Water Affairs, Söğütözü 14/E, Ankara, Turkey. – U. Breitenmoser, Centre for Fish and Wildlife Health, Univ. of Bern, Länggassstrasse 120, CH-3012 Bern, Switzerland*

During November 2010–February 2011, we used camera traps to estimate the population density of Eurasian lynx *Lynx lynx* in Ciglikara Nature Reserve, Turkey, an isolated population in southwest Asia. Lynx density was calculated through spatial capture–recapture models. In a sampling effort of 1093 camera trap days, we identified 15 independent individuals and estimated a density of 4.20 independent lynx per 100 km², an unreported high density for this species. Camera trap results also indicated that the lynx is likely to be preying on brown hare *Lepus europaeus*, which accounted for 63% of the non-target species pictured. As lagomorph populations tend to fluctuate, the high lynx density recorded in Ciglikara may be temporary and may decline with prey fluctuation. Therefore we recommend to survey other protected areas in southwestern Turkey where lynx is known or assumed to exist, and continuously monitor the lynx populations with reliable methods in order to understand the populations structure and dynamics, define sensible measures and management plans to conserve this important species.

The Eurasian lynx *Lynx lynx* is the largest felid in almost all of its range in Asia and Europe. Although it is globally listed as Least Concerned by IUCN due to its large distribution, several of its subpopulations in Europe and southwest Asia are fragmented and considered endangered (Breitenmoser et al. 2008). While there have been a variety of detailed studies done on the European populations (Haller and Breitenmoser 1986, Okarma et al. 1997, Linnell et al. 2007, Zimmermann et al. 2007, Breitenmoser and Breitenmoser-Würsten 2008, Pesenti and Zimmermann 2013), almost no such research has been carried out on the populations in southwest Asia where even basic information such as distributions and abundance still remain unknown.

To generate reliable information on a local subpopulation in southwest Asia, we estimated the lynx population density by performing a camera trapping survey at Ciglikara Nature Reserve (Ciglikara NR) in Turkey. Our goals were: 1) to estimate lynx density in Ciglikara NR through spatial capture–recapture (SCR) model framework, and 2) to provide baseline information for a possible population monitoring programme in the region.

## Material and methods

### Study area

The study was conducted in Ciglikara NR (36°31′N, 29°49′E, 159 km², Fig. 1), an IUCN Category Ia site established in 1991 at Taurus Mountains in Antalya, Turkey. Elevation ranges from 1300 to 2450 m, and ridges of at least 1900 m altitude surround the central part of the reserve. The area represents a temperate conifer biome island in the Mediterranean climate region with the dominant tree species of Lebanon cedar *Cedrus libani* and Greek juniper *Juniperus excelsa*. The rate of endemism in flora is over 20% (Başaran et al. 2012). Although it was not shown in Turan (1984), which provides the only distribution map of lynx in the country, the lynx population in the region forms the southwestern edge of the species' distribution in Turkey (Avgan unpubl.).

### Preliminary survey

By carrying out an extensive camera trapping survey, we tested 14 sites on potential roads in various periods between 17 August and 28 November 2010 in order to identify suitable trap stations and pre-mark lynx individuals, which is believed to enhance the identification and hence the photo-capture rate of lynx in capture–recapture surveys (Zimmermann et al. 2007). Because the difference between road or trail type is known to affect the detection probability of animals (Harmsen et al. 2010), traps were set only on roads. We subsequently selected the sections of roads characterised by high concentrations of lynx activity as potential camera trap stations and plotted them in a geographic information system along with their associated details (i.e. elevation, shortest route to the site). In order to ease our

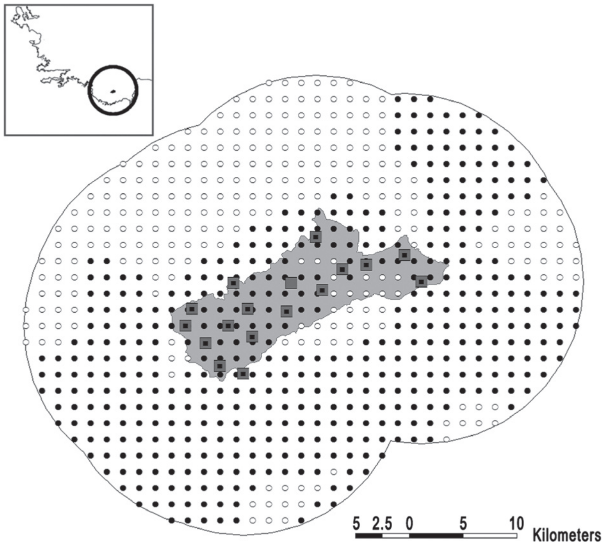


Figure 1. Details of the study area. Dark grey squares are camera trap sites whereas the ones with black spots indicate positive lynx detections. Black and white dots indicate suitable and unsuitable habitats respectively in the state-space that is shown with a thin line. The grey area is Ciglikara Nature Reserve. The inset shows the location of the reserve in southwestern Turkey (in circle).

access to camera trap stations in winter, we tried to select the sites located on south slopes.

### Survey setup

Winter is considered to be the best time for camera trapping due to more extensive movements of lynx before and during the species' mating season in March (Breitenmoser et al. 2006). We started the capture–recapture survey on 30 November 2010 before the first snowfall, mainly because setting traps during winter conditions would have been too difficult.

We carried out our survey simultaneously at 17 camera trap stations, each having a pair of opposing cameras to record both flanks of an individual simultaneously. We used digital Cuddeback Capture "Non-IR", Reconyx PC90 and PC900 and analogue Band-Genossenschaft camera trap models. In order to avoid any sampling biases, we did not set the cameras at known marking sites and did not use baits or lures. Wherever possible, we camouflaged the cameras with branches, lichens and rocks to hide them from humans and to avoid trap-shyness of lynx, known to influence the results by changing the detection probability of target species (Wegge et al. 2004). All cameras were active 24 h day$^{-1}$ and were checked in every 5–16 days, depending on snowfall that could have hampered the functionality of the cameras. To avoid data losses, we retrieved new images at our each visit to the trap sites.

The capture–recapture studies on lynx in Europe use a grid system in placing the cameras (Laass 1999, Zimmermann et al. 2007). We used a 2.5 × 2.5 km (6.25 km²) grid, which was starting to be applied for the European populations (Zimmermann unpubl.). By setting one station in every second grid cell, we placed a trap station in every 12.5 km². If no suitable sites were detected in a cell, we set the station in the adjacent empty cell. We excluded cells with > 2/3 of their area (> 4.15 km²) above 2000 m elevation (timberline in the south slopes) as we observed a decrease in photo-capture rates starting from November at this altitude (Results). Average minimum distance between adjacent trap stations was 2.5 ± 0.5 km (range = 1.7–3.9 km).

### Identification of individuals and sex

We identified the individuals from their distinct spot patterns at each flank shown in the photographs (Fig. 2). While the individuals photographed during the preliminary survey had clearly distinct spot patterning, their coat was changed into a greyish colour with longer hair in early November, making it more difficult to distinguish the black spots, especially on the photos of Reconyx cameras due to their slow shutter speed. Therefore, as the primary feature in identifying individuals, we relied upon the spot patterns on the lower hind legs that had shorter fur and were less blurred. We also used the spots on shoulders and inside the legs as secondary features whenever possible.

Because adult and sub-adult animals cannot be distinguished with certainty from pictures, we estimated the density of 'independent lynx', hence all individuals except juveniles. A male was only identified if his scrotum was seen in a picture. We identified females if we have a photograph with a good view underneath the tail, or they were photographed with juveniles.

### Analysis

Capture–recapture studies of lynx in Europe prior to our study have been carried out over periods of 60 days, made

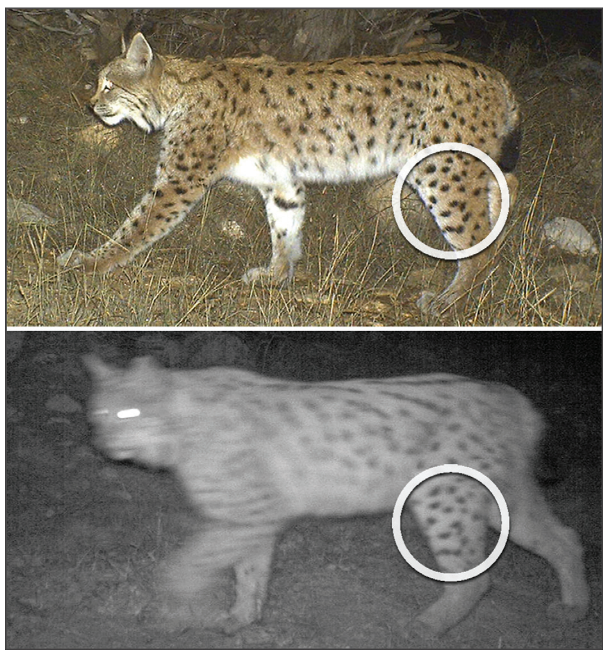

Figure 2. Two photos of Lx06 showing the coat patterns on the legs (in circles), which we used as the primary feature in identifying the individuals. The photo on the top was taken with a Cuddeback Capture "Non-IR" camera in summer, and the other was with a Reconyx camera during early-winter.

up of 12 occasions of 5 days each, to meet the assumption of population closure (Zimmermann et al. 2007, Melovski et al. 2008, Weingarth et al. 2012). In order to test whether a population can be closed for a longer period, we decided to conduct our survey up to 65 days, and use the longest duration without violating the assumption of demographic population closure, which we tested through the CloseTest program provided by Stanley and Burnham (1999).

For estimating lynx density by means of SCR analysis, we used the SPACECAP (Singh et al. 2010) software package accessed through the program R. Under the Bayesian modelling framework (Royle et al. 2009a, b), SPACECAP computes the density of species by using the spatial locations of captures in combination with the capture histories. SCR models assume that 1) each individual has an independent activity centre with a fixed location, 2) capture probability is decreased with increasing distance from the individual's activity centre, and 3) captures are independent events (Foster and Harmsen 2012).

For the SPACECAP package, we prepared three files on the details of captures, trap deployments including dates when specific traps were active, and potential home-range centres. The trap array was embedded in a larger area called the state-space, which had to be chosen large enough so that no individual outside of the state-space had any probability of being photo-captured on the array. In order to define the state-space we followed Pesenti and Zimmermann (2013) and buffered the trap stations by 15 km. The state-space was later described as a grid of 714 equally spaced centres, each of which were $1.5 \times 1.5$ km (2.25 km$^2$), corresponding to an area of 1606.5 km$^2$. We estimated the lynx density for all habitats (white and black dots; Fig. 1) and also for per unit of suitable habitat (black dots; Fig. 1) which we defined as all areas except human settlements, intensively used agriculture lands, lakes and elevations above 2000 m. In this case, whether a potential activity centre lies in suitable habitat ($=1$) or not ($=0$) is directly provided in the input matrix of the potential home-range centres. We identified 457 (1028.25 km$^2$) centres as suitable lynx habitat fragments while the remaining 257 centres were within unsuitable habitat (white dots; Fig. 1). Bayesian analysis of the model was conducted using data augmentation by increasing the data set with 100 all-zero encounter histories (Royle et al. 2007). We ran the model with three Markov chain Monte Carlo with 80 000 iterations, a burn-in of 40 000 and a thinning rate of three. We checked for chain convergence using the Gelman–Rubin statistic (Gelman et al. 2004), R-hat, which compares between and within chain variation. R-hat values below 1.1 indicate convergence (Gelman and Hill 2006). Values for all estimated parameters were below 1.09.

## Results

### Preliminary survey

Lynx were captured 67 times at 11 out of 14 potential trap stations during our 618 trap days preliminary survey, and we managed to identify 14 independent lynx plus 5 juveniles within this period.

### SCR survey and analysis

Because CloseTest results suggested a population closure ($\chi^2 = 15.25$; DF $= 11$; $p = 0.17$), we fixed the survey duration as 65 days, comprising 13 sampling occasions of 5 days each, between 30 November 2010 and 2 February 2011.

Camera traps were inactive for 12 trap days during the survey and the effective trapping effort was calculated as 99%. In a total of 1093 effective trap days, we obtained 75 captures of 15 independent lynx, among which we identified six males and five females. Except Lx16, we identified all individuals unequivocally. We excluded two lynx captures (2.7% of the total lynx captures) from the analyses because their photos showed no diagnostic details to correctly identify the individual. Lynx were photographed at 16 of the 17 camera stations (Fig. 1), with a minimum interval of 11 h between two captures of the same individual at the same station.

The posterior mean of the baseline encounter rate, $\lambda 0$ (95% posterior interval), was 0.214 (0.152–0.290), and the movement parameter was estimated as 2.90 (2.24–3.67). The 95% home range radius estimate was 7.09 km. We calculated the density by dividing the estimated posterior mean lynx population size (Nsuper $= 43.27$) by the area of the state-space within suitable lynx habitat (1028.25 km$^2$), which resulted in a mean posterior density estimate of 4.20 independent lynx/100 km$^2$ (2.33–6.22). When all habitats were considered the posterior mean density was equal to 3.17 independent lynx/100 km$^2$ (1.74–4.80).

Camera traps were triggered a total of 710 times and empty images comprised 11% of all captures, obviously caused by snowfall or wind. Excluding these false triggers ($n = 76$), photos of poachers (people with rifles, $n = 13$) as well as those of lynx ($n = 75$), non-target species represented 77 % ($n = 546$) of the total number of captures (Table 2). The most frequently captured species was brown hare *Lepus europaeus* (63%, $n = 343$), whereas the least was Bezoar goat *Capra aegagrus* (0.002%, $n = 1$). No ground birds such as chukar *Alectoris chukar* were photographed.

## Discussion

Lynx were recaptured 58 times (number of captures – number of individuals – number of unidentified lynx = number of captures) at 16 of our 17 trap sites during the capture–recapture study, indicating that we were successful in identifying their travel routes in Ciglikara NR during our preliminary survey. In order to increase the capture probability, an important requirement for capture–recapture studies (Otis et al. 1978), we highly recommend identifying and testing potential trap stations prior to surveys. The preliminary survey also allowed us to observe the change in photo-capture rates over time at the trap stations in different elevations. At trap station number 6 (1850 m a.s.l.), lynx photo-capture rate (number of captures per trap day) decreased from 0.44 in September to 0.10 in November during our preliminary survey. Therefore late summer to autumn can be a more suitable time period for the future camera trapping surveys in Ciglikara NR, especially if the number of camera traps and/or manpower is limited as in our study.

Lynx population density estimates from Europe have been derived from radio-telemetry data (Haller and Breitenmoser 1986, Breitenmoser et al. 1993, Breitenmoser-Würsten et al. 2001, Okarma et al. 1997), snow-tracking (Linnell et al. 2007) and capture–recapture surveys (Weingarth et al. 2012, Pesenti and Zimmermann 2013, Zimmermann et al. 2013). The estimates vary widely from 0.4 independent lynx/100 km² in Germany (Weingarth et al. 2012) to 3.2 resident individuals/100 km² in Poland (Okarma et al. 1997), while the highest density reported so far from a SCR survey was 1.47 independent lynx/100 km² for suitable lynx habitats (Pesenti and Zimmermann, 2013). The density of 4.2 independent lynx/100 km² suitable lynx habitat estimated in our survey at Ciglikara NR is so far the highest density ever reported within the global range of Eurasian lynx. We estimated the 95% home-range radius as 7.09 km. It was calculated as 10.71 and 12.75 in similar SCR studies done in Switzerland (Pesenti and Zimmermann, 2013, Zimmermann et al. 2013), which indicates that the lynx home-range in Ciglikara NR is likely to be smaller than the home-ranges in Swiss populations, and therefore the density is higher in the former.

While SCR analysis are known to be robust to the changes in the size of the sampling area, surveying small areas result in lower datasets and reduce the precision of the estimates (Sollmann et al. 2012, Zimmermann et al. 2013). The reason behind the wide confidence intervals in the movement parameter and the density estimates of our study was probably because of sampling low numbers of individuals and large proportions of individuals that were captured only once throughout the survey. We could detect only 15 independent individuals in the state-space of our capture–recapture survey, and five of them were captured only once (Table 1). Results of our entire camera trapping study of 2148 trap-days between 17 August 2010 and 30 March 2011 proved that keeping the survey duration longer may not radically increase the number of detected lynx individuals. Even in such a long period of time, although we captured the lynx 200 times, we identified only a maximum of 22 independent lynx (17 both flanks, three right flank, two left flank) plus eight juveniles in the study area during this period. Therefore sampling high number of individuals may not be achieved by keeping the duration of the survey longer, but increasing the size of the study area. Zimmermann et al. (2013) recommends using a minimum of 760 km² trap array for the lynx capture–recapture studies. However, because the density of lynx in Ciglikara NR is higher than the European populations, we believe that precise results can be guaranteed by surveying areas that are relatively smaller than 760 km² through SCR models.

The reason behind the observed high lynx density should be related with the prey base of the lynx in Ciglikara NR. Population density of carnivores is known to correlate with prey availability (Fuller and Sievert 2001). Eurasian lynx, including the Caucasus subspecies in Turkey, *Lynx lynx dinniki*, is known to hunt smaller ungulate species preferentially (Heptner and Sludskii 1972), but there is no population of such prey available even at a moderate abundance in Ciglikara NR (see the low photo-capture rate of Bezoar goat at Table 2; the only other ungulate detected was wild boar, which is not known to be a staple prey of lynx; Breitenmoser and Breitenmoser-Würsten 2008). Although it should be tested through scat analysis, the most likely lynx prey in Ciglikara seems to be the brown hare, which is known to be an important alternative prey in many areas of the species' global range (Breitenmoser and Breitenmoser-Würsten 2008). The high rate of brown hare captures (Table 2) indicates a healthy population in our study area. However, lagomorph populations are known to fluctuate which are followed by a similar fluctuation of the Eurasian lynx populations (Heptner and Sludskii 1972). Eurasian lynx show a considerable numerical response to changing availability of their staple prey (Breitenmoser et al. 2010), if no equally profitable alternative prey is available. Therefore if the observed high lynx density is a result of a healthy hare population, it may only be temporary and decline with decreasing hare abundance.

This is a risky situation. Even at such a high density, the relatively small Ciglikara NR can hold only a limited number of lynx. The reserve is part of the lynx range in southwestern Turkey, which is believed to be isolated from other lynx populations in the northeastern part of the country that are connected with the Caucasus populations. The distribution and structure of the lynx population in southern Turkey are not known. Likely, it is a fragmented population with more or less isolated nuclei in the protected areas, hence a metapopulation. The connectivity between

Table 2. Number and percent (P) of captures of all species. P is calculated from all captures (n = 710), while P-NT is from the captures of non-target species only (n = 546).

| | Captures | P | P-NT |
|---|---|---|---|
| Brown hare *Lepus europaeus* | 343 | 0.48 | 0.63 |
| Eurasian lynx *Lynx lynx* | 75 | 0.11 | – |
| Red fox *Vulpes vulpes* | 50 | 0.07 | 0.09 |
| Feral horse *Equus ferus* | 47 | 0.06 | 0.09 |
| Grey wolf *Canis lupus* | 31 | 0.04 | 0.06 |
| Caucasian Squirrel *Sciurus anomalus* | 28 | 0.04 | 0.05 |
| Wild boar *Sus scrofa* | 26 | 0.03 | 0.05 |
| Feral dogs *Canis familiaris* | 14 | 0.02 | 0.03 |
| Badger *Meles meles* | 6 | 0.001 | 0.01 |
| Bezoar goat *Capra aegagrus* | 1 | 0.001 | 0.002 |
| "Poachers" (people with rifles) | 13 | 0.02 | – |
| Empty images | 76 | 0.11 | – |
| Total | 710 | | |

Table 1. Details of independent lynx individuals photographed during the survey. Lx07 was identified before, but not captured during the survey. The two captures of unidentified lynx are not shown.

| | Lx01 | Lx02 | Lx03 | Lx04 | Lx05 | Lx06 | Lx08 | Lx09 | Lx10 | Lx11 | Lx12 | Lx13 | Lx14 | Lx15 | Lx16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex | M | F | F | F | F | M | M | – | – | M | F | M | M | – | – |
| Number of captures | 14 | 3 | 1 | 12 | 2 | 4 | 16 | 4 | 1 | 4 | 3 | 6 | 1 | 1 | 1 |
| Number of of sites | 6 | 2 | 1 | 5 | 2 | 2 | 5 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 1 |

subpopulations (e.g. existence of wildlife corridors), population structure and dynamics, feeding ecology and prey population dynamics have to be understood in order to define sensible conservation and management approaches.

Our study presented here is the first capture–recapture survey carried out in the Asian range of the Eurasian lynx, and demonstrated that camera trapping surveys were a relatively cost-efficient approach not only in obtaining quantitative data (i.e. population density), but also qualitative information (i.e. potential prey base) in studying this cryptic species. Given the assumed isolated status of the lynx in southwestern Turkey, we recommend a further survey in Ciglikara NR to observe possible changes in lynx abundance, and similar surveys in other protected areas in the region to understand the population structure.

*Acknowledgements* – We thank the Turkish General Directorate of Nature Conservation and National Parks for permission to conduct research in Ciglikara NR and their logistic support during the survey. We are grateful to Elias Pesenti for his assistance in GIS analysis, Hasan Uysal and Mehmet Ali Başaran for their help in fieldwork.

## References

Başaran, M. A. et al. 2012. Çığlıkara Tabiatı Koruma Alanı'nda doğal kaynak değerlerinin belirlenmesi. – Batı Akdeniz Ormancılık Araştırma Enstitüsü.

Breitenmoser-Würsten, Ch. et al. 2001. Untersuchungen zur Luchspopulation in den Nordwestalpen der Schweiz 1997–2000. – Report, KORA.

Breitenmoser, U. and Breitenmoser-Würsten, C. 2008. Der Luchs – ein Grossraubtier in der Kulturlandschaft. – Salm Verlag.

Breitenmoser, U. et al. 1993. Spatial organisation and recruitment of lynx (*Lynx lynx*) in a re-introduced population in the Swiss Jura Mountains. – J. Zool. 231: 449–464.

Breitenmoser, U. et al 2006. Guidelines for the monitoring of lynx. – KORA.

Breitenmoser, U. et al. 2008. *Lynx lynx*. – In: IUCN 2013. IUCN Red List of threatened species. Ver. 2013.2. <www.iucnredlist.org>. (accessed on 18 March 2014).

Breitenmoser U. et al. 2010. Eurasian lynx – changing predation impact as a source of conflict with reintroduced lynx in Switzerland. – In: Macdonald D. and Loveridge A. (eds), Biology and conservation of wild felids. Oxford Univ. Press, pp. 493–506.

Foster, R. J. and Harmsen, B. J. 2012. A critique of density estimation from camera-trap data. – J. Wildlife Manage. 76: 224–236.

Fuller, T. K. and Sievert, P. R. 2001. Carnivore demography and the consequences of changes in prey availability. – In: Gittleman, J. L. et al. (eds), Carnivore conservation. Cambridge Univ. Press, pp. 163–178.

Gelman A. and Hill, J. 2006. Data analysis using regression and multilevel/hierarchical models. – Cambridge Univ. Press.

Gelman, A. et al. 2004. Bayesian data analysis. – CRC/Chapman and Hall.

Haller, H. and Breitenmoser, U. 1986. Zur Raumorganisation der in den Schweizer Alpen wiederangesiedelten Population des Luchses (*Lynx lynx*). – Z. Säugetierkunde 51: 289–311.

Harmsen, B. J. et al. 2010. Differential use of trails by forest mammals and the implications for camera trap studies: a case study from Belize. – Biotropica 42: 126–133.

Heptner V. H. and Sludskii, A. A. 1972. Mammals of the Soviet Union. Vol III: Carnivores (Felidea). Moscow: Vyssha Shkola (in Russian). English translation: Hoffmann, R. S. (Ed). – Smithsonian Inst. and the National Science Foundation.

Laass, J. 1999. Evaluation von Photofallen für ein quantitatives Monitoring einer Luchspopulation in den Schweizer Alpen. – MSc thesis, Univ. of Vienna.

Linnell, J. D. C. et al. 2007. An evaluation of structured snow-track surveys to monitor Eurasian lynx *Lynx lynx* populations. – Wildlife Biol. 13: 456–466.

Melovski, D. et al. 2008. First camera trap survey in the national park Mavrovo, Macedonia. – Proc. Int. Conf. on Biological and Environmental Sciences, September 2008.

Okarma, H. et al. 1997. Predation of Eurasian lynx on roe deer and red deer in Białowiez – a primeval forest, Poland. – Acta Theriol. 42: 203–224.

Otis, D. et al. 1978. Statistical inference from capture data on closed animal population. – Wildlife Monogr. 62: 1–135.

Pesenti, E. and Zimmermann, F. 2013. Density estimations of the Eurasian lynx (*Lynx lynx*) in the Swiss Alps. – J. Mammal. 94: 73–81.

Royle J. A. et al. 2007. Analysis of multinomial models with unknown index using data augmentation. – J. Comput. Graph. Stat. 16: 67–85.

Royle J. A. et al. 2009a. Bayesian inference in camera trapping studies for a class of spatial capture–recapture models. – Ecology 90: 3233–3244.

Royle J. A. et al. 2009b. A hierarchical model for estimating density in camera trap studies. – J. Appl. Ecol. 46: 118–27.

Singh P. et al. 2010. SPACECAP: a program to estimate animal abundance and density using spatially-explicit capture–recapture. R package ver. 1.0.6. – Available at: <http://cran.r-project.org/web/packages/SPACECAP/index.html>. (accessed on 18 March 2014).

Sollmann, R. et al. 2012. How does spatial study design influence density estimates from spatial capture–recapture models? – PLoS ONE 7, e34575.

Stanley, T. R. and Burnham, K. P. 1999. A closure test for time-specific capture–recapture data. – Environ. Ecol. Stat. 6: 197–209.

Turan, N. 1984. Türkiye'nin Av ve Yaban Hayvanları – Bölüm 1: Memeliler. Ankara.

Wegge, P. et al. 2004. Effects of trapping effort and trap syness on estimates of tiger abundance from camera trap studies. – Anim. Conserv. 7: 251–256.

Weingarth, K. et al. 2012. First estimation of Eurasian lynx (*Lynx lynx*) abundance and density using digital cameras and capture-recapture techniques in a German national park. – Anim. Biodivers. Conserv. 35: 197–207.

Zimmermann, F. et al. 2007. Abondance et densité du lynx: estimation par capture–recapture photographique dans le Nord du Jura suisse. – Report, KORA.

Zimmermann, F. et al. 2013. Optimizing the size of the area surveyed for monitoring a Eurasian lynx (*Lynx lynx*) population in the Swiss Alps by means of photographic capture–recapture. – Integr. Zool. 8: 232–243.