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Status and distribution of the lynx (*Lynx lynx*) in the Italian Alps 2005–2009

Status in razširjenost risa (*Lynx lynx*) v italijanskih Alpah 2005–2009

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Abstract: To assess the status of lynx we analysed lynx signs of presence within the range of the Italian Alps from 2005 to 2009. A total of 268 signs have been collected, compared to 411 signs during the previous pentad. The distribution of the confirmed signs of lynx presence is confined to three concise areas: the North-eastern Alps of Friuli VG, the Trentino province and the Ossola valley in the Piedmont region. Occupancy modelling revealed a decrease of the lynx range by one third: The estimated number of occupied 100 km^2 cells decreased from 34 (pentad: 2000–2004) to 21 (pentad: 2005–2009). Less than 10% of the Italian Alps are colonized. We estimated the number of lynx present in all the Italian Alps at less than 15 individuals. Therefore, the persistence of lynx in the Italian Alps highly depends on immigration from neighbouring countries.

Keywords: Alps, distribution, Italy, *Lynx lynx*, monitoring, occupancy

Izvleček: Z namenom opredeliti status risa v italijanskih Alpah smo analizirali znake prisotnosti v obodobju 2005 do 2009. Skupno je bilo zbranih 268 znakov prisotnosti, primerjalno v pretekli pentadi pa 411 znakov. Razporeditev potrjenih znakov prisotnosti risa je omejeno na tri omejena, ločena območja: SV Alpe Julijske krajine, province Trentino ter doline Ossola v regiji Piedmont. Modeliranje zasedenosti prostora je pokazalo zmanjšanje razširjenosti risa za eno tretjino: ocenjeno število poseljenih 100 km^2 celic se je zmanjšalo iz 34 (pentada:2000–20004) na 21 v pentadi 2005–2009. To predstavlja manj kot 10 % površine Itlijanskih Alp. Ocenjujemo, da je na celotnem območju italijanskih Alp prisotnih manj kot 15 risov. Tako je obstoj risa na tem območju močno odvisen od imigracije živali iz sosednjih držav.

Ključne besede: Alpe, razširjenost, Italija, *Lynx lynx*, monitoring, zasedenost

Introduction

Lynx spread into north-eastern Italy at the beginning of the 1980s as a consequence of reintroduction projects in Austria and Slovenia (Guidali et al. 1990, Molinari 1998, Bologna & Mingozzi 2003). This established a population nucleus in north-eastern Italy with a connection to the Slovenian lynx occurrence. A second, isolated lynx occurrence was reported from the Southern Dolomites in the Trentino region (Ragni et al. 1998). Besides, some scattered observations were registered from the Val d'Aosta and the Piedmont region close to the Swiss border (Molinari et al. 2001, Bologna & Mingozzi 2003). The trend of the two most prominent lynx occurrences in Italy varied greatly. The one in Trentino was considered extinct by 1999 (Molinari et al. 2001), while the one in the north-eastern Alps persisted (Molinari et al. 2006).

In the frame of the SCALP (Status and Conservation of the Alpine Lynx Population, Molinari-Jobin et al. 2012), each Alpine country updates the status and distribution of lynx in the respective territory in 5-year intervals. The first status reports for Italy summarized the data from the reintroductions until 1995 (Molinari 1998, Ragni et al. 1998). The data from 1995 to 1999 were analysed by Molinari et al. (2001), and those from 2000 to 2004 by Molinari et al. (2006). Here, we give an overview on the development of the status and distribution of lynx in Italy summarizing data from 2005–2009. In fact, we compared the distribution of lynx signs in the period 2000–2004 with those of 2005–2009 by means of site-occupancy models (MacKenzie et al. 2006). These models jointly estimate the probability of occurrence and detection and therefore correct the distribution estimate for detection probability, i.e., the probability to detect the presence of a species at a site where it occurs.

Methods

We used a stratified approach to monitor lynx: the information for the whole Italian Alps is based on collected lynx signs of presence, in the north-eastern Alps camera traps were used to identify individual lynx and finally two male lynx were fit with GPS-GSM collars.

Signs of presence were collected analogous to the previous pentad (2000–2004, Molinari et al. 2006) by a network of people, mainly game wardens and foresters, who have attended special training courses. The number of trained people varied regionally: 3 Liguria, 44 Piemonte, 28 Val d'Aosta, 16 Lombardia, 58 Trentino Alto Adige, 26 Veneto, 54 Friuli V.G. (229 in total). Whenever possible, these "lynx experts" verified the signs of presence reported to them by the general public. Within each region, one or two persons were responsible for the centralisation of the data. By the end of the year the data were transferred to a common database. We distinguished three levels of reliability in accordance with the SCALP guidelines (Molinari-Jobin et al. 2012) and the possibility to verify the collected data:

C1: Confirmed "hard facts", verified and undisputable records of lynx presence such as (1) dead lynx, (2) captured lynx, (3) good-quality and geo-referenced lynx photos (e.g., from camera traps), and (4) samples (e.g. excrements, hair) attributed to lynx by means of scientifically reliable analyses.

C2: Records confirmed by a lynx expert (e.g. trained member of the network) such as (1) killed livestock or (2) wild prey, and (3) lynx tracks or other assessable field signs.

C3: Unconfirmed observations (kills, tracks, other field signs too old or badly documented, where however the description conforms to a lynx sign) and all observations such as sightings and calls which by their nature cannot be verified.

A dynamic site-occupancy model (MacKenzie et al. 2002, MacKenzie et al. 2003, MacKenzie et al. 2006, Royle & Kéry 2007, Kéry & Schaub 2011) was used to compare Alpine lynx distributions between two periods (2000–2004 and 2005–2009). This model jointly estimates the probability of occurrence and detection. It corrects the distribution estimate for detection probability, i.e. the probability to detect a specimen, where it indeed occurs. We compared two periods: 2000–2004 with 2005–2009. For this purpose we covered the Italian Alps with a grid of 756 squares of 100 km^2 each. Our analysis is based on two assumptions (Molinari-Jobin et al. 2012): (1) Lynx distributions remained unchanged within the two periods. This assumption may have been violated to some degree. As a consequence, our estimate of occupancy may refer to the area of use rather than the permanent presence of lynx (MacKenzie et al. 2006). (2) Owing to the large number of persons and organisations that collaborate in the Alpine lynx monitoring, we assumed that there is a non-zero chance of detecting a lynx in every occupied 100 km^2 cell in each year (i.e. no cell was devoid of any monitoring efforts). Only if this assumption is met we can treat years without a lynx record as a zero rather than as a missing value in the detection history fed into the site-occupancy model. We strongly believe that this assumption holds for the vast majority of cells in our study area. If invalid, our probabilities of detection are underestimated, while probabilities of occupancy are overestimated.

We defined a multi-season occupancy design and modelled as data seasons of four-months (January to April, May to August, September to December) out of the five years in which lynx records were obtained in a 100 km^2 cell. Hence, within a season we ignored more than one record per cell and simply distinguished between cells and seasons in which no lynx was recorded (yielding a “0”) and those with at least one record (yielding a “1”). The dynamic site-occupancy model is a state-space model, i.e., it distinguishes a latent (only partly observed) ecological process, which produces a state of occurrence or non-occurrence, and a dependent observation process, which produces the actual detection/nondetection observations. The ecological process is defined by the occurrence probability (= occupancy) in the first year (ψ) and the dynamic parameters of survival (also called extinction), ε, and of colonisation, γ. The observation process is defined by the annual detection probability p_t. We fitted a separate model to the two periods (2000–2004, 2005–2009) using only the confirmed data (C1 and C2). We assumed that the probabilities of first-year occupancy (ψ) and of extinction (ε) and colonisation (γ) were constant over the 756 100 km^2 cells. We also assumed that the detection probability differed only by season, but not among cells nor among years. We performed the occupancy analyses using the program PRESENCE (Hines 2006).

The site-occupancy model yields a detection-corrected estimate of the species distribution based on the number of occupied 100 km^2 cells. For comparison with the previous status report (Molinari et al. 2006), we buffered the location of each point with a 5 km radius, resulting in an area of approx. 80 km² for each record. This area corresponds roughly to an average female lynx home range size in the Alps (Breitenmoser-Würsten et al. 2001). All maps were drawn in ArcGIS 9.3.1 (Environmental Systems Research Institute, Inc. Redlands, CA).

Results

From 2005–2009, a total of 268 signs of lynx presence have been collected (Table 1), compared to 411 signs during the previous pentad (Molinari et al. 2006). The number of reported presence signs decreased steadily from 2005 to 2009. The distribution of the confirmed signs of lynx presence is confined to three concise areas: the North-eastern Alps of Friuli VG, the Trentino province and the Ossola valley in the Piedmont region (Fig. 1). Unverified signs origin in the Belluno province, South Tyrol and in the Western Alps where a few records are reported close to the French border. For the years 2005 to 2009, no signs of reproduction have been reported.

We photographed lynx four times on passages, and three times at kills in the north-eastern Alps during this pentad. The same lynx was pictured all the time, with one exception. Besides, in March 2007 a male lynx was captured and fit with a GPS/GSM collar in the Carnic Prealps of Friuli VG. The home range of this lynx covered 120 km^2 (Nadalini et al. 2010). Additionally, another male lynx was caught in February 2008 in Switzerland that dispersed to the Trentino region (Haller 2009), where he used a home range of 327 km^2 (Groff et al. 2011).

The area occupied by lynx (estimates of 5 km radius buffer) ranged from 731 km^2 (C1 data) to 1868 km^2 (C2 data) and to 4185 km^2 (C3 data). The area covered with C1 data increased based on intensified use of camera traps, while the area covered with C2 and C3 data decreased compared to the previous pentad (C2: 2491 km^2, C3: 6534 km^2, Molinari et al. 2006). The Italian Alps comprise an area of 51.052 km^2. Lynx signs of presence were recorded on less than 5% of the Italian Alps, considering confirmed data (C1 and C2) only, and less than 10% considering all data.

Table 1: Number of lynx records collected per year and category.
Tabela 1: Število zabeleženih znakov prisotnosti po letih in kategorijah.

Category 1	2005	2006	2007	2008	2009	Total
Photo	5	2		1	2	10
Scats	6	1				7
Total	11	3		1	2	17
Category 2						
Wild prey remains	14	14	1	1	2	32
Tracks	36	32	5	6	13	92
Total	50	46	6	7	15	124
Category 3						
Wild prey remains	5	6	5	2	1	19
Tracks	15	5	7	2	2	31
Sightings	21	17	11	11	11	71
Vocalisations	1	1		1	1	4
Scats		2				2
Total	42	31	23	16	15	127
Total all categories	103	80	29	24	32	268

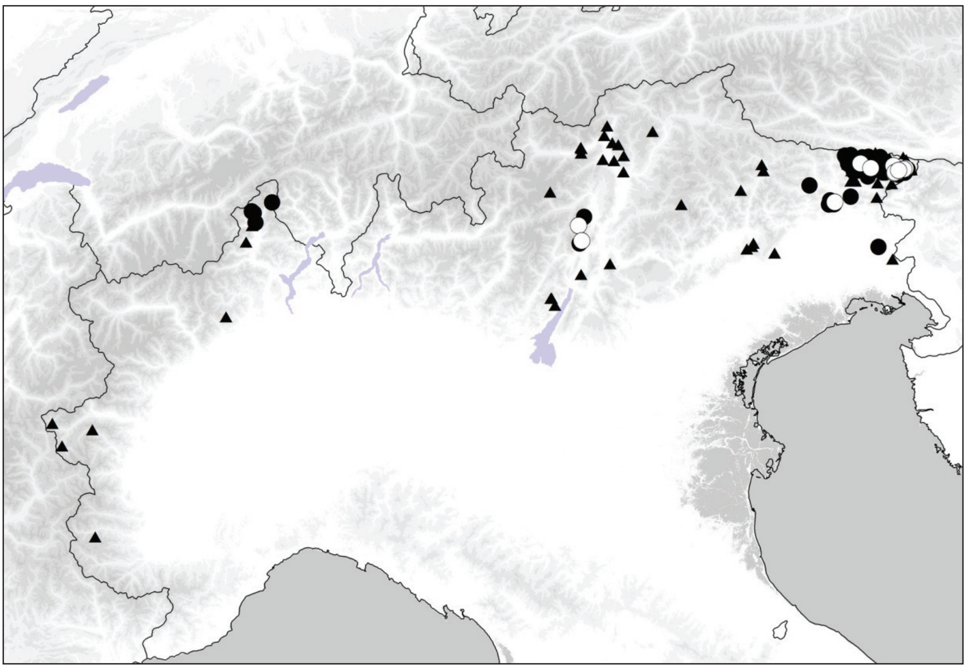

Figure 1: Distribution of lynx signs of presence in the Italian Alps for the five-year period 2005–2009 (white points = confirmed hard fact data C1; black points = confirmed data C2; black triangles = unconfirmed data C3).

Slika 1: Razporeditev znakov prisotnosti risa v italijanskih Alpah v petletnem obdobju 2005–2009 (bele točke = potrjeni neposredni dokazi prisotnosti C1; črne točke = potrjeni podatki C2; črni trikotniki = nepotrjeni podatki C3).

Occupancy modelling revealed differences between the two pentads in the occupied area: the number of cells recording lynx decreased from 30 (2000–2004 period) to 19 (2005–2009 period, Table 2). The estimated number of occupied cells decreased from 34 (first pentad) to 21 (second pentad). The area occupied by lynx had decreased by more than one third. The probability that lynx colonize a previously unoccupied cell was 0 for both periods. The probability of local extinction decreased from 0.13 (2000–2004 period) to 0 (2005–2009 period). Given a cell is occupied by lynx, the probability of detecting lynx was low and varied between periods and seasons (Table 2). In our analysis, the best season for detecting lynx was from January to April.

Table 2: Observed number of occupied 100 km^2 cells and parameter estimates under the site-occupancy model (posterior means and standard deviations are shown).

Tabela 2: Opaženo število zasedenih 100 km^2 celic in ocena parametrov po modelu zasedenosti (site-occupancy model) (prikazane so ocenjene srednje vrednosti in standardne deviacije).

Metric of distribution	2000-2004	2005-2009
Number of occupied cells	30	19
Initial occupancy (ψ)	34.47 ± 6.20	21.17 ± 4.91
Ratio observed/estimated number of occupied cells	0.87	0.90
Probability of extinction (ε_i)	0.13 ± 0.05	0
Probability of colonisation (γ_i)	0	0
Detection probability (p) by season		
January – April	0.35 ± 0.05	0.22 ± 0.04
May – August	0.11 ± 0.03	0.04 ± 0.02
September – December	0.27 ± 0.04	0.16 ± 0.04

Discussion

Lynx signs of presence have decreased from the previous (2000–2004) to the current (2005–2009) pentad. The occupied area diminished by one third. Lynx presence was confirmed only in three out of seven Alpine regions: Friuli VG, Trentino Alto Adige and Piedmont. The distribution of signs of presence indicates a continuous occurrence in Friuli. Only single individuals are suspected to occur in Trentino Alto Adige and Piedmont. An underestimation of the lynx range is possible. However, the network of trained people did not decrease, i.e. contacts remained the same as in the previous pentad and more people have been trained especially in the Piedmont region. Moreover, we used occupancy modeling to take the observation process into account.

The occupancy model estimated the probability of local extinction at 0.13 for the 2000–2004 period and at 0 for the 2005–2009 period. This may indicate that the distribution has stabilized at the presently low level, with less than 10% of the Italian Alps colonized. The persistence of lynx in the Italian Alps highly depends on immigration from neighbouring countries. However, the number of lynx is estimated at up to 5 individuals in the Slovenian Alps with a decreasing trend (Kos et al. this volume). There is a high chance that lynx from the Swiss population will immigrate, as Switzerland is the only Alpine country from which regular reproduction is reported (Zimmermann et al. 2011). However, the aim of connecting the north-western and the south-eastern lynx subpopulations (Molinari-Jobin et al. 2003) is far from being reached. The south-eastern Alpine occurrence seems to have lost its expansion potential.

Four individual lynx were identified in the Italian Alps in 2009: two by means of radio-tracking and two by means of camera traps. Three of these lynx were identified in Friuli VG and one in the Trentino province where there is still no prove that other lynx frequent the area. We estimated the number of lynx present in all the Italian Alps at less than 15 individuals.

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