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Short Communication

# Lethal male–male interactions in Eurasian lynx

Jenny Mattisson[a,b,*], Peter Segerström[b], Jens Persson[b], Malin Aronsson[b], Geir Rune Rauset[b], Gustaf Samelius[b], Henrik Andrén[b]

[a] Norwegian Institute for Nature Research, NO-7485 Trondheim, Norway
[b] Grimsö Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences, SE-730 91 Riddarhyttan, Sweden

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ABSTRACT

Eurasian lynx (*Lynx lynx*) is considered a solitary, territorial felid with a low degree of direct intraspecific interactions. Between 2002 and 2011 we observed four aggressive interactions between five different male Eurasian lynx, where two were lethal. All interactions occurred during the mating season and three of the interactions resulted in takeover of the home range by the intruder. Thus, in this study we demonstrate that aggressive interactions, sometimes with severe consequences, occur in male Eurasian lynx and suggest that they are driven primarily by access to female lynx in the mating season.



Lethal fighting is rare in long-lived mammals, and is only expected to occur when the future value for the individual is substantially increased by the contested resource (Enquist and Leimar 1990). For solitary carnivores, male territoriality is a consequence of competition for females (Sandell 1989) and lethal interactions are only predicted to occur if victory leads to a significant increase in future mating opportunities (Enquist and Leimar 1990). Eurasian lynx (*Lynx lynx*) are in general described as solitary carnivores where direct interactions mainly occur between females and her young of the year and between females and males during mating season (Breitenmoser-Würsten et al. 2007). Lynx exhibit a polygamous mating system, and consequently males establish territories that overlap with several females. In northern Scandinavia, home range sizes of male lynx average 1776 km$^2$ and that of female lynx average 777 km$^2$ (Mattisson et al. 2011). Although lynx are viewed as territorial they still allow a certain degree of intrasexual overlap in home ranges (Schmidt et al. 1997; Breitenmoser-Würsten et al. 2007; Mattisson et al. 2011) and direct intraspecific interactions occur occasionally both within and between sexes also outside mating season (Wölfl and Wölfl 1996; Sunde et al. 2000; Mattisson et al. 2011). Aggressive interactions have been documented in several solitary felids such as cougar (*Puma concolor*; Akeson et al. 2005), Canadian lynx (*Lynx canadensis*; Mowat and Slough 1998), tiger (*Panthera tigris*; Smith 1993), including Eurasian lynx (Wölfl and Wölfl 1996; Sunde et al. 2000). During a long-term study on Eurasian lynx in Northern Sweden, we documented several aggressive interactions between lynx individuals, all occurring in the same valley within 20 km of each other.

The study area is located in and around Sarek National Park, and is characterized by deep valleys, glaciers, and high alpine plateaus with peaks up to 1700–2000 m a.s.l. (see Mattisson et al. 2011 for a detailed description of the study area). Between 2002 and 2011 we observed four cases of aggressive interactions between five different adult male lynx (Table 1). Two of these interactions resulted in the death of one of the males. This article reports the details of these male–male interactions.

The lynx were captured by darting from helicopter and immobilized with medetomidine-ketamine, following pre-established protocols (Arnemo et al., 2011) and equipped with either a radiocollar (Telonics Mod 335 or Mod 400) or an intraperitoneally implanted VHF-transmitters (IMP/400/L, Telonics Inc., Mesa, AZ, USA). GPS-collars (Televilt PosRec$^{TM}$ C300, TVP positioning AB, Lindesberg in 2002–2007 and GPS plus mini, Vectronic Aerospace GmbH, Berlin, Germany, in 2008–2011) were additionally fitted on four individuals. The handling protocol was approved by the Swedish Animal Ethics Committee and fulfilled the ethical requirements for animal research. Dead lynx were sent to the Swedish National Veterinary Institute (SVA) for verification of mortality cause and examination of general body conditions. Lynx home ranges (100% Minimum Convex Polygons, MCP) and mean overlap were estimated using Ranges8 (v2.7, Anatrack Ltd., Wareham, UK).

## Case 1—lethal

Male lynx L-9627 was equipped with a VHF-transmitter in 1998 when he was at least 3 years old (tattooed as an adult in March

* Corresponding author at: Norwegian Institute for Nature Research, NO-7485 Trondheim, Norway. Tel.: +47 40452829.
*E-mail address:* jenny.mattisson@nina.no (J. Mattisson).

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**Table 1**
Monitoring details of the five male Eurasian lynx involved in the aggressive interactions documented in the Sarek area in 2002–2011.

| Lynx | First capture | Last contact | Comment |
|---|---|---|---|
| L-9627 | 1996-03-27 | 2002-03-25 | Killed by L-9978 |
| L-9978 | 1999-02-23 | 2005-03-15 | Killed by L-03134 |
| L-03134 | 2003-04-04 | 2010-05-28 | Lost contact with lynx |
| L-08179 | 2008-03-07 | | Still monitored (2012-06-01) |
| L-10196 | 2010-03-24 | 2012-03-31 | Lost contact with lynx |

1996). He was radio-tracked biweekly and was stationary in the same area between 1998 and 2002. During a telemetry flight event on the 24th of March 2002, L-9627 was observed alive but severely injured and with bite marks on his head. Fresh tracks from L-9627 and another lynx were observed on the site and when backtracked there were clear signs of fighting in the snow. Another male (L-9978, who was equipped with a VHF-transmitter as an adult in 1999) was observed from the air together with a radio-collared female 700 m away with no obvious signs of injury. On the 25th of March 2002, L-9627 was found dead at the same location he was found the previous day. The necropsy showed that he was most likely killed by a lynx, which suggests that he was lethally injured by male L-9978. Subsequently, L-9978 took over the range previously used by the deceased L-9627 (Fig. 1a).

## Case 2—lethal

Lynx L-9978 remained in the range used by L-9627 for three years and was equipped with a GPS-collar during this period. During a telemetry flight on 30th of March 2005 a mortality signal was detected from his GPS-collar. At the time of retrieval of the dead lynx, the condition of the corpse was in a late state of decomposing. The cause of death was difficult to establish but the necropsy showed bleedings and fracture on the head indicating that the lynx had been exposed to trauma. Location data reveals that death occurred between 14th and 15th of March 2005. GPS-data from a neighboring male lynx (L-03134, GPS-collared as an adult in 2003) shows that he had been on the exact same site during these two days and that there clearly had been close interactions between the two males (Fig. 1b). This suggests that L-03134 had killed or caused lethal injuries to L-9978. L-03134 weighed 33 kg at capture on 24th of February 2005 and L-9978 weighed 25.6 kg on 28th of February 2005. Subsequently, L-03134 took over the range previously used by the deceased L-9978 (Fig. 1a).

## Case 3—non-lethal

Lynx L-03134 remained for three years in the former range of L-9978 and L-9627. On 7th of March 2008 we attempted to recapture L-03134. When localized, L-03134 was observed leaping injured

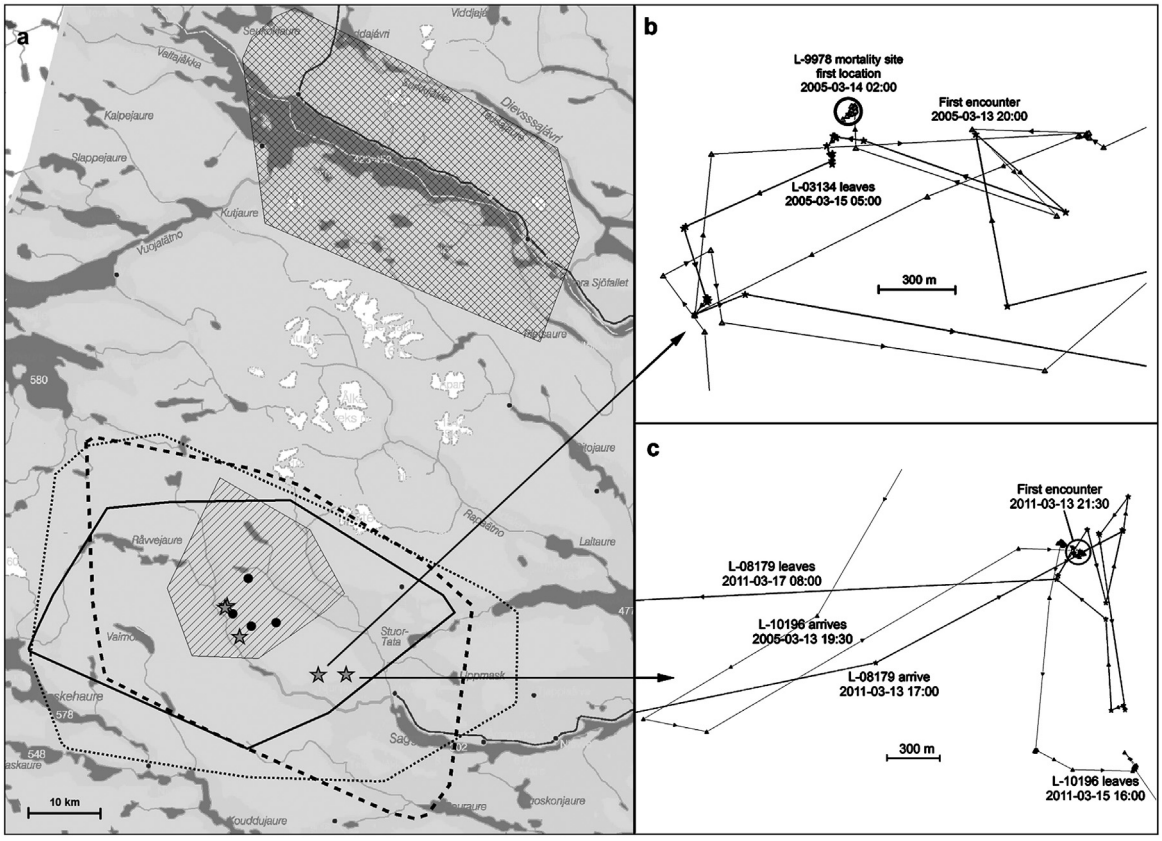


**Fig. 1.** (a) Home ranges of four male lynx that replaced each other through aggressive interactions in 2002–2011. Striped area: L-9627 in 1998–2002 (only VHF-data); solid border: L-9978 in 2002–2004; striped border: L-03134 in 2005–2007 and dotted border: L-08179 in 2008–2011. Stars indicate sites of interactions and solid dots center points of the four ranges. The crosshatch area shows the home range of L-03134 after being replaced at his former range. (b) GPS-locations (every third hour) of the lethal interaction between L-9978 (gray triangles) and L-03134 (black stars) and (c) GPS-location of the aggressive interaction between L-10196 (gray triangles; 24 locations/day) and L-08179 (black stars; 8 locations/day).

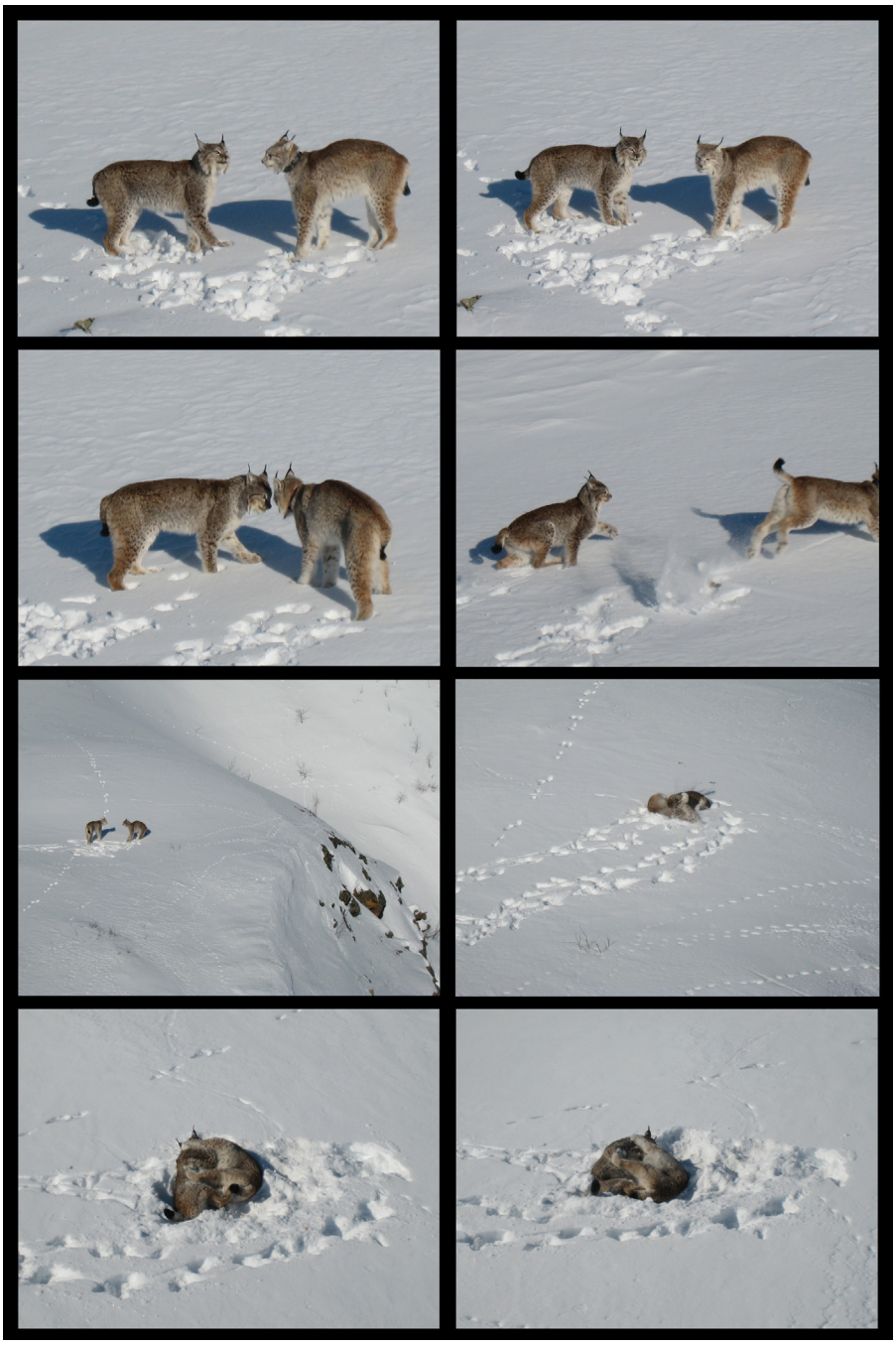

**Fig. 2.** Aggressive interactions between two male lynx (L-03134 with implanted VHF transmitter and L-08179 with GPS-collar) observed on the 29th of March 2008. Photo: Peter Segerström.

from a bed site. The area was covered by tracks from more than one lynx, signs of fighting, and blood-stained bed sites. Because of his injuries we decided to not recapture L-03134. The tracks of the other lynx were followed and it was located nearby, looking healthy and was darted at the site. Some minor injuries were observed on one front leg and one paw. The lynx was fitted with a GPS-collar, estimated as an adult male and given the identity L-08179. On 25th of March, 18 days later, L-03134 and L-08179 were observed together from helicopter, involved in a fight (Fig. 2). The fight was observed for 9 min. After this event lynx L-08179 took over the range of L-03134 suggesting that he was the winner of the prolonged fight, and he was still monitored in the same area in June 2012 (Fig. 3). L-03134 left his former range and was re-collared on April 19th 2008. He was alive at least until summer 2010 when we lost contact with him (37 km from his former range; Fig. 1a).

### Case 4—non-lethal

In 2011, lynx L-08179 still occupied the range of the previous three males. At this time both L-08179 and a neighboring male (L-10196, captured as an adult in 2010) were equipped with GPS-collars. GPS data from both individuals revealed that L-08179 was

**Fig. 3.** Aggressive interaction between two of male lynx (L-03134 and L-08179) with parts of the winners home range in the background. Photo: Peter Segerström.

challenged by L-10196 on the 13th of March 2011. L-10196 entered the range of L-08179 and encountered the 3–6 h old tracks of L-08179 which he presumably followed. Two hours later the two males met and interacted directly for at least 4 h. L-08179 stayed in the area 3.5 days after the interaction occurred, while L-10196 moved (after 18 h) to a rest site 1 km away where he remained for another 25 h (Fig. 1c). One week later, he was located back in his original range. Field visits to the site revealed tracks and several blood-stained daybeds, suggesting that fighting had occurred. This time the male lynx that occupied the range (L-08179) remained in the area after the interaction, and is still (June 2012) monitored in that range.

The four events of aggressive male–male interactions reported here occurred within a confined area. The challenging males' new home ranges overlapped substantially with the home ranges of the deceased or chased-off males (Fig. 1a, Table 2) and the centers of the home ranges of the four males that replaced each other were within a radius of 4 km. Before these interactions the home range overlap between these males was low (Table 2). The two lethal interactions reported here, constitute 33% of confirmed adult male mortalities ($n = 6$) in the study area. Lethal killing was not documented elsewhere although we have had radio-marked lynx males in other parts of the study area. Furthermore, we have not observed lethal interaction among lynx males in other study areas in Sweden and Norway (Andrén et al. 2006).

The described cases of intraspecific interactions in male Eurasian lynx clearly represent attempts on territory displacement. All observed aggressive interactions occurred during the mating season in March. In 3 of 4 occasions when we documented a dominant male being challenged by another male the challenger took over the range, and consequently mating opportunities with the overlapping females. In fact, in all of these cases, the new male was observed with one of the collared females in the area after the interaction (either visual or from GPS-data). Multiple paternity have been observed in captive lynx (Naidenko et al. 2007) implying that the challenger can still gain direct reproductive success (same year) even if the female is already fertilized. In 3 of the 4 cases the intruder was the winner, suggesting that lynx do not challenge another male without a high probability to win. Physical intraspecific confrontations are likely avoided by sophisticated scent-marking system (Wölfl and Wölfl 1996) as injuries attained from fighting can have long term consequences. During most of the year, home range overlap between males was about 20% (Mattisson et al. 2011) suggesting less aggressive interactions outside mating season.

The study area has a low turnover in adult lynx compared to other areas of Scandinavia where hunting is more intensive (Andrén et al. 2006). A lower turnover of lynx results in fewer vacated areas, and hence, fewer opportunities for male lynx to establish home ranges and breed. Our observations of fights that lead to mortality or severe injuries implies that access to females is limited in our study area as fighting for resources that can be gained elsewhere is seldom fierce (Enquist and Leimar 1990). A low turnover allows for territorial dynamics where younger individuals have to challenge older established males to obtain their own territory and secure future reproduction. The winners of the aggressive interactions reported above remained in the conquered range for three to four years before being challenged by new males. Male lynx in areas with high hunting pressure often get shot during their prime age and their ranges are in general quickly occupied by a new male (Odden, J., personal communication), and in these areas males can gain access to a home range and the females associated with it without challenging resident males. The observations from this study demonstrate that aggressive interactions occur among male Eurasian lynx and provide further details on previously documented aggressive interactions and intraspecific killing in Eurasian lynx (Wölfl and Wölfl 1996; Sunde et al. 2000). We suggest that

**Table 2**
Overlap of home ranges and distances between center points in home ranges of male lynx before (simultaneous ranges) and after aggressive interactions. The range overlap after the encounter was estimated between the previous home range of the deceased or defeated lynx and the home range of the winner. The winners are marked in bold.

| Range occupant | Challenger | Year | Overlap of home ranges (MCP) | | Distance between center points of home ranges (km) | |
|---|---|---|---|---|---|---|
| | | | Before | After | Before | After |
| L-9627 | **L-9978** | 2002 | 0% | 97% | 28 | 6 |
| L-9978 | **L-03134** | 2005 | 24% | 94% | 25 | 8 |
| L-03134 | **L-08179** | 2008 | –[a] | 75% | –[a] | 4 |
| **L-08179** | L-10196 | 2011 | 19% | 29%[b] | 31 | 26[b] |

[a] No data on L-08179 before encounter.
[b] This is estimated on simultaneous ranges as no overtaking occurred.

access to mating opportunities is the primary reason initiating these high-risk territorial strives.

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