



## Lynx eats cat: disease risk assessment during an Iberian lynx intraguild predation

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### Abstract

Lethal interactions between members of the carnivore guild are well represented in literature. In the Iberian lynx, interspecific killing (without prey consumption) of some mesocarnivores, such as the Egyptian mongoose, genet, and red fox, has been reported. Although vaguely documented, evidence suggests feral cats fall victim to interactions with this apex predator. Here, we describe the first documented case of interspecific killing and partial consumption of a feral cat by an adult male Iberian lynx reintroduced in Southwestern Spain. Ulterior analyses demonstrated that the victim was viremic to feline leukemia virus. To prevent the dissemination of the virus and a potential outbreak in the Iberian lynx population, control measures, including the clinical evaluation of the male Iberian lynx, and intensive monitoring were implemented in order to detect intraspecific interactions. After 3 weeks, the lynx was evaluated, presented good condition and resulted negative to both ELISA and RT-PCR. Thanks to the long-term monitoring, this case could be detected and measures to prevent an outbreak could be implemented.

**Keywords** Disease risk · Feline leukemia virus · Iberian lynx · Intraguild predation · Spill-over

One of the most common and best-documented antagonistic relationships in carnivore ecological networks is intraguild predation (IGP) (Montoya et al. 2006; Lourenço et al. 2014). Contrary to predator-prey interactions, IGP is motivated both by competition and predation, often producing concurrent

effects on the ecology of the interacting populations (Polis et al. 1989). Typically, top predators are known to modulate mesopredator populations and thereby prey species by means of IGP (top-down effect; which is highly dependent on human context; Haswell et al. 2017). In IGP, killer may benefit from removing a potential predator for itself or its offspring, increase its prey population as it regulates competition for the same food source, or even it may gain energy from its victim's consumption (Palomares and Caro 1999).

The Iberian lynx (*Lynx pardinus*) is a trophic-specialist, medium-sized cat considered an apex predator which inhabits the Iberian Mediterranean ecosystem (Monterroso et al. 2016). Because IGP from Iberian lynx to most sympatric mesocarnivores has been largely demonstrated (Palomares et al. 1996, 1998; Palomares and Caro 1999; Viota et al. 2012), a top-down effect has been proposed to occur (Monterroso et al. 2015). Interestingly, consumption of the victim by the aggressor Iberian lynx has never been reported. Whereas most research has focused on wild mesocarnivores, the information about IGP from Iberian lynx towards domestic cats (*Felis catus*) is scarce. There is evidence of contact inferred from disease transmission (Meli et al. 2009; Palomares et al. 2011) and, prior to this communication, there are just few cases detected in routine monitoring. In

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Andalusia, from 2006 to 2018, five cat carcasses (including one European wildcat *Felis silvestris*) have been found in Iberian lynx territories, with signs suggesting lynx as the author of the killings (e.g., neck bites, measured intercanine distance ~ 32 mm; LIFE project unpublished data). Although none of these cases followed a necropsy examination, a health check in one of the documented killing lynxes revealed a FeLV-provirus positive status by qPCR, which it presumably could get infected after the cat contact.

Implications of this particular IGP are paramount considering the conservation status of the Iberian lynx (Rodríguez and Calzada 2015) and the potential role of this interaction on disease transmission (see Meli et al. 2009). Here, we describe (1) the first observation of an Iberian lynx killing and consuming a domestic cat, (2) the subsequent findings associated with this interaction, and (3) the measures taken both to determine the sanitary status of the Iberian lynx and to prevent a potential FeLV outbreak after the episode.

The study area is located in Matachel river valley in SE Extremadura (SW Spain). Since 2014, conservation efforts to restore the Iberian lynx in Extremadura have been carried out within the framework of the project LIFE+10NAT/ES/570 which aims to recover the historical range of the species in Spain and Portugal. Nearly 60% of the reintroduced lynxes in Extremadura have been released in a single ca.10000 ha of private land, consisting of a mixture of holm oak trees (*Quercus ilex*), dense scrub (i.e., gum rockrose *Cistus ladanifer*), and open pasture. After Iberian lynx reintroduction, between January 2015 and December 2017, we found several cases of IGP from lynx to other mesocarnivores (12 Egyptian mongoose *Herpestes ichneumon*, one stone marten *Martes foina*, and one least weasel *Mustela nivalis*). To date, 36 Iberian lynxes have been released in Extremadura and 43 kittens have been produced (32 surviving up to 2018). The small population size during the initial years of the reintroduction, low genetic diversity along with the co-existence with other carnivores that may act as disease reservoirs may put the Iberian lynx reintroduction at risk of stochastic events such as epidemics (De Castro and Bolker 2005). Among all other pathogens, the Feline Leukemia Virus (FeLV) has shown to be critical in the Iberian lynx population since the emergence of an outbreak in 2007 in Doñana, one of the two last strongholds of the species at that moment (López et al. 2009). That aggressive outbreak killed 2/3 of the infected lynxes, probably due to increased host susceptibility to pathogens (Meli et al. 2010; Geret et al. 2011), since the FeLV sequences isolated from that outbreak revealed its relationship with naturally occurring FELV-A infections in domestic cats (Geret et al. 2011). Under this scenario, a routine FeLV epidemiological surveillance was implemented from the very beginning of the reintroduction

program in Extremadura. Since then, only one lynx was identified as FeLV-provirus positive by PCR in samples of spleen and bone marrow out of 27 lynxes sampled to date (Masot et al. 2017).

On December 13, 2017, a VHF radio-collared male Iberian lynx (known as “Komodo,” reintroduced in June 2014, weighing 7.85 kg.) was seen by three private ranch rangers/wardens at 18:20 h in an open pasture area that included few farming facilities. At the time of the observation, rangers were on foot. They were able to identify the individual thanks to the color of its radio collar since it is the only individual in the area fitted with a black radio collar. On close observation (between 30 and 40 m), it was determined that the lynx was consuming a black-fur prey. Rangers stayed at that distance for less than 5 min, and then they moved further away. “Komodo” stayed by the prey for at least 40 min. The rangers contacted the project personnel to inform about the observation. Once the lynx left the area, inspection of the site by field technicians revealed the rests of a domestic cat carcass (Fig. 1a), including the skin, head, four limbs, spleen, stomach, intestines, and genitourinary system. Subsequently, the carcass was retrieved from the field, placed in a plastic bag, and located inside a refrigerator and the project’s veterinarian was informed about the case. The veterinarian performed a necropsy in order to obtain samples for disease screening. The cat was confirmed to be a male. During close examination of the head, the left ocular globe was missing, and the skull presented two ~ 5 mm puncture wounds in the frontal bone, most probably inflicted by the lynx’s canines (Fig. 1b). An attempt to collect blood for FeLV screening was performed from the right and left internal iliac veins, which were the largest veins found in the carcass. A total of 0.4 ml of blood was obtained and placed in an EDTA tube. Consequently, two FeLV point-of-care enzyme-linked immunosorbent assays (IDEXX SNAP® Combo Plus, IDEXX Laboratories, ME, USA) were performed, both yielding positive results. This test was used as it detects p27 antigen and confirms viremia. In previous months, a black cat had been identified several times by camera-traps in a wildlife underpass frequently utilized by this lynx in the area (Fig. 2). We believe this is the same individual that “Komodo” killed.

Although vaccination against FeLV using a recombinant vectored feline leukemia vaccine (Purevax FeLV®, Merial, France) is routinely carried out as a preventative measure in all reintroduced lynxes previous to their release, this individual had received a booster more than 2 years ago from the time of contact with the FeLV-positive cat, so it could be at risk of infection due to an empirical waning immunity or lack of sterilizing immunity provided by this type of vaccine (Meli et al. 2009). Furthermore, this lethal IGP took place during lynx mating season, and if “Komodo” resulted viremic to FeLV, even transiently, it would increase the chances of spreading the infection throughout the reintroduced



**Fig. 1** a Remains of the cat after predation by the lynx. b Puncture wounds in frontal bone of the cat's skull (white arrows)

population in this area via both male-male aggression or male-female mating (López et al. 2009). When facing a potential FeLV outbreak in an Iberian lynx population, quick decision-making is crucial to successful management (López 2009). So in order for both to avoid a potential virus dissemination and to ensure a FeLV-negative status in this Iberian lynx, a control program was implemented, including (1) evaluation of the author of the IGP case and (2) intensive monitoring of this individual with particular track of social interactions.

To evaluate the FeLV status of the author of the IGP, an attempt to capture the individual was performed as of the 2nd week after the lynx-cat interaction, since viremia is usually evident 2–4 weeks after infection and it presumably could be detected by the ELISA test and RT-PCR testing (Hofmann-Lehmann et al. 2008; Levy and Burling 2018). “Komodo” was captured during the 3rd-week post-interaction. Under anesthesia, we performed venipuncture of the femoral vein and 14 ml of blood were collected in EDTA, heparin, and plain tubes for hematology, serum biochemistry, and infectious disease screening. Subsequently, we ran two ELISA tests, both resulting negative. On physical examination, the individual weighed 13.7 kg and it was considered to have a good body condition (3/5 body condition score). It presented a moderate tick load in the neck and three 2-mm sublingual papillomas. The rest of the examination exposed

no other anomalies, deeming an overall healthy individual. Hematology and serum biochemistry revealed no abnormalities according to the reference values of the species (according to García et al. 2010), and RT-PCR against canine distemper virus, feline coronavirus, feline calicivirus, feline herpesvirus 1, feline parvovirus, feline immunodeficiency, and feline leukemia viruses also resulted negative (see Meli et al. 2009 for further details). To ensure the effectiveness of the vaccination, it was decided to provide a new FeLV vaccine booster to the lynx prior to its release back to the field.

The intensive monitoring in the field consisted of tracking potential interactions between this Iberian lynx and other individuals via telemetry and camera-trapping, in case it already spread the infection to individuals that share part of its home range (mainly a radio-collared female, and their offspring, which included a 6–7-month-old male and female). In a FeLV-positive lynx scenario, all individuals that would have had interactions with this lynx would have had to be captured and screened. In the 3 weeks between the IGP and the clinical evaluation of “Komodo,” he maintained contact with four individuals. Once we detected the individual was negative to FeLV, we stopped the intensive and continued the routine monitoring.

The negative results of both ELISA and RT-PCR tests indicate that this male Iberian lynx was not viremic nor the virus



**Fig. 2** Iberian lynx (“Komodo”) and feral cat using the same wildlife underpass

was latent into the bone marrow at the moment we evaluate it. The negativity of this individual after a known contact with a FeLV-infected cat may be due to several non-exclusive reasons: (1) the individual was naturally resistant to the virus; (2) the vaccination conferred its protective immunity; (3) viremia would have not yet developed or would have been already controlled at the time of the capture; (4) just one isolated contact with a FeLV-positive cat would have decreased the probability to acquire infection, as described in domestic cats; and/or (5) the infected cat would have had low chances to bite the lynx before its death (the main transmission route of this virus is via saliva) (Hartmann 2012). This is the second case reported of FeLV-negative Iberian lynx after known contact with the virus, after a negative adult female that mated and reproduced with an infected male within the 2007 outbreak (López et al. 2011).

Since its release, “Komodo” has been routinely monitored via telemetry and camera-trapping, and we continue to perform monthly visual examinations in an attempt to prematurely detect potential physical abnormalities (i.e., weight loss) which may lead to changes in its clinical condition. Although no abnormalities have been observed, planning on capturing the lynx before the next breeding season is underway. The IGP interaction observed suggest the importance of maintaining epidemiological disease surveillance for selected diseases in the Iberian lynx and the sympatric carnivore guild, including domestic species (López 2009). Because unpredictable disease outbreaks are potentially dramatic for small Iberian lynx populations, both long-term monitoring and disease risk assessment are considered paramount to ensure the viability of the Iberian lynx during the restoration of the species and may act as a valuable conservation tool (Acevedo-Whitehouse 2009; Alexander 2009). These two factors allowed a prompt response after detecting this case of IGP which could have become dramatic from a sanitary point of view. Thus, we recommend continuing the current health monitoring program of all reintroduced Iberian lynx populations.

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