Rehabilitation notes: juvenile Eurasian lynx (*Lynx lynx*)

Stéphanie Borel,[1] Andreas Ryser,[2] Mainity Batista Linhares,[1] Anja Molinari-Jobin,[2] Marie-Pierre Ryser-Degiorgis[1]

AUTHOR AFFILIATIONS
[1]Institute for Fish and Wildlife Health, Department of Infectious Diseases and Pathobiology, Vetsuisse Faculty, University of Bern, Bern, Switzerland; [2]Foundation KORA Carnivore Ecology and Wildlife Management, Ittigen, Switzerland

ABSTRACT: Orphan lynx rehabilitation is very challenging, and it is important to aim for high standards of animal care. Rehabilitation requires pre-established procedures and clearly defined responsibilities. Suitable infrastructure with competent staff needs to be identified in advance. In the same way as other wildlife species, an orphaned lynx should receive a thorough initial examination to assess the animal's chances of survival and rehabilitation. Collecting samples and subsequent laboratory analyses are required to complement clinical observations and avoid introducing diseases into the care center and potentially into the population where the animal will be released. A natural, balanced diet and a species-appropriate enclosure must be provided to minimize stress, captivity-related injuries, and habituation, finding a balance between conservation interests and animal welfare. Based on a previous study, this document aims to formulate captivity- and conservation-oriented recommendations for the rehabilitation of orphaned Eurasian lynx.

KEYWORDS: animal care, captivity, conservation, Felidae, health, management, welfare.

CORRESPONDING AUTHOR
Marie-Pierre Ryser-Degiorgis
Institute for Fish and Wildlife Health
Department of Infectious Diseases and Pathobiology
Vetsuisse Faculty, University of Bern
Bern, Switzerland
E: marie-pierre.ryser@vetsuisse.unibe.ch

Introduction

An orphaned animal is defined as a young animal that has lost its mother[1] and is too young to survive on its own.[2] For Eurasian lynx, an orphan was formerly defined as a juvenile that has lost its mother and is found emaciated, a situation which typically occurs in autumn near human settlements.[3]

Juvenile animals, whether domestic or wild, may become orphaned for various reasons. Maternal death may occur (e.g., accident, poaching, or disease); young animals may be abandoned due to a suboptimal maternal health condition[4,5] or inexperience (inadequate maternal behavior and care);[5,6] external factors may cause separation of mother and young. For example, mothers may abandon their litter during times of starvation.[4,7] Furthermore, young animals may be temporarily separated from their family group and mistaken for orphans.[8] It is necessary to observe a possible orphan carefully and from a distance for several hours before concluding that it has been abandoned.[9] Surveillance can be conducted by placing a camera trap with a black flash (so as not to dazzle the animal) and by monitoring the area with binoculars, thermal night vision

J. Wildlife Rehab. 42(3):7–18.

Orphaned lynx brought to a wildlife care center for rehabilitation.

goggles, or thermal cameras for one or two nights. Emaciated juvenile lynx observed alone near human settlements can be directly considered orphans.[10]

Description

Taxonomy

The Eurasian lynx (*Lynx lynx*), is the largest of the four lynx species occurring worldwide (*L. lynx, L. pardinus, L. rufus*, and *L. canadensis*), with four subspecies occurring in Europe: *L. lynx lynx* (Northern or Boreal lynx), *L. lynx martinoi* (Balkan lynx), *L. lynx dinniki* (Caucasian lynx) and *L. lynx carpathicus* (Carpathian lynx).[11,12] Although the subspecies are not always easy to distinguish, they show variations in body size, weight, skull shape, and coat pattern.[3,13,14] The Carpathian lynx is distributed in distinct populations in several European countries such as Switzerland because it has been used for reintroductions.[15]

Physical description

Depending on the parts of the distribution range and the season, the coat of the lynx is brown grey to reddish, with few to many dark spots on the back, flanks, and legs. The spots are often more distinct on the legs and flanks than on the back.[3] This coat pattern is classified into four categories: large spots, small spots, rosettes, and unspotted.[16] The belly as well as the sides of the muzzle, chin, and cheeks are white.[17] The ears are relatively large for the size of the skull, and they are characterized by tufts of black hair up to 4 cm long at the tips and white color on the backs. As in the other lynx species, the tail is short. In Switzerland, female Carpathian Eurasian lynx weigh 15 to 21 kg, and males weigh 19 to 26 kg.[18] Their body measurements have been published by Marti and Ryser-Degiorgis (2018).[18]

Habitat

The Eurasian lynx is a solitary and territorial animal.[3] Home ranges vary in size from 50 to 300 km^2,[3] with territories of females being slightly smaller than those of males.[19] Lynx show a preference for heterogeneous forests and avoid human disturbance.[20] The selection of the terrain is influenced by the season and time of day. In winter, lynx are generally found at lower altitudes. At night, they may also use open habitats, such as meadows, where prey may be more abundant. During the day, however, lynx prefer dense undergrowth and rugged terrain away from human infrastructure.[21]

Range

Eurasian lynx are currently present in 23 countries in Europe, distributed in 11 populations.[22] They almost disappeared from the old continent in the 19th century but were reintroduced to Central and Western Europe in the 1970s.[15] Individuals from the Carpathian Mountains (*L. lynx carpathicus*) were released in the Alps, the Jura, the Palatinate Forest-Vosges, the Dinaric, and the Bohemian-Bavarian Mountains.[15] Additionally, lynx from unknown genetic origin were reintroduced into the German Harz Mountains and into the Kampinoski National Park in Poland.[23] Natural recovery also contributed to the current lynx distribution.[24] Nevertheless, reintroduced populations in Central and Western Europe are still small, fragile, and isolated and are either classified as endangered (Jura, Alps, and Dinaric) or critically endangered (Harz, Vosges, Bohemian-Bavarian, and Kampinoski).[25] In these regions where genetic variability is limited, the lynx is protected. On the contrary, boreal lynx populations, which are found in Nordic countries (Finland, Sweden, Norway, and Baltic states) are large and hunted.

Natural diet

The lynx is considered an obligate predator.[26] The Eurasian lynx's wild prey in the Swiss Jura Mountains are mainly roe deer (*Capreolus capreolus*) and chamois (*Rupicapra rupicapra*), sometimes red fox (*Vulpes vulpes*) and brown hare (*Lepus europaeus)*, and very rarely domestic cat (*Felis catus*), wild cat (*Felis sylvestris*), marmot (*Marmota marmota*), pine marten (*Martes martes*), capercaillie (*Tetrao urogallus*), and badger (*Meles meles*).[27] An ungulate carcass is consumed by a lynx in 1 to 7 days, with an average meat quantity of 3.2 kg per night for a single female and 3.4 kg for a male. This can go up to 4.9 kg for a family group composed of a female and two large juveniles in early winter.[27]

Birth and care of young

Females reach sexual maturity around 2 years and males around 3 years.[3] Mating season takes place from February to April.[3] Eurasian lynx in Switzerland are born from the beginning of May to mid-June, with a peak in the second part of May (around May 17 to 31),[3] after a pregnancy duration of 54 to 73 days.[28] A litter

consists of one to four cubs, usually two. Cubs are born with eyes and ears closed and weigh 240–430 g.[28] During the "stationary phase" after birth, juvenile lynx spend most of their time in the den.[3,29] From August to October, lynx cubs become slowly more mobile. From 9 weeks of age, they are able to digest meat.[3] Their lactating mother leaves them alone for longer periods as she expands her territory to hunt and satisfy their ever-growing energy needs. From November, larger juveniles can follow their mother on a hunt to learn how to kill prey by themselves.[3] They will then seek their own territory at the time of dispersal, from January to the beginning of May, with a peak from March to April.[30,31]

Rehabilitation considerations

The success of rehabilitation depends on many factors: health status,[2,32,33] age and body condition at the time of admission,[33-35] facilities, skills of veterinary staff, funding, date and season of admission,[33] individual levels of boldness,[38] time spent in captivity,[39-41] and release sites.[36,37] It is recommended to use these parameters to establish a prognosis and triage cases (i.e., to decide whether to treat or euthanize an animal).[42-46] This triage is essential because providing euthanasia on admission limits costs, required staff, and especially the stress and suffering of animals with very low chances of survival. The probability of recovery should be kept in mind throughout the entire animal care period. It is important to remember that although the goals of rehabilitation may include public awareness, goals should mainly focus on species conservation; returning rehabilitated orphaned or injured animals to the wild allows them to contribute to reproduction.[47,48]

Overall, factors potentially influencing captive conditions should be optimized (i.e., facilities, skills of veterinary staff, release site and season, and time spent in captivity) to maximize the cost–benefit ratio. It is also crucial to determine financial and decisional responsibilities for all steps in rehabilitation before taking an animal into captivity and to include all agreements in an orphan management plan. This will avoid welfare-relevant delays in decision-making. Suitable wildlife care centers (WCC) must be identified in advance, and institutions and people to contact in the event of an orphaned lynx discovery must be listed. It is crucial to establish a communication scheme to facilitate rapid decision-making while limiting the chain of players.[10]

Clinical examination

Upon arrival, orphaned lynx should be examined from a distance to determine if their health condition allows for a more thorough examination under anesthesia. If it does not, individuals can be stabilized without anesthesia.[49] The vital parameters of orphaned Eurasian lynx are summarized in Table 1.

If the cub is weak or already in captivity, it can be caught with a hand net. If the cub is vigilant, a baited small box trap can be used, or distance anesthesia can be employed using a blowpipe without previous physical immobilization.

For chemical immobilization, an intramuscular injection of 0.1 mg/kg medetomidine and 5 mg/kg ketamine[50] allows rapid induction, good muscle relaxation, and analgesia even sufficient for soft tissue surgery.[51] To prevent any risk of regurgitation, it is preferable to place the anesthetized animal in lateral or sternal recumbency.[52,53] Whether the animal will be intubated or not, it is essential to check the oral cavity to make sure that nothing obstructs the airways. Corneas must be protected from drying out with an ophthalmic gel,[54] eyes should be covered with a clean cloth, and noise production must be avoided (including human voices). Ear plugs may be used to reduce auditory stimuli.[52] Leg folds are recommended under field conditions to prevent an escape in case of premature recovery. They are not necessary when working indoors or in an enclosure, but may be helpful. Monitoring of vital parameters should be initiated as soon as possible, including the regular determination of body temperature, heart and respiratory rate, pulse, color of the mucosa, and capillary refill time. A pulse oximeter fixed on the tongue may also be used to observe arterial oxygen saturation. Although hypoxemia is described as a known adverse effect in lynx,[55] injectable anesthesia with this protocol has proved to be safe in wild-born lynx of all ages.[10,56] However, oxygen supplementation is generally recommended during injectable anesthesia.[57] Under field conditions, intranasal administration is most practicable, but in a WCC, intubation is preferable because it allows the best maintenance and airways protection,[58] requires little equipment, and is inexpensive.

Once the animal is safe regarding the anesthesia, a full clinical examination can start, preferably by another team member, so that one person is fully dedicated to anesthesia monitoring. Age is best estimated based on body size and dentition.[59] Sex must be determined, which can be done by measuring the anogenital distance in lynx less than 6 months old when testicles are not yet visible (see Table 2). Clinical examination should begin with the determination of body condition and hydration state followed by a coat inspection (in particular a search for skin wounds, claw damages, and ectoparasites on the skin or in the ears); examination of eyes, nose, and anogenital orifices; close examination of dentition state and oral mucosa; cardiac auscultation; and palpation of superficial lymph nodes and abdominal organs. This initial clinical examination contributes to careful triage and possible euthanasia of individuals that are not viable, will not be able to reproduce due to anatomic defects, or may pose a health risk to the population (see Table 3 for euthanasia justifications).

As a next step, it is imperative to collect blood samples for hematology, biochemistry, and genetics as well as for pathogen screenings and serological tests. This requires several tubes, some

TABLE 1. Vital parameters of anesthetized orphaned Eurasian lynx[147]

PARAMETER	SMALL JUVENILE ≥3 to <6 months (n=6)	LARGE JUVENILE ≥6 to <11 months (n=9)
Body temperature	37.2–39.2°C	36.7–40.2
Heart rate	100–132 beats/min	80–144 beats/min
Respiratory rate	16–28 breaths/min	14–36 breaths/min
Weight	2–5.7 kg	3.5–7 kg

Data from the Insitute for Fish and Wildlife Health (FIWI) database.

TABLE 2. Anogenital distance (cm) of free-ranging juvenile Eurasian lynx from Switzerland.*

AGE	1–2 MONTHS	3–4 MONTHS	5–6 MONTHS	7–8 MONTHS
FEMALE	1.48 (1.4 – 1.5) (4)	1.87 (1.0 – 2.6) (18)	2.11 (1.5 – 3.5) (30)	2.92 (1.4 – 4.7) (11)
MALE	3.10 (2.5 – 3.5) (2)	3.87 (3.2 – 4.8) (11)	4.11 (2.5 – 5.3) (31)	4.70 (3.5 – 6.3) (8)

*First parenthesis = range; second parenthesis = number of examined lynx.
Data from lynx necropsies database of the Institute for Fish and Wildlife Health (FIWI).

TABLE 3. Veterinary justification for euthanasia of wild animals in all age classes, at any time of the rehabilitation process.[42-45]

ISSUES	Justifications
COMATOSE STATE, MORIBUND ANIMAL	Vital parameters are affected
SYSTEMIC DEBILITATING DISEASE, SEVERE NEUROLOGICAL DISORDERS	Poor chance of survival, risk of pathogen transmission to co-specific and/or humans
PROLAPSE OR RUPTURE OF A LARGE AREA OF TISSUE	High risk of infection and complications
CHRONIC OR OPEN FRACTURE	High risk of infection and complications
JOINT DISORDERS	Long-term consequences, complete recovery unlikely
CONGENITAL MALFORMATION	Handicap
PERMANENT BLINDNESS	Inability to move properly, hunt, and avoid danger
NEWBORN ANIMALS	High risk of habituation
SPINAL TRAUMA WITHOUT DEEP PAIN	Low chances of recovery
JAW FRACTURE, SEVERE TEETH LESIONS	Reduced ability to eat, high risk of infection and complications
BEHAVIORAL ABNORMALITIES (E.G., STEREOTYPIES, HABITUATION)	Poor chance of survival upon release, risk of undesirable interactions with humans

of which can be deep-frozen for later examination. The amount of blood that can be collected depends on the animal's weight, health status, and body condition.[60] Blood samples are best taken from the cephalic veins, but sampling is also possible from the jugular or femoral veins. Although different collecting tubes exist, vacuum-sealed plastic tubes are best to keep samples clean. Alternatively, an over-the-needle catheter can be placed, which can also be used to administer fluids or drugs intravenously.[43] Blood values (hematological and biochemical parameters) for captive Eurasian lynx have been published by others[61] but they should be used with caution as free-ranging conditions may influence certain values.[62-65] Additional samples such as oral, conjunctival, and rectal dry swabs are necessary to test for pathogen shedding.[56] The procedure can end with morphometric measurements.[18,66]

Dehydration, a common problem in orphans,[67] must be assessed (Table 4) to determine the amount of fluid to be administered and to select the method of administration. Since it is not realistic to leave an intravenous catheter in place after the end of anesthesia in a wild-born lynx, even a young and weakened one, fluid boluses are recommended. The first bolus of crystalloid or colloid at rates of 20 ml/kg can be given at the beginning of the procedure, and if necessary, a second of 10 ml/kg can be given 30 minutes later. Repeated reassessment is crucial to assess whether rehydration is successful.[43]

Once the health status has been determined and any clinical problem detected, therapy can be performed or initiated. Wounds can be cleaned by curettage and disinfected with a topical antiseptic, such as povidone-iodine. Subcutaneous injection of long-acting antibiotics can be given when there are signs of infection (e.g., amoxicillin 15 mg/kg).

After examination and care (at least 30 to 40 minutes after the injection of ketamine,[68] but preferably after 1 hour[56]) medetomidine can be antagonized with intramuscular injection of atipamezole at 5mg/mg medetomidine,[55] preferably in the caudal tight musculature.[56]

Health monitoring

Before introducing the animal into a large outdoor enclosure, it is recommended to respect a quarantine period until all laboratory results are available,[56] as should be the case for any free-ranging animal that will later be reintroduced into the wild, either for translocation or rehabilitation at the capture site.[69-71] Eurasian lynx should be tested for a range of possible pathogens, in particular, feline parvovirus, feline coronavirus, feline calicivirus, feline herpesvirus, feline immunodeficiency virus, feline leukemia virus, and canine distemper virus.[56]

Ideally, the quarantine pen should be adjacent to an outdoor enclosure and can serve as a shift yard for temporary housing for sick or injured individuals.[71] The smaller pen should allow blowpipe or dart gun anesthesia if indicated by health concerns. Additionally, treatments should also be administered as quickly as possible. Indeed, human presence, manipulations, and anesthesia cause significant stress to wild-born animals,[72,73] increasing the level of blood glucocorticoids.[74] This stress can delay recovery[75] or lead to other pathologies due to decreased immunity,[76] offsetting the benefits of therapy. For this purpose, as soon as the animal can eat, it is preferable to continue the treatment per os rather than manipulating the animal for injections.[77] Daily visual checks without direct contact can be achieved by using cameras,[78] and the progress of the animal can be followed without disturbance.

Diet in captivity

Free-ranging juvenile lynx usually start eating meat from the age of 9 weeks but are still suckling.[3] However, previous experience has shown that six-to-eight-week-old cubs are already capable of feeding on meat only.[10] For younger individuals that would require milk bottle-feeding, a complete protocol has been established for Iberian lynx[79] that may be used for Eurasian lynx.

Refeeding of emaciated animals should theoretically be done gradually to avoid any electrolyte imbalance or maldigestion. Refeeding syndrome refers to a group of clinical signs and

metabolic disturbances that appear within a few days of refeeding of malnourished individuals.[80] Although most of the veterinary literature on this topic concerns the domestic cat, it seems reasonable to assume that, as a feline, the lynx may also be prone to developing this syndrome. Felines are particularly at risk given their natural intolerance to glucose and their inability to regulate their proteolysis.[81] The sudden supply of carbohydrates to a fasting organism leads to potentially life-threatening electrolyte imbalance.[80,82,83] In domestic carnivores, recommendations include stabilizing the animal before refeeding[84] and offering liquid feeds with high digestibility, energy density, and protein content; this may be complemented by a range of food supplements.[81] Wet cat food can then be offered, such as a high protein and energy recovery diet (for example, Prescription Diet a/d from Hill's Pet Nutrition).[85] The recommended amount for the first week of refeeding is 5–10 kcal/kg/day, divided into four to six meals.[86] However, for wild-born animals, frequent feedings represent disturbances inducing considerable stress or, on the contrary, habituation. Habituation to humans and human-associated activities in captivity must be kept to a minimum. Especially when wild mammals get used to human presence and noises associated with food, this habituation may result in a loss of fear of predators, a greater likelihood of getting close to human settlements, an inability to hunt, and therefore decreased survival probability upon release.[38,87-89] Thus, food should be distributed with minimal contact (for example, through a trapdoor).[44] In addition, we formerly documented that young lynx were able to digest much larger and less frequent meals than generally recommended[10] without showing signs of refeeding syndrome.

TABLE 4. Dehydration assessment.[148]

% DEHYDRATION	CLINICAL SIGNS
5 (MILD)	Minimal loss of skin turgor, semidry mucous membranes, normal eye
8 (MODERATE)	Moderate loss of skin turgor, dry mucous membranes, weak rapid pulses, enophthalmos
10 (SEVERE)	Considerable loss of skin turgor, severe enophthalmos, tachycardia, extremely dry mucous membranes, weak/thready pulses, hypotension, altered level of consciousness

Once the animal's status allows it, it is important to progressively strive for feeding a diet with composition and presentation close to natural conditions (i.e., roe deer and chamois carcasses for Eurasian lynx). This shall promote the consumption of similar food when the animal is released back into the wild.[41,90] From a nutritional point of view, whole prey (i.e., including internal organs, without the digestive tract) is to be preferred because it is rich in protein and minerals and has an adequate calcium/phosphorus ratio.[91] Nutritional deficiency can lead to immune deficiency (decrease in bone marrow elements, neutropenia, involution of secondary lymphoid tissues) and decreased efficiency of the skin or mucous barriers (increasing the risk of bacterial infection).[92] In addition, giving natural food containing indigestible hair and feathers positively influences the microbiota[93] and promotes the ability to digest such food once the animal is released.[94] Last but not least, feeding whole carcasses is an important form of enrichment in captivity; it increases feeding time and provides greater sensory stimulation than feeding pieces of meat,[78] reduces time spent sleeping and resting,[95] decreases stereotypical behavior,[96,97] and therefore contributes to stress minimization. Thus, appropriate feeding not only maintains normal species behavior but also reduces health risks.

Before releasing a wild carnivore, it is essential to ensure that it will be able to hunt and feed itself, a sine qua non condition for its survival in the wild.[98] For this purpose, some authors advise giving live prey.[41,99,100] However, this is forbidden by law in some countries, in which circumstances offering native prey carcasses is the most judicious alternative. Several previous experiences have shown that orphaned lynx fed only with carcasses were able to hunt on their own once in the wild.[101-103] Nevertheless, in such cases, post-release monitoring is particularly important to ensure that the animal is self-sufficient.

Housing

Size

Sufficient enclosure size is crucial.[97] For two lynx in permanent captivity, the minimum size enclosure dictated by the Swiss Animal Welfare Ordinance[104] is 30 m^2 outdoors and 20 m^2 indoors. This legal requirement is to be understood as an absolute minimum and not as a recommendation. A German WCC with experience in lynx rehabilitation uses for one to three orphans either a 90 m^2 indoor enclosure adjacent to a 500 m^2 outdoor enclosure, or a 60 m^2 indoor enclosure adjacent to a 108 m^2 outdoor enclosure (F. Brandes, pers. comm. 2022). It is important to note, however, that enclosure quality (i.e., rich environment with structures, hides, and climbing possibilities) also plays a decisive role in the well-being of captive animals and is even more important than enclosure size.[97]

Layout

Animal welfare and the expression of normal behavior are two crucial issues that require a quality enclosure.[97,107,108] This is known for wild animals in zoos[109] but should be emphasized even more for wild-born orphans in provisory captivity. The inability of wild animals born in nature to adapt to captivity is known to potentially lead to physical injuries, behavioral deficiencies, and even neurological damage,[39,46,94,97,107,110] as well as to poor health in general.[97] To reduce stress and prevent captivity-related injuries in wild felids, an appropriate environment must be provided and may include various components, such as climbing and hiding structures or platforms of different heights,[108] both in the quarantine pen and the outdoor enclosure. There should be a sufficient number of visual barriers to increase enclosure complexity. If the enclosure size allows, a total of seven visual barriers is

recommended.[111] Walls with straight angles should be avoided (absent in the wild, they increase the stress of captive animals).[112] Walls of the quarantine enclosure must hamper biting or scratching by the animals to prevent serious teeth and claw injuries, a recurrent problem in provisory captivity of orphaned and quarantined lynx.[10,56] It would be interesting to test whether enclosures offering visibility of the surroundings could reduce escape attempts. This, however, would require the enclosure to be located in a natural environment far from human disturbances.

Substrate

The floor of quarantine enclosures must be easily cleanable and should be made of cement or concrete. It can then be covered with 10 to 15 cm of natural substrates such as wood shavings or straw.[111] These substrates prevent the animal from injuring its paws or lips while eating on the ground, though some animals may ingest them.[10,113]

For the outdoor pen, a natural soil made of earth, grass, plants, rocks, and tree trunks is most suitable as it mimics a natural environment.

Group size and composition

As previously documented, intraspecific contact also plays an essential role in the welfare of captive lynx.[114] Interactions with conspecifics are important for feline cubs of all ages[115] but particularly between 2 and 3 months old for Eurasian lynx.[116] Similarly, it is recommended not to keep a juvenile Iberian lynx isolated but to instead promote its socialization and development by holding it together with one or two other cubs.[79] Keeping orphaned lynx in small groups shall allow them to play together and develop their motor and cognitive skills, which are essential for hunting.[116] Based on previous experiences, it is possible to socialize orphans of the same or different sex even if they are not sisters and brothers.[10] If an orphaned lynx is kept alone in a WCC, it is recommended to put it in contact with another felid of the same age—if possible, place the orphan with an individual of the genus *Lynx*, and if not, with a domestic cat.[79,117]

Care in the wild

When no suitable facilities are available, feeding the orphaned lynx in the wild can be an alternative.[101] This represents a method very close to natural conditions and most respectful of animal welfare, with human intervention limited to providing food until the cub can survive on its own. However, the juvenile animal should be in apparent good health and possibly old enough to be able to shred a carcass by itself (from approximately 5 months of age, i.e., from October, when part of the permanent teeth have erupted)[59] and defend itself against possible predators. The feeding area should be easily accessible for carcass disposal, but relatively far from human facilities.[10] Under these conditions, this method has many advantages.[10] An initial assessment of the general condition of the animal at a distance is recommended to evaluate whether this type of management may be a responsible option. Thereafter, as long as the animal is under surveillance, there is the option to act if there would be indications of a serious health impairment.

Release

Only fit and healthy animals that can survive on their own in the wild should be released.[88] The most appropriate time to release rehabilitated lynx seems to be the peak of the dispersal period, from March to April, when juveniles are 10 to 11 months old[3,30] and leave their mother to become independent, as this mimics normal behavior.[8,32,99,118-120] Once ready to survive in the wild, rehabilitated lynx should be released as soon as possible to minimize the risk of habituation and captivity-related health issues.[10]

Soft and hard release methods have been successfully applied for Eurasian lynx in Europe.[121-123] There does not seem to be any difference between these two methods in terms of survival.[99] However, if it is desired that the animals stay in a specific location, a soft release can be advantageous because it seems to increase the likelihood that animals stay near the release site.[123] However, this is valid only for lynx-free regions. In an established lynx population, released animals have to find free space to establish their own territory.

Regardless of the method used, the most important thing is to monitor the released animal. Different tracking methods exist, each with their own advantages and disadvantages.[124,125] GPS tracking, one of the most effective methods, allows monitoring to determine if the animal is succeeding in hunting, feeding, and surviving in the wild. Camera trapping may also contribute to documenting if the animal has reproduced and thus reached the ultimate goal of rehabilitation.

Conclusion

Rehabilitation of lynx orphans has been practiced in several countries in Europe, with both positive and negative experiences reported. To improve the rehabilitation process with respect to both animal welfare and conservation, we summarized the experiences reported and the practices used in Switzerland, where the rehabilitation of eight orphaned lynx has been documented.[10] This article offers, for the first time, clear advice for the rehabilitation of orphaned lynx, detailing methods of anesthesia and care, housing possibilities, feeding techniques, and determining the best time to release them.

The downsides and benefits of a wildlife care center have been discussed and debated in numerous studies for years.[45,126,127] Wildlife rehabilitation is sometimes strongly criticized as having no conservation value and being time-consuming and expensive.[128] However, others consider the reality that human factors are largely responsible for wildlife mortality as sufficient to justify this investment.[129] Indeed, the Eurasian lynx is no exception to the rule, and human activities, such as road traffic or poaching, are the main documented causes of lynx deaths in Switzerland,[130,131] France,[132] Sweden,[133] and Croatia.[134] Although the Eurasian lynx is not globally classified as an endangered species, the size of most populations in continental Europe are below the recommended threshold for long-term survival,[135] especially considering that the reintroduced ones are characterized by poor genetic variability.[136,137] Thus, even if populations are stable, or slightly increasing as is the case in Switzerland,[138] rehabilitation of orphans could contribute to species conservation at the local level, similar to the

results of rehabilitation of endangered species such as the Iberian lynx (*Lynx pardinus*) in Spain,[139] wombat (*Vombatus ursinus*) in Australia,[140] orangutan (*Pongo* sp.) in Indonesia,[141] and jaguar (*Panthera onca*) in Argentina.[99] Orphan lynx rehabilitation could also contribute to genetic exchanges if orphans would be switched between populations.[101] Furthermore, although reintroductions may work with zoo-born animals,[142] carnivore translocation and reintroduction programs using wild-caught (including rehabilitated) animals are in general more successful than those using captive-bred animals.[89,143-146] Thus, orphaned lynx could be valuable in the framework of translocation programs in Europe.

Literature cited

1. Liran S, Tkaczynski P, Deschner T, Löhrrich T, Wittig RM, Crockford C. Maternal effects on offspring growth indicate post-weaning juvenile dependence in chimpanzees (*Pan troglodytes verus*). *Front Zool.* 2020; 17:1. doi: 10.1186/s12983-019-0343-8 PMID: 31911809.
2. Kelly A, Halstead C, Hunter D, Leighton K, Harris M. Factors affecting the likelihood of release of injured and orphaned woodpigeons (*Columba palumbus*). *Anim Welf.* 2011; 20:523–34.
3. Breitenmoser U, Breitenmoser-Würsten C. Der Luchs. Ein Grossraubtier in der Kulturlandschaft. Bern: Salm-Verlag; 2008.
4. Turner DC, Bateson P. The domestic cat. The biology of its behaviour. New York: Cambridge University Press; 2014.
5. Lezama-García K, Mariti C, Mota-Rojas D, Martínez-Burnes J, Barrios-García H, Gazzano A. Maternal behaviour in domestic dogs. *Int J Vet Sci Med*. 2019; 7:20–30. doi: 10.1080/23144599.2019.1641899 PMID: 31620484.
6. Nowak R, Porter RH, Lévy F, Orgeur P, Schaal B. Role of mother–young interactions in the survival of offspring in domestic mammals. *Rev Reprod*. 2000; 5:153–63. doi: 10.1530/ror.0.0050153 PMID: 11006165.
7. Chase CCL, Lutz KA, McKenzie EC, Tibary A. Blackwell's five-minute veterinary consult. Hoboken NJ USA: Wiley; 2017.
8. Robertson CPJ, Harris S. The condition and survival after release of captive-reared fox cubs. *Anim Welf.* 1995; 4:281–94.
9. Tuomi P. Rehabilitation Notes: Sea otter pups (*Enhydra lutris*). *J Wildl Rehab*. 1990; 13–. Available from: https://theiwrc.org/wp-content/uploads/2010/07/Volume-13-No-3-Fall-1990.pdf.
10. Borel S, Ryser A, Batista Linhares M, Molinari-Jobin A, Ryser-Degiorgis M-P. Management of lynx orphans in Switzerland, 1981–2019: a case study. *J Wildl Rehab.* 2022;42(1):7–24.
11. Versteege L, editor. EAZA Eurasian lynx ESB Annual Report 2002. 2003.
12. Kitchener AC, Breitenmoser-Würsten C, Eizirik E, Gentry A, Werdelin L, Wilting A, et al. A revised taxonomy of the *Felidae.* The final report of the Cat Classification Task Force of the IUCN/SSC Cat Specialist Group. Cat News Special Issue. 2017; 11:80. http://www.catsg.org/fileadmin/filesharing/5.Cat_News/5.3._Special_Issues/5.3.10._SI_11/CatNews%20Special%20Issue11%20revised%20taxonomy%20small.pdf
13. Kubala J, Gregorová E, Smolko P, Klinga P, Iľko T, Kaňuch P. The coat pattern in the Carpathian population of Eurasian lynx has changed: a sign of demographic bottleneck and limited connectivity. *Eur J Wildl Res.* 2020; 66. doi: 10.1007/s10344-019-1338-7.
14. Gomerčić T, Sindičić M, Đuras Gomerčić M, Guzvica G, Frković A, Pavlovic D, et al. Cranial morphometry of the Eurasian lynx (*Lynx lynx* L.) from Croatia. *Vet Arhiv.* 2010; 80–. https://www.researchgate.net/publication/228618644_Cranial_morphometry_of_the_Eurasian_lynx_Lynx_lynx_L_from_Croatia.
15. Breitenmoser U, Breitenmoser-Würsten C, Capt S. Reintroduction and present status of the lynx (*Lynx lynx*) in Switzerland. *Hystrix It J Mamm*. 1998;10:17–30. doi: 10.4404/hystrix-10.1-4118.
16. Thüler K. Spatial and temporal distribution of coat patterns of Eurasian lynx (*Lynx lynx*) in two re-introduced populations in Switzerland. KORA Bericht. 2002:1–35. https://www.semanticscholar.org/paper/Spatial-and-Temporal-Distribution-of-Coat-Patterns-Th%C3%BCler/518bd68b3ad266fd3236a819700c8ebce3c13796.
17. lsen LH. Guide Delachaux des traces d'animaux. Paris: Delachaux et Niestlé; 2013.
18. Marti I, Ryser-Degiorgis M-P. Morphometric characteristics of free-ranging Eurasian lynx *Lynx lynx* in Switzerland and their suitability for age estimation. *Wildl Biol.* 2018:wlb.00432. doi: 10.2981/wlb.00432.
19. Breitenmoser-Würsten C, Zimmermann F, Molinari-Jobin A, Molinari P, Capt S, Vandel J-M, et al. Spatial and social stability of a Eurasian lynx (*Lynx lynx*) population: an assessment of 10 years of observation in the Jura Mountains. *Wildl Biol.* 2007; 13:365–80. doi: 10.2981/0909-6396(2007)13[365:SASSOA]2.0.CO;2.
20. Ripari L, Premier J, Belotti E, Bluhm H, Breitenmoser-Würsten C, Bufka L, et al. Human disturbance is the most limiting factor driving habitat selection of a large carnivore throughout Continental Europe. *Biological Conservation.* 2022; 266:109446. doi: 10.1016/j.biocon.2021.109446.
21. Filla M, Premier J, Magg N, Dupke C, Khorozyan I, Waltert M, et al. Habitat selection by Eurasian lynx (*Lynx lynx*) is primarily driven by avoidance of human activity during day and prey availability during night. *Ecol Evol.* 2017; 7:6367–81. doi: 10.1002/ece3.3204 PMID: 28861240.
22. Chapron G, Kaczensky P, Linnell JDC, von Arx M, Huber D, Andrén H, et al. Recovery of large carnivores in Europe's modern human-dominated landscapes. *Science.* 2014; 346:1517–9. doi: 10.1126/science.1257553 PMID: 25525247.
23. von Arx M, Breitenmoser-Würsten C, Zimmermann F, Breitenmoser U. Status and conservation of the Eurasian lynx (*Lynx lynx*) in Europe in 2001. KORA Bericht. 2004:1–330. Available from: https://www.kora.ch/?action=get_

file&id=102&resource_link_id=1a2
24. Linnell JDC, Breitenmoser U, Breitenmoser-Würsten C, Odden J, von Arx M. Recovery of Eurasian lynx in Europe: what part has reintroduction played? In: Hayward MW, Somers MJ, editors. Reintroduction of top-order predators. Oxford, UK: Wiley-Blackwell; 2009. pp. 72–91.
25. von Arx M. *Lynx lynx*. 2018 [cited 30.12.21]. Available from: https://www.iucnredlist.org/species/12519/134346234.
26. Mattisson J, Persson J, Andrén H, Segerström P. Temporal and spatial interactions between an obligate predator, the Eurasian lynx (*Lynx lynx*), and a facultative scavenger, the wolverine (*Gulo gulo*). *Can J Zool*. 2011; 89:79–89. doi: 10.1139/Z10-097.
27. Jobin A, Molinari P, Breitenmoser U. Prey spectrum, prey preference and consumption rates of Eurasian lynx in the Swiss Jura Mountains. *Acta Theriol*. 2000; 45:243–52. doi: 10.4098/AT.arch.00-26.
28. Sunquist ME, Sunquist F, Whittaker T. Wild cats of the world. Chicago, London: The University of Chicago Press; 2002.
29. Simón MA, Gil-Sánchez JM, Ruiz G, Garrote G, McCain EB, Fernández L, et al. Reverse of the decline of the endangered Iberian lynx. *Conserv Biol*. 2012; 26:731–6. doi: 10.1111/j.1523-1739.2012.01871.x PMID: 22734818.
30. Schmidt K. Maternal behaviour and juvenile dispersal in the Eurasian lynx. *Acta Theriol*. 1998; 43:391–408. doi: 10.4098/AT.arch.98-50.
31. Zimmermann F, Breitenmoser-Würsten C, Breitenmoser U. Natal dispersal of Eurasian lynx (*Lynx lynx*) in Switzerland. *J Zool Lond*. 2005; *267*:381–. doi: 10.1017/S0952836905007545.
32. Grogan A, Kelly A. A review of RSPCA research into wildlife rehabilitation. *Vet Rec*. 2013; 172:211. doi: 10.1136/vr.101139 PMID: 23436601.
33. Molony SE, Baker PJ, Garland L, Cuthill IC, Harris S. Factors that can be used to predict release rates for wildlife casualties. *Anim Welf*. 2007; 16:361–7.
34. Ringsby TH, Saether B-E, Solberg EJ. Factors affecting juvenile survival in house sparrow (*Passer domesticus*). *J Avian Biol*. 1998; 29:241–. doi: 10.2307/3677106.
35. Overskaug K, Bolstad JP, Sunde P. Fledgling behavior and survival in Northern tawny owls. *The Condor*. 1999; 101:169–74. doi: 10.2307/1370460.
36. Best D, Mullineaux E. Basic principles of treating wildlife casualties. In: Mullineaux E, Keeble EJ, editors. BSAVA Manual of Wildlife Casualties. 2nd ed. Gloucester: British Small Animal Veterinary Association; 2016. pp. 6–29.
37. Wobeser GA. Disease in wild animals. Investigation and management. Berlin, Heidelberg: Springer Berlin Heidelberg; 2007.
38. Bremner-Harrison S, Prodohl PA, Elwood RW. Behavioural trait assessment as a release criterion: boldness predicts early death in a reintroduction programme of captive-bred swift fox (*Vulpes velox*). *Anim Conserv*. 2004; 7:313–20. doi: 10.1017/S1367943004001490.
39. McPhee ME. Generations in captivity increases behavioral variance: considerations for captive breeding and reintroduction programs. *Biol Conserv*. 2003; 115:71–7. doi: 10.1016/S0006-3207(03)00095-8.
40. Tolhurst B, Grogan A, Hughes H, Scott D. Effects of temporary captivity on ranging behaviour in urban red foxes (*Vulpes vulpes*). *Appl Anim Behav Sci*. 2016; 181:182–90. doi: 10.1016/j.applanim.2016.05.004.
41. Doussain A. Réhabilitation et relâcher des animaux sauvages après un séjour en centre de sauvegarde. Doctoral Thesis in Veterinary Medicine, National Veterinary School–Alfort. 2018.
42. Vogelnest L. Veterinary considerations for the rescue, treatment, rehabilitation and release of wildlife. In: Vogelnest L, Woods R, editors. Medicine of Australian mammals. Collingwood Victoria, Australia: CSIRO Publishing; 2008. pp. 1–12.
43. Mullineaux E, Keeble EJ, editors. BSAVA Manual of Wildlife Casualties. 2nd ed. Gloucester: British Small Animal Veterinary Association; 2016.
44. Miller EA, editor. Minimum standards for wildlife rehabilitation. St. Cloud Minnesota, Suisun California: National Wildlife Rehabilitators Association; International Wildlife Rehabilitation Council; 2012.
45. Molina-López RA, Mañosa S, Torres-Riera A, Pomarol M, Darwich L. Morbidity, outcomes and cost–benefit analysis of wildlife rehabilitation in Catalonia (Spain). *PLoS ONE*. 2017; 12:e0181331. doi: 10.1371/journal.pone.0181331 PMID: 28719647.
46. Guy AJ, Curnoe D, Banks PB. A survey of current mammal rehabilitation and release practices. *Biodivers Conserv*. 2013; 22:825–37. doi: 10.1007/s10531-013-0452-1.
47. Williams K. The essentials of wildlife rehabilitation [updated 31 May 2021; cited 31 May 2021]. Available from: https://conbio.org/groups/sections/africa/act/the-essentials-of-wildlife-rehabilitation.
48. S. Dubois, D. Fraser. Conversations with stakeholders, Part I: goals, impediments, and relationships in wildlife rehabilitation. *J Wildl Rehab*. 2003; 26:14–22. Available from: https://www.researchgate.net/publication/296756953_Conversations_with_stakeholders_Part_I_Goals_impediments_and_relationships_in_wildlife_rehabilitation.
49. Chinnadurai SK, Strahl-Heldreth D, Fiorello CV, Harms CA. Best-practice guidelines for field-based surgery and anesthesia of free-ranging wildlife. I. Anesthesia and analgesia. *J Wildl Dis*. 2016; 52:S14-27. doi: 10.7589/52.2S.S14 PMID: 26845296.
50. Hahn A. Zoo and wild mammal formulary. Hoboken, NJ: Wiley-Blackwell; 2019.
51. Arnemo JM, Linnell JDC, Wedul SJ, Ranheim B, Odden J, Andersen R. Use of intraperitoneal radio-transmitters in lynx *Lynx lynx* kittens: anaesthesia, surgery and behaviour. *Wildl Biol*. 1999; 5:245–50. doi: 10.2981/wlb.1999.023.
52. Arnemo JM, Evans AL. Biomedical protocols for free-ranging brown bears, wolves, wolverines and lynx. Technical Report. Inland Norway University of Applied Sciences; 2017.
53. Eshar D, Mason D, Avni-Magen N, Kaufman E, Paz A, Beaufrère H. Evaluation of the effects of sternal versus lateral

recumbency on trends of selected physiologic parameters during isoflurane anesthesia in zoo-housed black-tailed prairie dogs (*Cynomys ludovicianus*). *J Zoo Wildl Med.* 2017; 48:388–93. doi: 10.1638/2016-0192R2.1 PMID: 28749308.
54. Peche N, Köstlin R, Reese S, Pieper K. Postanaesthetic tear production and ocular irritation in cats. *Tierarztliche Praxis.* 2015; 43:75–82. Epub 2015/01/19. doi: 10.15654/TPK-140182 PMID: 25599242.
55. Behnke R, Walzer C. Health, husbandry and management of Eurasian lynx (*Lynx lynx*)–Vet handbook and husbandry guidelines. 2020.
56. Ryser-Degiorgis M-P, Meli ML, Breitenmoser-Würsten C, Hofmann-Lehmann R, Marti I, Pisano SR, et al. Health surveillance in wild felid conservation: experiences with the Eurasian lynx in Switzerland. *Cat News Special Issue.* 2021; 14:64–75. Available from: https://www.researchgate.net/publication/355137857_Health_surveillance_in_wild_felid_conservation_experiences_with_the_Eurasian_lynx_in_Switzerland.
57. Gunkel C, Lafortune M, Gary West, Heard DJ, Caulkett N. Felids. In: West G, Heard D, Caulkett N, editors. Zoo animal and wildlife immobilization and anesthesia. Ames (Iowa): Blackwell Pub; 2007. pp. 443–57.
58. Cracknell J. Airway Management. In: West G, Heard D, Caulkett N, editors. Zoo animal and wildlife immobilization and anesthesia. Ames, USA: John Wiley & Sons, Inc; 2007.
59. Marti I, Ryser-Degiorgis M-P. A tooth wear scoring scheme for age estimation of the Eurasian lynx (*Lynx lynx*) under field conditions. *Eur J Wildl Res.* 2018; 64:1–13. doi: 10.1007/s10344-018-1198-6.
60. Taylor S, Spada E, Callan MB, Korman R, Leister E, Steagall P, et al. 2021 ISFM consensus guidelines on the collection and administration of blood and blood products in cats. 2021; 23:410–32. doi: 10.1177/1098612X211007071 PMID: 33896248.
61. Goettling J, Goeritz F, Jewgenow K, Painer J. Serum chemistry and haematology for female Eurasian lynx (*Lynx lynx*). *Eur J Wildl Res.* 2016; 62:365–7. doi: 10.1007/s10344-016-0990-4.
62. Moen R, Rasmussen JM, Burdett CL, Pelican KM. Hematology, serum chemistry, and body mass of free-ranging and captive Canada lynx in Minnesota. *J Wildl Dis.* 2010; 46:13–22. doi: 10.7589/0090-3558-46.1.13 PMID: 20090014.
63. Schmidt DA, Barbiers RB, Ellersieck MR, Ball RL, Koutsos EA, Griffin ME, et al. Serum chemistry comparisons between captive and free-ranging giraffes (*Giraffa camelopardalis*). *J Zoo Wildl Med*. 2011; 42:33–9. doi: 10.1638/2009-0218.1 PMID: 22946367.
64. Lescano J, Quevedo M, Villalobos M, Gavidia CM. Hematology and serum biochemistry of free-ranging and captive Sechuran foxes (*Lycalopex sechurae*). *Vet Clin Pathol.* 2018; 47:29–37. Epub 2018/01/24. doi: 10.1111/vcp.12568 PMID: 29364544.
65. Shima AL, Berger L, Skerratt LF. Haematological and serum biochemical reference intervals of free-ranging Lumholtz's tree-kangaroos (*Dendrolagus lumholtzi*). *Aust Vet J.* 2021; 99:249–54. Epub 2021/03/09. doi: 10.1111/avj.13063 PMID: 33751570.
66. Ryser-Degiorgis M-P, Meli ML, Breitenmoser C, Hofmann-Lehmann R, Marti I, Pisano SRR, et al. Health surveillance as an important tool in wild felid conservation: experiences with the Eurasian lynx in Switzerland. In press. 2021.
67. Beecham JJ. Orphan bear cubs: rehabilitation and release guidelines. London, United Kingdom: World Society for the Protection of Animals; 2006.
68. National Office of Animal Health. Atipam 5.0mg/ml solution for injection for cats and dogs. NOAH Compendium datasheet. UK: 2019 [updated 30 Dec 2021; cited 30 Dec 2021]. Available from: https://www.noahcompendium.co.uk/?id=-469254.
69. Woodford MH. Quarantine and health screening protocols for wildlife prior to translocation and release into the wild. Paris, France: Office International des Epizooties; 2001.
70. Zsivanovits PH, Forbes NA. Suggestions to optimise recovery and release while minimizing the disease risks associated with raptor rehabilitation. *J Wildl Rehab.* 2004; 27:4–15. Available from: https://theiwrc.org/wp-content/uploads/2010/07/Volume-27-No.-2-Summer-2004.pdf.
71. Reiss A, Woods R, editors. National Zoo Biosecurity Manual. Commonwealth of Australia; 2011.
72. Morgan KN, Tromborg CT. Sources of stress in captivity. *Appl Anim Behav Sci.* 2007; 102:262–302. doi: 10.1016/j.applanim.2006.05.032.
73. Föllmi J, Steiger A, Walzer C, Robert N, Wenker C. A scoring system to evalute physical condition and quality of life in geriatric zoo mammals. *Anim Welf.* 2007; 16:309–18.
74. Fischer CP, Romero LM. Chronic captivity stress in wild animals is highly species-specific. *Conserv Physiol.* 2019; 7:coz093. doi: 10.1093/conphys/coz093 PMID: 31824674.
75. Hewson C. Stress in small animal patients: why it matters and what to do about it. *Ir Vet J.* 2008; 61:249–54.
76. Merlot E. Consequences of stress on immune function in farm animals. *INRA Prod Anim.* 2004; 17:255–64.
77. Ontario Ministry of Natural Resources and Forestry. Ontario Wildlife. Rehabilitation exam. A pre-requisite for applying to be a wildlife custodian under the Ontario Fish and Wildlife Conservation Act. 2020 [updated 2020; cited 4 Jun 2020]. Available from: https://www.readkong.com/page/ontario-wildlife-rehabilitation-exam-study-guide-for-the-6020011.
78. Llewellyn P. Rehabilitation and release. In: Mullineaux E, Keeble EJ, editors. BSAVA Manual of Wildlife Casualties. 2nd ed. Gloucester: British Small Animal Veterinary Association; 2016.
79. Rivas A, Martínez F, Sánchez Iñigo, Aguilar José María, Quevedo MA, Bergara Juana, et al. Hand-rearing of Iberian lynx cubs. Crianza artificial de cachorros de lince ibérico. *In:* Vargas A, Breitenmoser-Würsten C, Breitenmoser U, editors. Iberian lynx Ex situ conservation: an interdisciplinary approach. Fundación Biodiversidad / IUCN Cat Specialist

Group; 2009. pp. 109–24.
80. Mehanna HM, Moledina J, Travis J. Refeeding syndrome: what it is, and how to prevent and treat it. BMJ (online). 2008; 336:1495–8. doi: 10.1136/bmj.a301 PMID: 18583681.
81. Hugues A. Le syndrome de nutrition inappropriée. Physiopathologie et élaboration d'un protocole de réalimentation entérale des animaux de compagnie à risque. Doctoral Thesis in Veterinary Medicine, National Veterinary School–Alfort. 2015. Available from: http://theses.vet-alfort.fr/telecharger.php?id=1819.
82. Barras-Moret A-C, Guex E, Coti Bertrand P. Le syndrome de renutrition inappropriée : la clé du traitement est la prévention. *Nutrition Clinique et Métabolisme.* 2011; 25:86–90. doi: 10.1016/j.nupar.2011.04.006.
83. Tresley J, Sheean PM. Refeeding syndrome: recognition is the key to prevention and management. *J Am Diet Assoc.* 2008; 108:2105–8. doi: 10.1016/j.jada.2008.09.015 PMID: 19027417.
84. Outters G. Mécanismes engendrés par un jeûne. *La Semaine Vétérinaire.* 25 January 2011:35.
85. Brenner K, KuKanich KS, Smee NM. Refeeding syndrome in a cat with hepatic lipidosis. *J Feline Med Surg.* 2011; 13:614–7. Epub 2011/06/29. doi: 10.1016/j.jfms.2011.05.001 PMID: 21719333.
86. Boland K, Solanki D, O'Hanlon C. Prevention and treatment of refeeding syndrome in the acute care setting, Irish society for clinical nutrition and metabolism, 31p; 2013.
87. Griffin AS, Blumstein DT, Evans CS. Training captive-bred or translocated animals to avoid predators. *Conserv Biol.* 2000; 14:1317–26. doi: 10.1046/j.1523-1739.2000.99326.x.
88. Hall E. Release considerations for rehabilitated wildlife. Taronga Zoo: 2005 [cited 12 Jan 2020]. Available from: https://www.awrc.org.au/uploads/5/8/6/6/5866843/awrc_elizabeth_hall.pdf.
89. Jule KR, Leaver LA, Lea SEG. The effects of captive experience on reintroduction survival in carnivores: a review and analysis. *Biol Conserv.* 2008; 141:355–63. doi: 10.1016/j.biocon.2007.11.007.
90. Combet C. Pratique de la prise en charge de la faune sauvage de France métropolitaine par le vétérinaire praticien. Doctoral Thesis in Veterinary Medicine, National Veterinary School–Alfort. 2009. Available from: http://theses.vet-alfort.fr/telecharger.php?id=1079.
91. Rodier V. Alimentation des grands félins sauvages en captivité: extrapolation à partir du régime alimentaire en milieu naturel. Doctoral Thesis in Veterinary Medicine, National Veterinary School–Alfort. 2008. Available from: http://theses.vet-alfort.fr/telecharger.php?id=1209.
92. Inserm. Carences nutritionnelles: Etiologies et dépistage. Rapport, Inserm, 333p, Paris.; 1999.
93. Zhang L, Yang S, Xu Y, Dahmer TD. Influence of dietary feathers on the fecal microbiota in captive Arctic fox: do dietary hair or feathers play a role in the evolution of carnivorous mammals? *Integr Zool.* 2014; 9:583–9. doi: 10.1111/1749-4877.12069 PMID: 25420637.
94. O'Regan HJ, Kitchener AC. The effects of captivity on the morphology of captive, domesticated and feral mammals. *Mammal Rev.* 2005; 35:215–30. doi: 10.1111/j.1365-2907.2005.00070.x.
95. Gilkison JJ, White BC, Taylor S. Feeding enrichment and behavioural changes in Canadian lynx *Lynx canadensis* at Louisville Zoo. *Int Zoo Yearbook.* 1997; 35:213–6. doi: 10.1111/j.1748-1090.1997.tb01212.x.
96. McPhee ME. Intact carcasses as enrichment for large felids: effects on on- and off-exhibit behaviors. *Zoo Biol.* 2002; 21:37–47. doi: 10.1002/zoo.10033.
97. McPhee EM, Carlstead K. The importance of maintaining natural behaviors in captive mammals. In: Kleiman DG, Thompson KV, Baer CK, editors. Wild mammals in captivity. Chicago; 2010.
98. Houser A, Gusset M, Bragg CJ, Boast LK, Somers MJ. Prerelease hunting training and post-release monitoring are key components in the rehabilitation of orphaned large felids. *Afr J Wildl Res.* 2011; 41:11–20. doi: 10.3957/056.041.0111.
99. Miquelle DG, Jiménez-Peréz, Ignacio, Ignacio, López G, Onorato D, Rozhnov VV, Arenas R, et al. Rescue, rehabilitation, translocation, reintroduction, and captive rearing: lessons from handling the other big cats. In: Nyhus PJ, McCarthy T, Mallon D, editors. Snow leopards. London, United Kingdom: Academic Press is an imprint of Elsevier; 2016.
100. Martos A. Environmental enrichment for captive felids. In: Vargas A, Breitenmoser-Würsten C, Breitenmoser U, editors. Iberian lynx Ex situ conservation: an interdisciplinary approach. Fundación Biodiversidad / IUCN Cat Specialist Group; 2009. pp. 137–45.
101. Premier J, Gahbauer M, Leibl F, Heurich M. In situ feeding as a new management tool to conserve orphaned Eurasian lynx (*Lynx lynx*). *Ecol Evol.* 2021; 11:2963–73. Epub 2021/03/02. doi: 10.1002/ece3.7261 PMID: 33841758.
102. Anders O, Sacher P. Das Luchsprojekt Harz - ein Zwischenbericht. *Naturschutz im Land Sachsen-Anhalt.* 2005; 42(2):3–12. Available from: https://www.luchsprojekt-harz.de/luchsprojekt/de/veroeffentlichungen/downloads/Anders--Sacher-2005-Das-Luchsprojekt-Harz_Ein-Zwischenbericht.pdf?m=1517567671.
103. Kubala J, Guimarães NF, Brndiar J, Tomáš Iľko, Krajči M, Ľubomír Ferlica, et al. Monitoring of Eurasian lynx (*Lynx lynx*) in the Vepor Mountains and its importance for the national and European management and species conservation. Technical Report. 2019. Available from: https://www.lifelynx.eu/wp-content/uploads/2018/06/Monitoring-of-Eurasian-Lynx-Lynx-lynx-in-the-Vepor-Mountains.pdf.
104. Anonymous. Ordonnance du 23 avril 2008 sur la protection des animaux (OPAn). Annex 2, art. 10, Table 1, TSchV; RS 455.1. 2008 [cited 1 Apr 2020]. Available from: https://www.admin.ch/opc/fr/classified-compilation/20080796/index.html.

105. Boulat C. Elevage de jeunes lynx (*Lynx lynx*) en captivité en vue de leur relâcher. Protocoles réalisés en France jusqu'en 2008. Doctoral Thesis in Veterinary Medicine, National Veterinary School–Alfort. 2009.
106. ATHENAS. Nouveaux enclos à lynx: une structure inédite en Europe | Centre Athénas [updated 18 Jan 2021; cited 18 Jan 2021]. Available from: https://www.athenas.fr/nouveaux-enclos-a-lynx-une-structure-inedite-en-europe/.
107. Clubb R, Mason G. Animal welfare: captivity effects on wide-ranging carnivores. *Nature.* 2003; 425:473–4. doi: 10.1038/425473a PMID: 14523435.
108. Hartmann-Furter. Breeding European wildcats (*Felis silvestris silvestris*, Schreber 1777) in species-specific enclosures for reintroduction in Germany. In: Vargas A, Breitenmoser-Würsten C, Breitenmoser U, editors. Iberian lynx Ex situ conservation: an interdisciplinary approach. Fundación Biodiversidad / IUCN Cat Specialist Group; 2009. pp. 453–61.
109. Wolfensohn S, Shotton J, Bowley H, Davies S, Thompson S, Justice WSM. Assessment of welfare in zoo animals: towards optimum quality of life. *Animals*. 2018; 8. doi: 10.3390/ani8070110 PMID: 29973560.
110. Wenisch E. Les stéréotypies des animaux élevés en captivité: étude bibliographique. Doctoral Thesis in Veterinary Medicine, National Veterinary School–Toulouse. 2012.
111. Mellen JD. Captive environments for small felids. In: Shepherdson DJ, Mellen JD, Hutchins M, editors. Second nature. Environmental enrichment for captive animals. Washington, London: Smithsonian Institution Press; 1998.
112. Kleiman DG, Allen ME, Thompson KV, Lumpkin S, editors. Wild mammals in captivity. Principles and techniques. Chicago: University of Chicago Press; 1996.
113. Ryser-Degiorgis M-P, Marti I, Pisano SRR, Pewsner M, Wehrle M, Breitenmoser-Würsten C, et al. Management of suspected cases of feline immunodeficiency virus infection in Eurasian lynx (*Lynx lynx*) during an international translocation program. *Front. Vet. Sci*. 2021; 8:1169–. doi: 10.3389/fvets.2021.730874.
114. Naidenko SV. Aggression in lynx adult–cub relations: can it be a reason for the dissolution of litters? *Ethol Ecol Evol.* 2001; 13:283–95. doi: 10.1080/08927014.2001.9522777.
115. Khan BN, Ahmad R, Ali Z, Mehmood S, Raza H, Azhar M, et al. Impact of different captive environmental conditions on behavior of African lions and their welfare at Lahore Zoo and Safari Zoo, Lahore. *Pak J Zool.* 2018; 50. doi: 10.17582/journal.pjz/2018.50.2.523.531.
116. Alekseeva GS, Antonevich AL, Erofeeva MN, Naidenko SV. Social play in the development of sibling relations in Eurasian lynx (*Lynx lynx*). *Biol Bull Russ Acad Sci.* 2014; 41:364–71. doi: 10.1134/S1062359014040025.
117. Vargas A, Sánchez Iñigo, Martínez F, Rivas A, Breitenmoser U. Interdisciplinary methods in the Iberian lynx (*Lynx pardinus*) Conservation Breeding Programme. In: Vargas A, Breitenmoser-Würsten C, Breitenmoser U, editors. Iberian lynx Ex situ conservation: an interdisciplinary approach. Fundación Biodiversidad / IUCN Cat Specialist Group; 2009. pp. 56–71.
118. Kelly A, Scrivens R, Grogan A. Post-release survival of orphaned wild-born polecats *Mustela putorius* reared in captivity at a wildlife rehabilitation centre in England. *Endang Species Res.* 2010; 12:107–15. doi: 10.3354/esr00299.
119. Yoxon G. Exploring the depths: Eurasian otter rescue and rehabilitation. In: Parsons ECM, editor. An introduction to marine mammal biology and conservation. 1st ed. Burlington Mass.: Jones & Bartlett Learning; 2013.
120. Grogan A, Kelly A. Rehabilitation and release. In: Mullineaux E, Keeble EJ, editors. BSAVA Manual of Wildlife Casualties. 2nd ed. Gloucester: British Small Animal Veterinary Association; 2016. pp. 81–92.
121. Rodriguez A, Barrios L, Delibes M. Experimental release of an Iberian lynx (*Lynx pardinus*). *Biodivers Conserv.* 1995; 4:382–94. doi: 10.1007/BF00058423.
122. Vandel J, Stahl P, Herrenschmidt V, Marboutin E. Reintroduction of the lynx into the Vosges moutain massif: from animal survival and movements to population development. *Biol Conserv.* 2006; 131:370–85.
123. Černe R, Molinari-Jobin A, Krofel M, Kubala J, Šivec N, Aleš Pičulin N, et al. Population level reinforcement plan. Action A.4 - Elaboration of plans for reinforcement of the Dinaric-SE Alpine population and for creation of a new "stepping stone" population. 2019 [cited 25 May 2021]. Available from: https://www.lifelynx.eu/wp-content/uploads/2019/02/Population-Reinforcement-Plan-A4-Final-Version-13-Feb-2019.pdf.
124. Interreg Central Europe. Transnational toolbook for population-level lynx monitoring. 2018 [cited 25 May 2021]. Available from: https://www.interreg-central.eu/Content.Node/Lynx-Monitoring-Methods.pdf.
125. Molinari-Jobin A, Woelfl S, Marboutin E, Molinari P, Breitenmoser U. Monitoring the lynx in the Alps. *Hystrix.* 2012; 23:49–53. doi: 10.4404/hystrix-23.1-4553.
126. Lawrence J. A study of the benefits of raptor rehabilitation to the public. Senior Thesis Projects, 1993–2002, University of Tennessee. 1997. Available from: https://trace.tennessee.edu/utk_interstp2/17/.
127. Sleeman JM, Clark EE. Clinical wildlife medicine: a new paradigm for a new century. *J Avian Med Surg.* 2003; 17:33–7. doi: 10.1647/1082-6742(2003)017[0033:CWMANP]2.CO;2.
128. Sharp B. Post-release survival of oiled, cleaned seabirds in North America. *Ibis.* 1996; 138:222–8. doi: 10.1111/j.1474-919X.1996.tb04332.x.
129. Tardieu L, Rollock W, Garcia GW. Wildlife rehabilitation: a case study of the neo-tropical opossum *Didelphis marsupialis insularis* Allen 1902. *Braz Biol.* 2019. doi: 10.1590/1519-6984.214757 PMID: 31576932.
130. Schmidt-Posthaus H, Breitenmoser-Würsten C, Posthaus H, Bacciarini L, Breitenmoser U. Causes of mortality in reintroduced Eurasian lynx in Switzerland. *J Wildl Dis.* 2002; 38:84–92. doi: 10.7589/0090-3558-38.1.84 PMID: 11838233.