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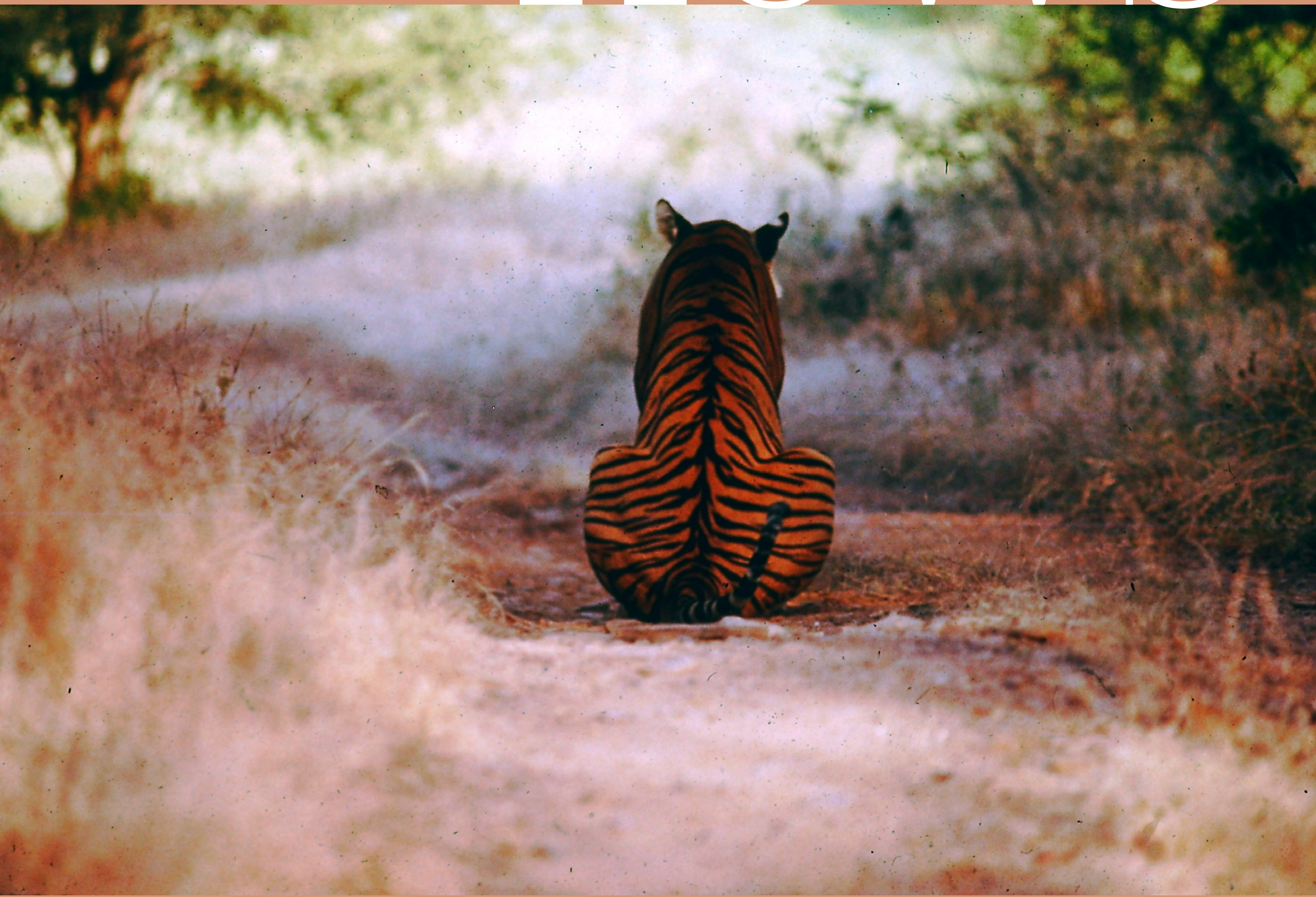

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Original contributions and short notes about wild cats are welcome
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Early disease risk control in free-ranging snow leopards taken into captivity

We provide practical information on health care to recently rescued free-ranging snow leopards *Panthera uncia* taken into captivity. We aim to address the most frequently asked questions on snow leopard health by people involved in captive rehabilitation initiatives across range countries, who may have limited access to wildlife health expertise. Most of the recommendations we provide also apply to other big cat species.

In an authoritative chapter recently published in "Snow Leopards" (Elsevier Eds), Dale Miquelle and colleagues provided a detailed account of lessons learned on rescue, rehabilitation, translocation, reintroduction and captive rearing from handling big cats (Miquelle et al. 2016). A wide variety of aspects are documented and discussed, including planning, science, genetic restoration, public policy and publicity, but relatively limited information is provided regarding the health care of rehabilitated big cats, besides the importance of disease screening. In the present paper we intend to provide a set of pragmatic recommendations on the health care of snow leopards recently brought into captivity, based on our personal experience and on "frequently asked questions" by biologists and managers involved in snow leopard conservation projects across Asia.

Throughout their distribution, snow leopards are occasionally taken into captivity for brief or prolonged periods of time for the purposes of rehabilitation and unfortunately also for the illegal trade in live specimens or their parts. When not captured for illegal trade, adults are usually taken into captivity because of disease or trauma, and newborn/juveniles because they have been separated either intentionally or accidentally from their mother (Fig. 1). Rehabilitation could also concern individuals confiscated from illegal possessors. There are considerable challenges inherent in the rehabilitation of snow leopards and their return to the wild, particularly from the perspective of health. Capture, handling, transport, and change of environment are sources of extreme stress that may predispose animals to developing disease. Stress management, thorough medical examination, and where applicable treatments of wounds or disease are essential steps to maximise the survival of the newly captive animal, yet a wildlife veterinarian is rarely available at the early stage of their captivity. We discuss here three health measures that could help reduce the risk of disease in wild snow leopards recently taken captive.

Early husbandry and health care measures

If confined in a small cage or box upon entry into captivity, and before being moved into a larger space, snow leopards should be treated topically with an antiseptic iodine spray for any skin wound or an acaricidal spray in case of heavy infestation with ticks. Although sarcoptic mange has never been documented with certitude in free-ranging snow leopards, the disease has been described in other free-ranging *Panthera* species and should be suspected in case of encrusted pruriginous lesions in debilitated individuals. Adults could be treated with 200 µg/kg body mass of ivermectin injected under skin or given with food two weeks apart (Jalanka & Vane-Tempest 1990). Then the immediate priority is to address the animal's housing needs, by offering, confined, ventilated, and dark space, where the animal is untied, and held in strict quarantine isolation. For cubs less than six week of age, it is important to maintain the ambient temperature relatively high, ca. 21-23 °C, but not higher to prevent hair loss, and provide a wooden or carton box in which they can take safe refuge when they are stressed. It is also important to change litters often because of the copious amounts of urine produced by cubs every day. Sibling juveniles can be left together for warmth and comfort. Confinement and darkness decrease stress and ease recaptures, while good natural ventilation with an incoming air supply very close to the floor and an evacuation outlet

Fig. 1. A snow leopard cub rehabilitated in Gilgit-Baltistan, Pakistan. The animal named "Leo" was eventually sent to the Bronx Zoo, New York (Photo Anonymous but collected by Mayoor Khan/WCS).

near the ceiling is essential to provide respiratory comfort. Contacts with other animals, either direct or indirect (e.g. through objects, clothing or footwear), particularly with domestic carnivores, must be avoided, and the keeper should minimise contacts with pets, which may be clinically healthy but not necessarily pathogen-free. Visits should be minimised, and if unavoidable should be timed to coincide with a "normal visit", such as for feeding. Last, captivity period should be kept as short as possible and all early husbandry measures should be designed to decrease imprinting of the rehabilitated animals to human beings and to human environment, enabling whenever possible a quick return to the wild (Fig. 2).

Nutrition and health

Food can also be an important source of pathogens for a captive snow leopard. A high standard of hygiene consisting in using clean, preferably boiled water, lathered and washed hands for at least 20 seconds, and detergents to eliminate organic matters must be followed when preparing food, and cleaning bottles, nipples, food containers, bowls and other utensils, which should never be used for other animals. Milk replacers and commercial pasteurised milk can be used to feed leopard cubs. When these are unavailable, raw cow's or goat's milk can be used, but must come from clinically healthy animals and be boiled before being provided. Weaned individuals should never be fed with blood, offal or meat originating from fetuses, stillbirths, or animals that died from disease or an unknown cause, including condemned meat or carcasses from local slaughterhouses. Although of very rare occurrence captive nondomestic cats have died from highly pathogenic avian influenza virus (subtype H5N1) after being fed carcasses of infected chickens (Keawcharoen et al. 2004), and also from bluetongue, presumably acquired from ingestion of fetuses and stillborn livestock (Jauniaux et al. 2008). Horse and donkey meat should be avoided because glanders occurs in many countries across the snow leopard's range (e.g. Afghanistan, China, India, Mongolia, Pakistan), and the responsible bacteria has caused fatal outbreaks in captive wild felids (Khaki et al. 2012).

Infectious disease risk and vaccination

A wide variety of infectious agents have been found in captive felids, including snow leopards, of which some have severe and sometimes fatal consequences to the host. A comprehensive list of infectious agents potentially harmful to snow leopards is available in Ostrowski & Gilbert (2016). Several important pathogens including canine distemper virus CDV and rabies are relatively short-lived in the environment and as they are susceptible to most disinfectants (Deem et al. 2000), appropriate hygienic measures and isolation of leopards during rehabilitation should considerably reduce the risk of infection for the captive snow leopard. In contrast, feline panleukopenia virus is ubiquitous, extremely resistant in the environment and the risk of infection in captive snow leopard is therefore relatively high, with clinical signs including weakness, anorexia, diarrheic faeces with blood, fever, vomiting, and nasal discharge, an ailment leading often to chronic debilitation or death.

Enclosures should be disinfected both prior to and following housing of snow leopards with products capable of neutralising the most resistant pathogens, particularly parvovirus (e.g. feline panleukopenia virus). Parvocidal disinfectants include household bleach (sodium hypochlorite, at a dilution of 36 ml per litter of water), and potassium peroxymonosulfate (e.g. Trifectant® or Virkon®, prepared according to manufacturer's instruction), whereas quarternary ammonium products are unable to neutralise the virus (Eleraky et al. 2002). The presence of organic material (e.g. faeces, soil etc.) reduces the efficacy of sodium hypochlorite, and should be removed before disinfection with bleach-based products. Disinfectants should be given sufficient time to ensure parvovirus is fully neutralised (10 minutes for bleach-based products).

One question that frequently arises when snow leopards are initially presented, is the availability and suitability of vaccines marketed for use in domestic animals. It must be emphasised that there are no vaccines specifically developed for nondomestic cats, and few clinical studies have been performed to establish the immunogenicity, the safety and the duration of immunity when domestic animal vaccines are used in wild felids. In some cases, modified live vaccines MLV, which are generally safe for domestic carnivores, have resulted in adverse effects and sometimes clinical infections and death when used in their nondomestic counterparts (Jacobson et al. 1988). While modern products are generally safer, they should in general not be used routinely in rehabilitated snow leopards, until safety and efficacy trials have been completed. One pathogen of particular importance to large felids is canine distemper virus, which is known to cause serious disease and death in several *Panthera* species, including snow leopards (Fix et al. 1989, Silinski et al. 2003). Due to the importance of this pathogen, recent safety and efficacy trials have been conducted in domestic cats *Felis catus*, and captive tigers *Panthera tigris* (Ramsay et al. 2016, Sadler et al. 2016). Tigers were vaccinated using an MLV product, and a recombinant vaccine based on a canary-pox vector, which has not been associated with clinical disease, but induces an inferior and shorter-lasting immune response (Sadler et al. 2016).

Tigers vaccinated with two doses of the recombinant product (1 ml initially, and 3 ml on day 39) failed to produce measurable antibody titers using a conventional virus neutralisation assay. However, eight tigers that received a subcutaneous dose of the MLV (1 ml initially, and 1 ml on day 171) produced a strong antibody response that was still detectable by day 196. Use of the MLV in a further 38 tigers produced no ill effects. A more limited trial in lions *Panthera leo* also invoked measurable antibodies and no clinical disease (Kock et al. 1998), which suggests that use of modified live CDV vaccines may be the most effective choice for use in snow leopards, and are likely to be safe in this species. However, several modified live CDV vaccines are marketed in a bivalent, or multivalent form, which include vaccines against two or more pathogens. Vaccines containing a modified live component against canine parvovirus should not be used in animals that may be pregnant, as this could represent a risk to the fetus.

The use of inactivated vaccines against feline parvovirus (i.e. feline panleukopenia), usually associated with feline calicivirus and herpes virus vaccines, is recommended and has indeed resulted in seroconversion in snow leopards (Sassa et al. 2006). However, inactivated vaccines can be less effective in evoking immunity than natural infections, and for obvious reasons experimental challenge studies have not been performed. Therefore, the protective value of inactivated vaccines to field strains in snow leopard habitat remains unknown. As far as possible sanitary isolation of rehabilitated snow leopards should be encouraged rather than immunisation.

Fig. 2. An anesthetised female snow leopard examined by biologists. The animal had been trapped illegally in a snare, recovered and kept captive for 18 months before being fitted with a GPS collar and released back into the wild. Eastern Pamirs, Tajikistan (Photo J. Bahriev/Panthera).

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