Received: 24 August 2020 | Revised: 23 October 2020 | Accepted: 26 October 2020

DOI: 10.1111/cobi.13786

Conservation Biology

Comment

Risks to conservation of species in the wild from promoting ex situ management: Response to Farhadinia et al. 2020

Leili Khalatbari[1,2,3] | **Helen M. K. O'Neill**[4] | **Stéphane Ostrowski**[5] | **Gholam Hosein Yusefi**[1,2] | **Arash Ghoddousi**[6] | **Hamed Abolghasemi**[7] | **Christine Breitenmoser-Würsten**[8] | **Urs Breitenmoser**[8,9] | **José Carlos Brito**[1,2] | **Sarah M. Durant**[5,10]

[1] CIBIO/InBIO, Research Center in Biodiversity and Genetic Resources, Vairão, Portugal

[2] Department of Biology, Faculty of Sciences, University of Porto, Porto, Portugal

[3] Mohitban Society, Tehran, Iran

[4] Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, Kent, UK

[5] Wildlife Conservation Society (WCS), The Bronx, New York, USA

[6] Geography Department, Humboldt-University of Berlin, Berlin, Germany

[7] Freelance conservationist, Rafsanjan, Kerman, Iran

[8] IUCN/SSC Cat Specialist Group, Muri, Switzerland

[9] Center of Fish and Wildlife Health, University of Bern, Bern, Switzerland

[10] Institute of Zoology, Zoological Society of London, London, UK

Correspondence
Leili Khalatbari, CIBIO/InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos da Universidade do Porto, R. Padre Armando Quintas, 4485–661 Vairão, Portugal.
Email: leili.khalatbari@cibio.up.pt

Article Impact Statement: Maintaining in situ populations is a conservation priority and captive management should be implemented with caution.

Funding information
Fundação para a Ciência e a Tecnologia, Grant/Award Numbers: CEECINST/00014/2018, PD/BD/132429/2017; Deutsche Forschungsgemeinschaft, Grant/Award Number: PArCS project #409732304

INTRODUCTION

Conservation of endangered species may include establishing ex situ populations to provide insurance against extinction in the wild. Farhadinia et al. (2020) looked at the use of ex situ management for 43 taxa (18 species, 23 subspecies, and 2 subpopulations) of mammalian megafauna and found that approximately one-third of these taxa currently have no ex situ populations and 23% have ex situ populations that are not currently viable. They argue that bringing these species, particularly those found in "politically unstable" regions, into captivity "should be considered more rigorously."

Although we agree that in certain cases, ex situ management can provide an important safety net to prevent species extinctions, it is not a panacea. Negative conservation impacts may arise throughout the establishment of ex situ populations, and species-specific biological factors influence whether ex situ management (and ultimately reintroduction or reinforcement) is appropriate. Although these considerations should be central to decisions about initiating ex situ management, Farhadinia et al. disregarded them. We rectify this gap and elucidate the problems that may arise during the establishment, management, and release of ex situ populations.

Initiating captive populations

Of the 43 taxa included in Farhadinia et al., 15 were identified as having no ex situ management and 10 others were identified as having ex situ populations too small to avoid risks of inbreeding depression. Consequently, effective ex situ management of these 25 taxa would require individuals to be captured from wild populations. Farhadinia et al. used an effective population size of >50 individuals to indicate a viable population, without

 © 2021 Society for Conservation Biology

TABLE 1 Differences in the variables evaluated by Farhadinia et al. (2020) against three alternative approaches of defining the subspecies and species taxonomic status of the taxa under evaluation and alternative definitions[a]

Variable	Farhadinia et al. 2020 (includes some recognized ssp[b], but not all, and subpopulations of unrecognized ssp)	Alternative 1 (recognized ssp used where possible; if no IUCN[c] Red List entry for ssp, then parent species red-list category is used)	Alternative 2 (recognized ssp used where possible; if no IUCN Red List entry for the ssp, then it is inferred from information on the parent species in the red list)	Alternative 3 (excludes all ssp; only the IUCN Red List entry for parent species is used)
Number of taxa	43	38	42	21
Number of range countries	54	49	55	32
Number of taxa with total in situ population <250	24	20	22	8
Number of taxa with total in situ population >1000	8	9	9	7
Taxa with decreasing population (%)	86.05	86.84	80.95	90.48
Taxa with ranges that cross national boundaries (%)	48.84	42.11	38.1	38.1
Taxa with armed conflict in range (%)	30.23	28.95	28.57	28.57
Number of taxa with no ex situ population – international	23	19	21	9
Number of taxa with no ex situ population – national	15	12	13	6
Taxa with no ex situ and ranges crossing international boundaries & conflict zones (%)	73.33	66.67	75	57.14
Taxa with no ex situ and ranges crossing conflict zones (%)	26.67	25	33.33	14.29

[a]Detailed data for the alternatives are in Appendix S1.
[b]Subspecies.
[c]International Union for Conservation of Nature.

considering the difference between actual population size (N) and effective population size (N_e) in captive populations. The average ratio of N:N_e is 0.26 (max 0.7) (Lees & Wilcken, 2009); thus, an ex situ population would need an N of 70–190 individuals to achieve an N_e of 50 and to be considered viable. Therefore, at least 5 additional taxa do not currently have sustainable captive populations. For half of these 30 taxa, creating a sustainable ex situ population would require capturing 50–100% of their wild population. When wild populations are very small, as is the case for many critically endangered (CR) taxa, they are vulnerable to stochastic events and inbreeding depression. Therefore, removing enough individuals from these populations to avoid inbreeding in ex situ populations poses an additional threat to their survival in the wild, and in the case of some CR taxa, would make them extinct in the wild, as was the case for red wolf (*Canis rufus*) (Hinton et al., 2017).

The practicality of establishing effective ex situ populations in politically unstable regions is another key concern. Ex situ management is substantially more expensive than in situ management (Balmford et al., 1995), and many countries have insufficient resources to effectively manage and maintain captive populations, especially during armed conflicts during which local resources and foreign aid are likely to be diverted elsewhere. Moving endangered species to other countries can be appropriate and effective when undertaken in collaboration with range governments and wildlife authorities. However, amidst political turmoil or periods of unrest, these agencies are likely to be stretched in their capacity to adequately engage with these initiatives; removing biodiversity under such circumstances may raise legitimate allegations of exploitation and neocolonialism (Hayward et al., 2018).

Maintaining a captive population

Ex situ management is extremely complex; species often have complicated husbandry requirements for survival, health, and reproduction. These requirements are usually identified over many years of experience in captive management, often through trial and error. For example, although all female cheetahs (*Acinonyx jubatus*) breed in the wild (Laurenson et al., 1992), a substantial proportion do not successfully breed in captivity, even when kept in optimal conditions (Wachter et al., 2011). Thus, ex situ management is unlikely to serve as comprehensive insurance for 2 CR subspecies of cheetah (*A. j. hecki* and *A. j. venaticus*), particularly because moving individuals into

captivity reduces their effective population size and further threatens their viability in the wild.

Difficulties in providing appropriate conditions to foster natural behavior and reproduction in captivity hinder the maintenance of genetic diversity. Moving large mammals between institutions for breeding has welfare implications and is very expensive, and there is no guarantee of successful reproduction. Assisted reproduction is becoming more widely used, but it is an invasive, expensive procedure that is, for many endangered species, untested and experimental (Weise et al., 2014).

Reintroduction or reinforcement

The ultimate objective of ex situ conservation should be reintroduction or reinforcement of wild populations; however, preparing animals for release is a complicated process, particularly for species, such as large carnivores, that rely on complex and learned behaviors to survive in the wild. Young predators learn many of their skills from their mothers. Although some hunting-related behaviors may be innate, predator and human-avoidance behaviors are usually learned (e.g., in cheetahs [Durant, 2000]), yet they have a direct impact on the likelihood of an animal surviving after release (Tetzlaff et al., 2019). Training animals to hunt and forage effectively in a captive setting is difficult, time-consuming, and expensive, and there is no guarantee of success. In addition, reintroductions ultimately depend on the timely cooperation of ex situ institutions making their, often valuable, captive populations available for release into the wild, which is not always guaranteed.

Finding suitable areas for release is also challenging, particularly when concurrent in situ conservation efforts are absent or limited, because the original threats to the species may persist. Reinforcing extant populations with captive individuals will put additional pressure on available resources and may result in intraspecific competition (Hayward et al., 2007), exacerbate human–wildlife conflict, and erode potential goodwill (Qin et al., 2015). Equally, if the species has been extirpated at reintroduction sites, then local human populations may have lost coping mechanisms for living alongside the species, which may lead to human–wildlife conflict (Linnell & Cretois, 2018).

Additional considerations

Several inconsistencies in the approach used by Farhadinia et al. are cause for concern. Most importantly, their "43 critically endangered species" included some subspecies, but not others (e.g., all subspecies of *Gorilla beringei* and *Gorilla gorilla* were included but not all subspecies of *Pongo pygmaeus*). Two subpopulations that are not recognized as subspecies (West African subpopulations of the African wild dog [*Lycaon pictus*] and the African lion [*Panthera leo*]) were also included. These inconsistencies have a substantial impact on their results, depending on which definition of species and subspecies is used (Table 1 & Appendix S1).

The existence of armed conflict in a species range was suggested as a reason for implementing ex situ management. However, as they acknowledge, periods of conflict do not inevitably lead to conservation harm (Collar et al., 2017). Using conflicts to justify diverting funding from in situ conservation toward ex situ management is inappropriate. Likewise, Farhadinia et al. claim that border zones can compromise conservation, but there is no justification given for this generalization. For 15 taxa, having transboundary ranges was the sole indicator of political instability (Table 1), but no evidence was provided showing they are at greater risk because of this. Ex situ populations are also susceptible to political instability; captive animals are sometimes mistreated or killed (Kinder, 2013).

CONCLUSION

Farhadinia et al. suggest using "ex situ management as an insurance against extinction," but insurance does not always pay out. For example, the northern white rhinoceros (*Ceratotherium simum cottoni*) is effectively extinct in the wild despite years of intensive ex situ management that cost substantial amounts of money (Gibbens, 2018).

Although we agree that ex situ management can be an important aspect of species conservation, which has been effective for certain species, its use should be considered on a species-by-species basis and incorporate biological, ecological, and socioeconomic information rather than broad-stroke generalizations based on threat levels and inferences about range-country governance. The difficulties associated with ex situ management and reintroduction and reinforcement discussed here are not exhaustive; multiple species-specific issues affect different taxa. Such difficulties may explain why very few of these species have been the subject of successful releases.

Ex situ management is resource intensive and often depletes limited in situ resources and efforts, with no guarantee of success, particularly for species with complex behaviors or threats. Where sufficient species-specific data are available, robust decision trees, based on input from a range of stakeholders and experts, can be useful tools for determining whether ex situ management may be appropriate (e.g., Canessa et al., 2016). The 5-step process proposed by International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) (IUCN SSC, 2014) provides best practice guidelines on when ex situ management is likely to successfully augment conservation efforts, but mammalian megafauna (especially large carnivores) often do not meet these conditions due to their intrinsic characteristics.

Generalized endorsement of ex situ management as an insurance against the extinction of megafauna, in the absence of more pragmatic recommendations, risks being an expensive distraction from addressing the real threats to many species in the wild. We, therefore, argue that in situ conservation should remain the primary focus of species conservation and that ex situ management as a tool to recover a species should only be initiated as a last resort after using IUCN SSC best practice guidelines.

ACKNOWLEDGMENTS

L.K. and J.C.B. were supported by Fundação para a Ciência e Tecnologia (PD/BD/132429/2017 and CEECINST/00014/2018/CP1512/CT0001). A.G. appreciates the financial support by the German Research Foundation (DFG; PArCS project #409732304). We thank the editor, J.G. Ewen and two annonymous reviewers for their valuable suggestions andproviding constructive comments.

ORCID

Leili Khalatbari https://orcid.org/0000-0003-2182-3084
Helen M. K. O'Neill https://orcid.org/0000-0002-9458-4494
Gholam Hosein Yusefi https://orcid.org/0000-0002-3258-8561
Arash Ghoddousi https://orcid.org/0000-0001-9605-3091
José Carlos Brito https://orcid.org/0000-0001-5444-8132
Sarah M. Durant https://orcid.org/0000-0003-0724-0878

LITERATURE CITED

Balmford, A., Leader-Williams, N., & Green, M. J. B. (1995). Parks or arks: Where to conserve threatened mammals? *Biodiversity and Conservation*, *4*, 595–607.

Canessa, S., Converse, S. J., West, M., Clemann, N., Gillespie, G., McFadden, M., Silla, A. J., Parris, K. M., & McCarthy, M. A. (2016). Planning for ex situ conservation in the face of uncertainty. *Conservation Biology*, *30*, 599–609.

Collar, N. J., Baral, H. S., Batbayar, N., Bhardwaj, G. S., Brahma, N., Burnside, R. J., Choudhury, A. U., Combreau, O., Dolman, P. M., Donald, P. F., Dutta, S., Gadhavi, D., Gore, K., Goroshko, O. A., Hong, C., Jathar, G. A., Jha, R. R. S., Jhala, Y. V., Koshkin, M. A., … Kessler, A. E. (2017). Averting the extinction of bustards in Asia. *Forktail*, *33*, 1–26.

Durant, S. M. (2000). Predator avoidance, breeding experience and reproductive success in endangered cheetahs, *Acinonyx jubatus*. *Animal Behaviour*, *60*, 121–130.

Farhadinia Mohammad S., Johnson Paul J., Zimmermann Alexandra, McGowan Philip J.K., Meijaard Erik, Stanley-Price Mark, Macdonald David W. (2020). Ex situ management as insurance against extinction of mammalian megafauna in an uncertain world. *Conservation Biology*, *34* (4), 988–996.

Gibbens, S. (2018). *After last male's death, is the northern white rhino doomed?* Washington, DC: National Geographic.

Hayward, M. W., Adendorff J., O'Brien J., Sholto-Douglas A., Bissett C., Moolman L. C., Bean P., Fogarty A., Howarth D., Slater R., & Kerley G. I. H. (2007). Practical considerations for the reintroduction of large, terrestrial, mammalian predators based on reintroductions to South Africa's Eastern Cape Province. *Open Conservation Biology Journal*, *1*, 1–11.

Hayward, M. W., Ripple, W. J., Kerley, G. I. H., Landman, M., Plotz, R. D., & Garnett, S. T. (2018). Neocolonial conservation: Is moving rhinos to Australia conservation or intellectual property loss. *Conservation Letters*, *11*, 1–7.

Hinton, J. W., Brzeski, K. E., Rabon, D. R., & Chamberlain, M. J. (2017). Effects of anthropogenic mortality on critically endangered red wolf *Canis rufus* breeding pairs: Implications for red wolf recovery. *Oryx*, *51*, 174–181.

IUCN (International Union for Conservation of Nature) SSC (Species Survival Commission). (2014). *Guidelines on the use of ex situ management for species conservation*. Version 2.0. Gland, Switzerland: IUCN.

Kinder, J. M. (2013). Zoo animals and modern war: Captive casualties, patriotic citizens, and good soldiers. Pages 45–75 in Hediger R, editor. *Animals and war: Studies of Europe and North America*. Leiden: Brill.

Laurenson, M. K., Caro, T., & Borner, M. (1992). Female cheetah reproduction. *National Geographic Research and Exploration*, *8*, 64–75.

Lees, C. M., & Wilcken, J. (2009). Sustaining the ark: The challenges faced by zoos in maintaining viable populations. *International Zoo Yearbook*, *43*, 6–18.

Linnell, J. D., & Cretois, B. (2018). *Research for AGRI committee—The revival of wolves and other large predators and its impact on farmers and their livelihood in rural regions of Europe*. Brussels: European Parliament, Policy Department for Structural and Cohesion Policies.

Qin, Y., Nyhus, P. J., Larson, C. L., Carroll, C. J. W., Muntifering, J., Dahmer, T. D., Jun, L., & Tilson, R. L. (2015). An assessment of South China tiger reintroduction potential in Hupingshan and Houhe National Nature Reserves, China. *Biological Conservation*, *182*, 72–86.

Tetzlaff, S. J., Sperry, J. H., & DeGregorio, B. A. (2019). Effects of antipredator training, environmental enrichment, and soft release on wildlife translocations: A review and meta-analysis. *Biological Conservation*, *236*, 324–331.

Wachter, B., Thalwitzer, S., Hofer, H., Lonzer, J., Hildebrandt, T. B., & Hermes, R. (2011). Reproductive history and absence of predators are important determinants of reproductive fitness: The cheetah controversy revisited. *Conservation Letters*, *4*, 47–54.

Weise, F. J., Stratford, K. J., & van Vuuren, R. J. (2014). Financial costs of large carnivore translocations – Accounting for conservation. *PLoS One*, *9*, e105042.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Khalatbari Leili, et al. Risks to conservation of species in the wild from promoting ex situ management: Response to Farhadinia et al. 2020. *Conservation Biology* 2021;1−4. https://doi.org/10.1002/cobi.13786.