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Editorial: New challenges and perspectives in conservation breeding programs

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Editorial on the Research Topic
New challenges and perspectives in conservation breeding programs

Faced with unprecedented extinction rates and escalating human impact on our planet, Conservation Breeding Programs (CBPs) remain the utmost tools to preserve animal biodiversity. This Research Topic aimed to bring together studies that deal with CBPs from different perspectives. Nine manuscripts have been published in this Research Topic encompassing different approaches (both *ex-situ* and *in-situ*) and animal species—primarily mammals, birds, and amphibians—in a variety of ecosystems spanning the Northern and Southern Hemispheres.

For an alarming number of animal species, CBPs represent the last line of defense against extinction. The ʻAlalā (*Corvus hawaiiensis*), the last endemic Hawaiian corvid, exemplifies this, surviving solely through captive breeding. Given its monogamous nature, mate selection and pair duration are pivotal for reproductive success in captivity. Using data recorded during four breeding seasons, Barrett et al. revealed that age, rather than pair duration, strongly influences reproductive outcomes, providing crucial insights for enhancing ʻAlalā CBPs.

A major factor that undermines CBPs' success is the limited understanding of animal reproductive biology and behavior, which remains well-documented for only a fraction of species, predominantly mammals (Wildt et al., 2010). In this Research Topic, Van Sluys et al. present the first ethogram of the critically endangered Plains-wanderer (*Pedionomus torquatus*), a ground dwelling bird endemic to Australia, paving the way for improved conservation management and husbandry of this species. Understanding the behavior of endangered species in their natural habitat is crucial for developing effective conservation strategies, a principle illustrated by the successful management of the giant panda (*Ailuropoda melanoleuca*). This iconic species serves as an example of a holistic approach in which husbandry practices align with animal behavior and physiology, which notably improve captive reproductive success from mating till cub rearing (Martin-Wintle et al., 2019; Ming-yue et al., 2021). These efforts contributed to the giant panda's downlisting from "Endangered" to "Vulnerable" on the International Union for

Conservation of Nature Red List. Collectively, these studies underscore the importance of animal behavior as a foundation for effective captive management.

When faced with small populations and low reproductive success in CBPs, assisted reproductive technologies (ARTs) associated with biobanking represent valuable tools to overcome fertility issues (Holt and Comizzoli, 2022). This is particularly relevant for amphibians, which are experiencing severe declines due to habitat degradation, population fragmentation, and diseases like chytrid fungus. In this interesting mini review, Silla and Byrne evaluate how ARTs may affect individual traits throughout amphibian life-stages, providing a "best-practice" framework for practitioners to assess the impact of protocol refinement on individual and population fitness. Additionally, targeted genetic intervention, such as promoting chytridiomycosis resistance, offers a novel conservation strategy for amphibian CBPs (Kosch et al., 2022).

Establishing ARTs requires optimized gamete collection protocols and anesthetic procedures that maximize gamete quality and quantity, while minimizing animal stress. Baquerizo et al. demonstrated that tiletamine hydrochloride plus zolazepam (Telazol®) yielded superior ejaculates in cheetahs (*Acinonyx jubatus*) undergoing electroejaculation compared to medetomidine, butorphanol, and midazolam. Similarly, in the Baw Baw frog (*Philoria frosti*), Gibert et al. found that gonadotrophin releasing hormone analogue (GnRHa) resulted in a higher proportion of offspring that reaches metamorphosis compared to GnRHa combined with metoclopramide. With robust physiological knowledge, ARTs like ovum-pick up, *in vitro* fertilization, and embryo transfer can be effectively implemented, sometimes leveraging protocols from domestic animals. However, in very small and infertile populations, ARTs might not be sufficient alone to support a viable and self-sustaining population. Under these circumstances, advanced cellular biotechnologies like somatic cell nuclear transfer, *in vitro* gametogenesis or gene editing might be necessary, raising significant ethical and welfare considerations (Korody and Hildebrandt, 2025). Interestingly, beyond species conservation, wildlife reproductive sciences can also contribute to human reproductive medicine, given shared reproductive features and challenges (Comizzoli et al., 2018). Wildlife reproductive success is affected by threats like those impacting human and livestock fertility, such as oxidative stress (Pintus and Ros-Santaella, 2021) and antimicrobial resistance (Doyle et al., 2025). Furthermore, reproductive sciences play a role in managing overabundant or invasive species, which pose a significant threat to biodiversity. Hormone- and immune-contraception are currently the least invasive and most ethically acceptable methods for wildlife and zoo population management (Asa and Moresco, 2019).

The burgeoning field of microbiota research is now providing new vital insights into wildlife health and welfare, knowledge that is essential for optimizing captive management practices and maximizing the health and survival of animals after reintroduction into the wild (Dallas and Warne, 2023). Maly et al. revealed significant differences in fecal microbiota between cheetahs from Namibia and the USA, with Namibian samples exhibiting greater bacterial diversity. The variation in microbial diversity between populations may help to understand the incidence of gastrointestinal and other diseases in captive cheetahs and to increase their survival and breeding success.

The goal of CBPs is to establish genetically diverse and demographically stable populations in their natural habitats, often through combined *ex-situ* and *in-situ* approaches. However, release outcomes are often jeopardized by high mortality, even when captive breeding is successful. To mitigate this, Nelson et al. developed a multi-step approach for the greater sage-grouse (*Centrocercus urophasianus*), which assesses landscape risk factors prior to translocation to maximize survival. As a promising alternative to traditional reintroduction methods, Galindo et al. illustrate the potential of embryo transfer as a valuable strategy to increase genetic diversity and minimize disease spread in translocated marsh deer (*Blastocerus dichotomus*). For more integrated conservation strategies, Staerk et al. developed a comprehensive and flexible decision-tree framework, balancing investment in habitat protection and captive breeding. To evaluate framework's effectiveness, the authors analyzed species composition and population size of 847 terrestrial vertebrates housed in European Union zoos, revealing that a significant proportion require further investment in captive breeding.

In conclusion, CBPs have been essential for safeguarding several mammals, birds, and amphibians. However, there is an urgent need to preserve other vertebrates like reptiles or fish, but also invertebrates like insects or mollusks, which account for the greatest proportion of animal species on our planet and in which biodiversity loss is equally dramatic (Cowie et al., 2022; Cox et al., 2022). Future efforts should prioritize establishing CBPs for these underrepresented taxonomic groups. A multidisciplinary approach, integrating wildlife biology with conventional and cutting-edge technologies, is crucial for successful CBPs. Importantly, habitat restoration and protection remain as fundamental as CBPs for the effectiveness of any conservation intervention.

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Conflict of interest

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