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Editorial: Applications of conservation physiology to wildlife fitness and population health

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Editorial on the Research Topic
Applications of conservation physiology to wildlife fitness and population health

Connecting physiological measurements in wild animals with individual fitness and consequently, the resilience of populations poses a significant challenge in conservation physiology. Physiological variables that indicate nutritional state, stress, disease, or injury are used extensively in veterinary practice and captive settings to assess the health and likelihood of reproductive success of many animals. However, it remains difficult to reliably assess the health and resilience of wildlife, especially with the variety of stressors they can encounter in their environment. The development and refinement of sampling methods that limit disturbance of animals, coupled with advancements in analytical methods have allowed researchers to begin to examine the relevance of these physiological parameters in wild animals for predicting population trends and responses to environmental perturbations.

This Research Topic includes nine articles that improve our understanding of the connections between physiological indicators in wild, freely roaming animals and their individual health and fitness, which in turn influences population health. Manuscripts in this Research Topic link environmental drivers, physiological responses, and individual fitness or population health for a variety of taxa, including insects (Herbst), amphibians (Awkerman et al.), birds (Jodice et al.; Maness et al.; Marciau et al.; McCloy and Grace), sea turtles (Stacy et al.), and large mammals (Laliberte et al.; Payne et al.).

Wild animals face a variety of stressors including food availability (Laliberte et al.; Maness et al.), disease (Payne et al.), weather and climate (Herbst; McCloy and Grace), human disturbance (Marciau et al.), and contaminant exposure (Jodice et al.). These stressors often occur simultaneously, with synergistic and/or cryptic sublethal effects on organisms (Awkerman et al.). To understand and predict the effects of such stressors on wild animal individuals and populations, we must first develop baseline knowledge of both physiological health measures for wild species and the diversity of potential stressors that they face. Two articles in this Research Topic address these first steps, by developing blood

analyte reference intervals for the critically endangered hawksbill sea turtle (*Eretmochelys imbricata*) (Stacy et al.) and assessing viral diversity in wild felids (Payne et al.).

Second, we must determine which physiological markers indicate responses to stressors, a step that four articles in this Research Topic address. Marciau et al. evaluates basal and stress-induced corticosterone and body condition as potential indicators of human disturbance in penguins, and finds no relationship (although chicks may be more sensitive than adults). McCloy and Grace correlate passerine bird body condition to temperature and rainfall and find highly species-specific responses, with many species exhibiting threshold effects. Jodice et al. finds that exposure to polycyclic aromatic hydrocarbons is correlated with hematological and biochemical biomarkers suggestive of poor health. Lastly, Awkerman et al. evaluates a suite of physiological measures indicative of anuran health and development that change in response to stressor exposure, while discussing how differences in ontogeny and ecology can limit the interpretation of these biomarkers across amphibian species.

Finally, we must link environmental stressors and physiological indicators with measures of evolutionary fitness. Three papers in this Research Topic address this step. Regarding environmental stressors and fitness, Herbst investigates effects of osmoregulatory stress on growth rates, emergence success, and fecundity in the aquatic alkali fly (*Cirrula hians*), Regarding physiological predictors of fitness, Maness et al. finds that heterophil/lymphocyte ratios predict long-term, while corticosterone concentrations predict short-term, fitness in a seabird; and Laliberte et al. correlates maternal adult serum beta-hydroxybutyric acid with juvenile survival in bighorn sheep (*Ovis canadensis*).

In conclusion, this Research Topic examines how practical physiological measures, suitable for field conditions, can be used to analyze demographic patterns in wildlife populations, assess their reactions to disturbances, and monitor the health of individuals, populations, and ecosystems. These insights can illuminate underlying ecological and evolutionary processes driving responses to stressors, and refine predictions of wild animal responses to environmental change at both individual and population levels. Human, wildlife, and ecosystem health are inextricably intertwined, where the well-being of each component is vital for the overall balance and sustainability of our planet. Considering that environmental health and protection of vulnerable species is of great interest to management professionals, research scientists, and conservationists, we recommended the following areas for increased research:

1) Baseline health information for wild animal species including reference intervals for healthy populations. Without basic knowledge of what healthy physiological parameters look like, we cannot evaluate what unhealthy physiological parameters are or how they may change with stressor exposure.
2) Studies that connect stressor experience with physiological change and fitness effects. For many species, this will require increased investment in long-term monitoring of physiology, survival, and reproductive success.
3) Evaluation of the synergistic effects of multiple stressors on wild animal physiological and behavioral responses, and downstream effects on fitness and population health. Laboratory studies of contaminants and other stressors typically involve isolating a stressor to determine its effect, but this is largely unrealistic in our current world of rapid environmental change on multiple fronts (e.g., disease, habitat degradation, contaminant exposure, changing weather/climate).
4) Meta-analyses that examine the utility of various field-relevant physiological measures for reflecting stressor experience and predicting fitness in diverse taxa.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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