significantly influenced their reproductive success (Leclerc et al. 2014).

The value of considering intraspecific variation in response to noise is well argued from a behavioral perspective in this review paper—an issue that is also highly relevant for research on other sources of environmental disturbance (e.g., artificial light at night). However, given the global extent of these pollutants, it is also important that the findings from individual behavioral-based studies can be readily used to inform conservation management and policy, so that the magnitude of the impact(s) can be determined and mitigation approaches implemented. Indeed, research on the effects of anthropogenic noise on wildlife provides an excellent example of a conservation issue that can be further evidenced by an improved understanding of animal behavior. This is a topic that has been well debated in the literature over recent years (Caro and Sherman 2013; Greggor et al. 2016). The challenge in achieving greater integration between these two disciplines broadly centers around reconciling the longer-term population-level focus of conservation management with the shorter-term individual-level responses that are commonly documented by researchers studying the effects of anthropogenic disturbance (e.g., noise and light) on behavior.

First, it is important to emphasize that documenting shifts in behavior provides crucial evidence regarding the potential impacts of acoustic disturbance across species, particularly as the mediation of critical behaviors such as foraging, communication movement, and vigilance are typically the first responses available to an animal facing environmental change. However, as Harding et al. (2019) note, longer-term measures of the fitness costs associated with noise exposure are also needed for gaining a detailed understanding of the population and ecosystem-level effects of noise. To date, there have been very few long-term sound exposure experiments that explore how animal behavior or physiology changes over time and how this affects metrics of individual and population-level fitness—not least because these are challenging experiments to design and implement. Second, with a rapidly expanding evidence base on the effects of noise across a range of taxa and biological responses (i.e., individual animal behavior to community-level structure), there is the opportunity to synthesize and analyze the results from multiple studies using meta-analyses to determine the weight of evidence regarding the specific impacts of different noise sources. However, as Harding et al. (2019) discuss, this requires accurate and consistent reporting of sound level metrics. This is especially relevant given the complex and diverse nature of anthropogenic noise, which varies in duration, amplitude, and frequency (see Mckenna et al. 2016). Encouraging more rigorous characterization of the acoustic environment offers an excellent avenue for improving our understanding of the impacts of noise exposure across species.

Behavioral research has the potential to help address a number of conservation challenges, particularly in light of the rapid environmental change that is the hallmark of the past century. However, the adoption of behavioral methods by conservation biologists has been relatively modest to date (Greggor et al. 2016). Anthropogenic noise research provides scientists and conservation practitioners with an excellent opportunity to highlight how the use of well-designed behavioral studies can greatly benefit our understanding of the diverse effects of this global pollutant. While great strides have been made over the past two decades in this field of research, there is a need for greater accuracy and consistency in the measurement and reporting of both the noise source and the biological response, so that evidence can be readily extracted and compared across multiple studies. As such, the review by Harding et al. (2019), outlining the importance of accounting for intraspecific variation, provides a valuable perspective on the future direction of behavioral-based research in addressing conservation challenges such as noise pollution.

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Intraspecific variation in animal responses to anthropogenic noise through long-term monitoring: a comment on Harding et al.

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We are surrounded by a complex arrangement of sounds creating acoustic patterns in space and time which constitute the soundscapes that humans and animals experience (Pijanowski et al. 2011). Soundscapes all around the globe are increasingly affected by anthropogenic sounds. The impacts of this anthropogenic noise pollution are not only shaped by the physical and acoustic features of the landscape, but also by the characteristics of the individual hearing the noise, making intraspecific variation among individuals central

to our understanding of the impacts of noise pollution. Harding et al. (2019) provides a timely review focusing on understanding intraspecific variation in response to noise pollution, which is key in promoting a more evidence-based approach to the subject. Here, we would like to further highlight how and why intraspecific variation necessitates *long-term* acoustic and behavioral monitoring as a vital tool to correctly interpret the effects of noise pollution on wildlife, a crucial step towards effective mitigation and conservation.

TOWARDS A MORE INTEGRATIVE APPROACH: THE VALUE OF LONG-TERM MONITORING

Monitoring the effects of noise pollution may include two main approaches: 1) monitoring the acoustic environment and 2) monitoring the effects of anthropogenic noise on wildlife behavior. While many ecological studies tend to focus only on the perspective of the affected animal, by considering both aspects, a study can achieve a broader understanding of the impacts of noise pollution. In regard to the monitoring of the acoustic environment, it is important to note that the characteristics of noise and the acoustic environment may both change with time due to seasonal changes, climatic conditions, or the introduction of new elements (natural or anthropogenic) to the soundscape. In such cases, only long-term acoustic monitoring will allow for accurate depiction of the soundscape experienced by focal populations (McKenna et al. 2016). As for measuring of the effects of noise on wildlife, long-term monitoring is essential for a number of reasons that we will now discuss, in turn.

PHENOLOGICAL TRAITS MATTER

As mentioned in several examples given by Harding et al. (2019), different groups of individuals, varying in their intrinsic characteristics (i.e., sex, age, physiological condition), may respond differently to noise disturbance. Importantly, the role of these intrinsic characteristics in shaping behavior can change over the annual cycle according to species-specific phenological traits. This can happen due to physiological changes that animals go through as seasons change, as well as changes to the specific role that acoustic signals and communication play in the animal's life history (e.g., a bird may have different acoustic needs during the breeding and non-breeding seasons). Moreover, the role of acoustic communication in an animal's life may change over time even without going through any intrinsic changes. For example, any change in predation pressure or resource availability might make acoustic communication less or more valuable, and long-term acoustic monitoring may capture these changes. In this respect, acoustic monitoring may even be used to identify behavioral indicators for non-acoustic changes to the environment (Berger-Tal et al. 2011).

...AS DOES PREVIOUS EXPOSURE

As emphasized by Harding et al. (2019), the role of repeated exposure and prior experience in reaction to noise is also important. Long-term acoustic monitoring allows for a continuous record of the acoustic environment along with accounts on the levels of individual exposure to that environment. We suggest that it is currently the best way to quantify the implications of previous and prolonged exposures to noise on wildlife responses (e.g., habitation or sensitization; Blumstein 2016).

EVOLUTIONARY IMPLICATIONS?

Variation is one of the key ingredients of evolution. This means that any interaction between intraspecific variation and human disturbance (in this case, noise) can have evolutionary consequences (Wong and Candolin 2015). These consequences will be determined by several factors such as the source of the variation (e.g., intrinsic vs. extrinsic), the ability of the individual to respond behaviorally to the disturbance through behavioral plasticity or flexibility, the properties of the disturbance, and its effects on individual fitness. So far, only a few studies have been published on the evolutionary responses of animals to noise (e.g., Lampe et al. 2014), and we suggest it may be the result of the scarcity of long-term monitoring-based studies. Since our world is only getting noisier, understanding how animals adapt, or fail to adapt, to anthropogenic noise is vital to conservation efforts worldwide.

In summary, Harding et al. (2019) rightly emphasizes the importance of incorporating intraspecific variation into future studies and, to this end, we believe that in order to fully understand the consequences of intraspecific variation in response to noise—and to improve our conservation efforts in this regard—long-term monitoring projects must be established.

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Why study intraspecific variation: a comment on Harding et al.

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Harding et al. (2019) touches on an import topic in our rapidly changing world—how can we predict and understand the responses of organisms to anthropogenic noise, and how can we use the information to mitigate negative effects of noise on populations and