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Editorial: What sensory ecology might learn from landscape ecology?

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Editorial on the Research Topic

What sensory ecology might learn from landscape ecology?

Increasing awareness by the mid-20th century that the spatio-temporal heterogeneity of the environment has a crucial impact on the flow of both matter and energy at various scales (population, community, and ecosystem level) gave rise to Landscape Ecology as ecological discipline (Naveh and Lieberman, 1984; Forman and Godron, 1986). Almost contemporarily, science witnessed the dawn of Sensory Ecology (Ali, 1978; Lythgoe, 1979; Huber and Markl, 1983; Barth, 1986; Dusenbery, 1992; recent review in Willemart, 2023), which focuses on understanding information flow in the environment (signal generation, propagation, perception, and interpretation). Just like the flow of matter and energy, information flow is far from constant owing to spatio-temporal variations of the biotic and abiotic environment (Endler, 1993; Pijanowski et al., 2011). These natural fluctuations have driven the evolution of plastic sensory systems in animals (Pyza, 2013; Maruska and Butler, 2021). However, the efficiency of information flow is threatened by rapid human modifications of the environment by increasing the acoustic, chemical, and visual noise, thereby interfering with the information necessary for communication and orientation (Pijanowski et al., 2011; Riffell et al., 2014; Duarte et al., 2021).

The present Research Topic is an effort to integrate Sensory Ecology and Landscape Ecology, calling attention to the importance of considering environmental heterogeneity in investigations of sensory adaptations of animals. A crucial first step is to measure the variation in a particular sensory landscape. In their contribution, Nilsson et al. highlight the importance of quantifying the distribution of light reaching animals' eyes in different environments. The authors demonstrate the association of vertical light gradients with weather conditions, time of day, and season. This information is vital for species that primarily use vision for finding suitable habitats, foraging, and for social interactions. Many animals, however, rely on chemical information in the environment, which is strongly influenced by the variability of air speed and direction. Analyzing air movement dynamics in a tropical dry forest in Costa Rica, DePasquale et al. found that air speed and turbulence increased with height above ground, peaked at midday, and may be lower in late than early successional parts of the forest. Species that use olfaction as primary source of information may have adapted to and even exploit this predictability of air movement patterns.

Spatio-temporal variations in the sensory environment are certainly the dominant driver of the evolution of sensory systems. Using statistical methods to control for effects of phylogenetic proximity and repeated measurements in their data sets, [Huang et al.](#) found strong evidence that relative eye size across six snake families from Taiwan changes with habitat type (bigger in terrestrial than aquatic snakes) and activity pattern (bigger in diurnal than nocturnal snakes). Thus, low light conditions associated with both aquatic and nocturnal lifestyles may have facilitated the evolution and/or improvement of sensory modalities alternative to vision, as is well-known in fish. Weakly electric fish, for instance, generate discharges of their electric organs to sense their environment and to communicate. In addition to an increased electrical activity during night time, [Mucha et al.](#) observed elevated electric organ discharges in visually complex habitats (floating vegetation in dense swamps) during the day in two species from Uganda. These findings emphasize the importance of spatio-temporal heterogeneity in light intensity concerning the use of different sensory modalities in these animals.

The evolution of signals goes hand in hand with the evolution of the sensory systems of receivers. The main drivers are sexual selection, competition, and predation. Despite their species specificity, signals may vary between and even within populations, as is the case with floral colors of a plant population in the Atacama Desert. [Martínez-Harms et al.](#) suggest that different color phenotypes, associated with different pigment compositions, are perceived differently by pollinators. This, eventually, enhances cross-pollination among individuals of the same phenotype and drives diversifying (positive) selection. By contrast, [Yeager and Barnett](#) found no evidence for positive selection in aposematic signal variation in a poison frog population from Ecuador. The authors argue that phenotype variation has not been reduced due to a weak purifying (negative) selection on a signal that is highly conspicuous to mates, rivals, and predators. In addition to sexual selection, competition, and predation, signal divergence between environments may be due to spatio-temporal variations in biotic and abiotic variables. In their contribution, [Schirmer et al.](#) show divergent color patterns in butterfly assemblages from two neighboring biomes in northeastern Brazil. The authors argue that darker wings in species from the rainforest are, presumably, associated with increased parasite-pressure, whereas lighter wing colors in the tropical dry forest may be an adaptive response to an elevated need for thermoregulation in this biome.

Although crucial for our understanding of the evolution of sensory systems and signals, information on spatio-temporal variations of the environment is frequently challenging to obtain. In their review, [Chhaya et al.](#) advocate the use of long-term acoustic monitoring to assess both the structure and the dynamics of acoustic communities (ensemble of vocalizing species in the environment), thereby providing real-time information on species distributions and movements. Similarly, [Gonzales et al.](#) propose long-term visual monitoring through remote sensing tools to map floral resource isolation and to investigate changes of resource patches over time. Such long-term monitoring techniques are key to identify anthropogenic changes in the sensory landscape that cause disturbances of information flow in the environment.

Human actions interfere with the environment at multiple levels. Anthropogenic climate change, for instance, increases the frequency of prolonged periods of excessive heat. [Perl et al.](#) investigated the impact of such heat waves during the final stage of pupal development on the behavior of a bumble bee species. The observed negative effects on vision, mechanoreception, olfaction, and taste show how human disturbances may alter the sensory systems of bumble bees and, thus, the way they perceive the environment. Yet, anthropogenic interference is not restricted to alterations of sensory systems. Signaling, as well, may be compromised in human-changed landscapes. [Koneru and Caro](#) demonstrate multiple ways of how visual signaling in animals is influenced by anthropogenic environmental changes. Human impacts range from alterations in pigment production through dietary changes to increasing colouration-background mismatches through changes in climate and landscape. [Nair and Balakrishnan](#) discuss how changes in the sensory environment interfere with the transmission and reception of acoustic sexual signals in katydids. In their study, the reduction of available signaling sites, owing to anthropogenic habitat modifications, provoked sub-optimal clustering of the males, thereby increasing competition over females.

Over the past decades, the impact of anthropogenic disturbances on ecosystem functioning has become a hot topic in Ecology. This Research Topic highlights the importance of integrative approaches, uniting Landscape Ecology and Sensory Ecology, to comprehend how natural and anthropogenically-driven environmental variations shape information flow and, eventually, natural selection in animals. Key questions for future research to answer in this context are: (1) To what extent do spatio-temporal variations in the abiotic environment at different geographic scales affect signal propagation? (2) To what extent do spatio-temporal variations in the biotic and abiotic environment drive the differentiation of sensory niches among animals? (3) Which environmental cues do animals use for decision-making, such as microhabitat choice? (4) How does anthropogenic interference influence the generation, propagation, reception, and discrimination of sensory information? We hope that this compilation of manuscripts stimulates new research in this direction, studying the sensory challenges for animals in a rapidly changing world.

Author contributions

MH, FG, PM, and DP drafted the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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References

- Ali, M. A. (1978). *Sensory Ecology: Review and Perspectives*. New York, NY: Plenum Press.
- Barth, F. G. (1986). Vibrationssinn und vibratorische Umwelt der Spinnen. *Naturwissenschaften* 73, 519–530. doi: 10.1007/BF00368159
- Duarte, C. M., Chapuis, L., Collin, S. P., Costa, D. P., Devassy, R. P., Eguluz, V. M., et al. (2021). The soundscape of the Anthropocene ocean. *Science* 371, 583. doi: 10.1126/science.aba4658
- Dusenbery, D. B. (1992). *Sensory Ecology: How Organisms Acquire and Respond to Information*. New York, NY: W.H. Freeman.
- Endler, J. (1993). The Color of light in forests and its implications. *Ecol. Monogr.* 63, 1–27. doi: 10.2307/2937121
- Forman, R. T. T., and Godron, M. (1986). *Landscape Ecology*. New York, NY: Wiley & Sons.
- Huber, F., and Markl, H. (eds.). (1983) *Neuroethology and Behavioral Physiology: Roots And Growing Points*. Berlin, Heidelberg: Springer-Verlag.
- Lythgoe, J. N. (1979). *The Ecology of Vision*. New York, NY: Oxford University Press.
- Maruska, K. P., and Butler, J. M. (2021). Reproductive- and social-state plasticity of multiple sensory systems in a cichlid fish. *Integr. Comp. Biol.* 61, 249–268. doi: 10.1093/icb/icab062
- Naveh, Z., and Lieberman, A. S. (1984). *Landscape Ecology: Theory and Application*. New York, NY: Springer-Verlag.
- Pijanowski, B. C., Villanueva-Rivera, L. J., Dumyahn, S. L., Farina, A., Krause, B. L., Napoletano, B. M., et al. (2011). Soundscape ecology: the science of sound in the landscape. *BioScience* 61, 203–216. doi: 10.1525/bio.2011.61.3.6
- Pyza, E. M. (2013). Plasticity in invertebrate sensory systems. *Front. Physiol.* 4, 226. doi: 10.3389/fphys.2013.00226
- Riffell, J. A., Shlizerman, E., Sanders, E., Abrell, L., Medina, B., Hinterwirth, A. J., et al. (2014). Flower discrimination by pollinators in a dynamic chemical environment. *Science* 344, 1515–1518. doi: 10.1126/science.1251041
- Willemart, R. (2023). The evolution of the concept of sensory ecology and the influence of behavioral ecology. *An. Acad. Bras. Cienc.* [In Press].