Landscape Ecology

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Landscapes and Soundscapes

Social information is used by animals to communicate, but it also affects their habitat selection and preferences.

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A European tree frog (*Hyla arborea*) encountered during amphibian monitoring work done as part of this research project

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The relationships between landscapes and their elements on the one hand, and the distribution of animals in such areas on the other, are studied by a branch of science known as "landscape ecology." It describes the exact characteristics of landscapes, the potential habitats they comprise, the distribution of these habitats in relation to one another, and the areas they occupy. For example, if we study an animal species living in a forest, we will describe the size of the area covered by the forest and the distance between the habitats of these animals.

In landscape ecology, it is assumed that the more fragmented a habitat is – in other words, the smaller and more isolated the individual "habitat patches" are – the less frequently and less abundantly it will be occupied by a specific species. The phenomenon is explained by metapopulation theory, which predicts that smaller and more isolated habitat patches are more difficult to colonize, and therefore have higher local extinction rates and lower colonization rates. Of course, the colonization of a specific habitat patch by animals depends not only on its accessibility (isolation from already colonized patches or migration routes), but also on its qualitative characteristics, which make it suitable for specific species (such as the presence of tree species and their age), and on food availability. Another important aspect is the extent to which the selected landscape elements (in the example discussed here, these would include fields, woodlands, buffer strips, roads, and so on) make it easier or harder for animals to move between habitat patches. This aspect is referred to as landscape connectivity. It is commonly believed that landscape connectivity and the spatial isolation of habitats impact significantly on the ability of organisms to move between habitat patches. Both of these factors can play a crucial role in limiting or facilitating the colonization of suitable habitat patches by animals, thus influencing the distribution of the population of a specific species in a specific area.

Social information

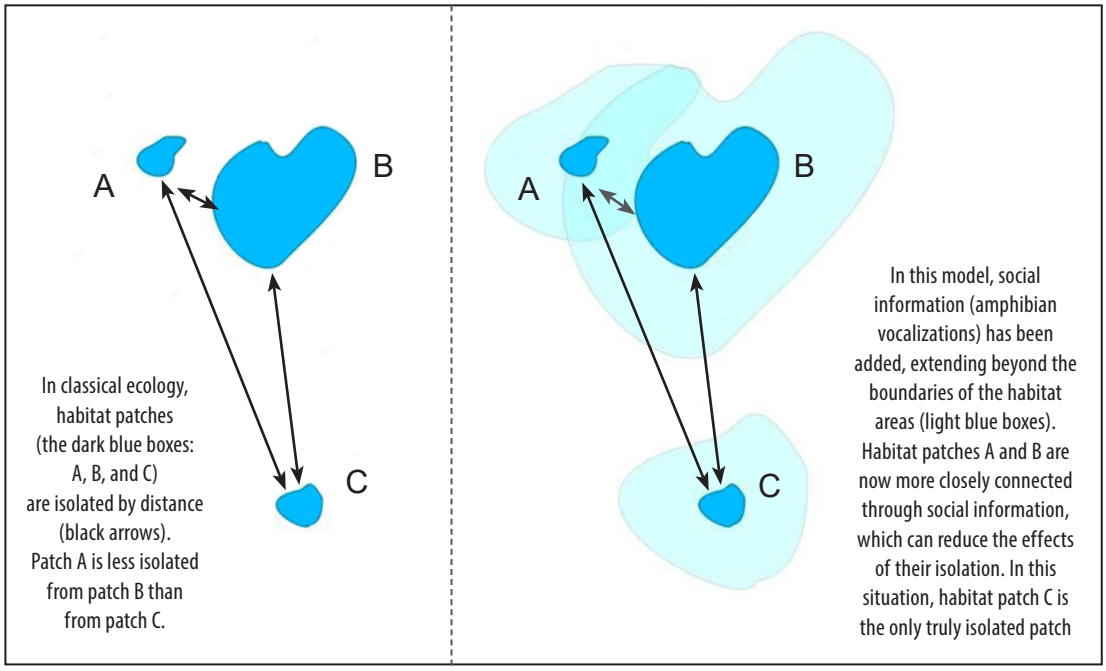
However, recent studies suggest that the colonization of habitat patches by animals depends not only on the quality or size of these patches and their distribution in landscapes – rather, animals also use social information to assess habitat suitability or quality. Social information means all the traces of animal presence and activity, as well as their physical presence in a specific place. The simplest examples include the sounds made by animals (such as bird songs or mating vocalizations of amphibians), but also scent traces, fragments of feathers, fur, and feces, and signs of foraging activity (such as remains of a carcass left behind by a predator). Social information can convey reliable messages about habitat quality and threats and therefore have a significant impact on biodiversity. Examples include the "landscape of fear" effect. Researchers have observed that potential prey may alter their behavior in areas where they have found traces that a predator is present. For example, they may manifest greater caution and avoid a given area or visit it at times when the predator is likely to be less active.

To study how both landscapes and social information affect the distribution of animals in a given area, tailless amphibians are useful as model species. The males of these amphibians are known for their distinctive mating calls during the breeding season, which can be heard from distances up to several hundred meters. In addition, the reproduction of tailless amphibians is typically linked to aquatic environments. Therefore, in the breeding season, they usually inhabit easily identifiable habitats (ponds, puddles), whose boundaries can be relatively clearly delineated. Some studies also suggest that the spatial isolation of habitats and the presence of barriers impact significantly on the ability of amphibians to move and find habitats for breeding, and isolated bodies of water are inhabited by fewer amphibian species than less isolated and larger bodies.

Colonization of new areas

My work explores how the occurrence of amphibians in a specific place is influenced by two sorts of "landscapes": the landscape in the classical sense, understood as landforms and the related distribution of specific types of habitats or structures, and the landscape created by social information, or in this case by the mating vocalizations of amphibians. The latter kind of landscape, created by sounds of various origins, is referred to as the "soundscape" in the literature. In my work, I therefore focus on explaining how soundscapes can complement classical landscape models (such as metapopulation theory) to help explain amphibian distribution.

In my research project, I will test two research hypotheses. One holds that mating calls coming from unoccupied, artificially built ponds will have a positive effect on the presence of amphibians there. To verify this hypothesis, I will select several dozen water bodies of different sizes, such as puddles, fragments of drainage ditches, ponds, and so on. These bodies



Diagrams showing how social information can affect the connectivity between habitat patches in a landscape

of water will be diverse in terms of the surrounding landscapes and their degree of isolation from other ponds. In addition, they will be surrounded by traps mimicking small ponds and fitted with loudspeakers emitting the mating calls of a selected amphibian species, such as the European fire-bellied toad (*Bombina bombina*). This will make it possible to measure the extent to which mating calls can provide an incentive for amphibians to colonize a habitat that is, for example, heavily isolated from other habitats or can only be accessed via a path that leads through landscape elements that are more difficult or risky for amphibians to cross.

However, I predict that the artificial ponds with emitted calls of selected species of tailless amphibians will be more likely to be colonized by such amphibians than ones without such vocalizations. Since the primary role of amphibian mating calls is to attract individuals of the same species, they may provide a stimulus needed to overcome the impact of low landscape connectivity and strong habitat isolation on migration decisions.

Species occurrence probability

The second research hypothesis posits that social information should be included as one of the variables in modeling the presence of amphibians in habitat patches. Ecology has long used mathematical models to predict the probability of the occurrence of a specific species in specific areas or even habitats. In the case of amphibians, many studies using such models have focused on how the physical characteristics of landscapes affect the distribution of these animals in specific areas. However, there are very few studies addressing the question of how social information might help explain the mechanisms affecting the abundance of amphibians in the landscapes being studied. I expect the use of additional variables describing social information to improve the accuracy of models predicting the occurrence of amphibians.

To verify this hypothesis, I will use data on the distribution and abundance of tailless amphibian species obtained from the monitoring work done as part of a study in one of the forest areas in the east of Poland. The data will be used to develop mathematical models to test the second hypothesis. In the analyses, the habitat sizes will be augmented to include the reach of the amphibian vocalizations. I predict that adding this information will result in mathematical models that are a better fit for the data than models based only on the physical area of water bodies and their spatial isolation.

Answering the questions posed in this study will help us better understand the role of social information in the life of amphibians, which are now regarded as the world's most endangered group of vertebrates. Since habitat loss and fragmentation are believed to be among the key factors behind the decline in their population numbers, understanding the factors affecting their habitat selection could provide valuable insights. Such knowledge could also translate into significant support for efforts aimed at the conservation of amphibian species through the development of more comprehensive conservation plans and colonization of suitable sites. ■

Further reading:

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