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Acoustic detection and occupancy models: A systematic review with insights for future monitoring programs

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Wildlife management requires monitoring to infer spatiotemporal changes in the distribution or abundance of species and communities of organisms. Technological advancements have increasingly facilitated monitoring species through new data collection methods. Such technological advancements include small-sized acoustic recording devices that can record a wide range of sound frequencies, making them especially suitable for analysis by recently developed statistical tools such as occupancy models. We reviewed 108 publications that used acoustic methods and occupancy modelling to synthesise and discuss the potential of combining these two methodologies in future research studies in ecology and conservation. We found that 50% of these studies limited their analysis to the simplest modelling solution, single-season and single-species models, even though many recorded multiple species and sampled across several seasons. This limited analysis hinders the retrieval of complete information from available datasets because more complex models, such as the multi-species occupancy models, provide more robust occupancy parameters for both commonly and rarely detected species. We also argue that multiple-season or dynamic models are easy to implement and essential for monitoring species' temporal fluctuations. Recent developments in occupancy include modelling false-positive detections, which have been applied in only 11 revised publications. This modelling approach seems particularly under-used as many species cannot be accurately distinguished solely based on acoustic data. Finally, we noted a geographical imbalance in implementing acoustic methods with occupancy models; research was performed primarily on study sites in North America. Coupling low-cost passive acoustic monitoring with a diversified set of occupancy models is a scalable methodology that can help to implement standardised protocols for regional and larger-scale monitoring programs. Long-term monitoring programs will significantly benefit from such protocols by informing habitat and wildlife management more effectively, which are thus critical for animal conservation in an increasingly anthropogenic landscape.

ORAL COMMUNICATION

Vegetation canopy height shapes bats' occupancy: a remote sensing approach

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Anthropogenic activities have significantly altered land cover on a global scale. These changes often have a negative effect on biodiversity, limiting the distribution of species. The extent of the effect on species' distribution depends on the landscape composition and configuration at a local and landscape level. To better understand this effect on a large scale, we evaluated how land cover and vegetation structure shape bat species' occurrence while considering species' imperfect detection. We hypothesise that intensification of anthropogenic activities, agriculture for example, reduces the heterogeneity of land cover and vegetation structure, and thereby, limits bat occurrence. To investigate this, we conducted acoustic bat sampling across 59 locations in southern Portugal, each with three spatial replicates. We derived fine-scale vegetation structural metrics by combining spaceborne LiDAR (GEDI) and synthetic aperture radar data (Sentinel-1 and ALOS/PALSAR-2). Additionally, we included land cover metrics and high-resolution climate data from CHELSA. Our findings revealed an important relationship between bat species' occupancy and vegetation structure, particularly with vegetation canopy height. Moreover,

forest and shrubland proportions were the main land cover types influencing bat species responses. All species' best-ranking occupancy models included at least one climatic variable (temperature, humidity, or potential evapotranspiration), demonstrating the importance of climate when predicting bat distribution. Our acoustic surveys had a species' detection probability varying from 0.19 to 0.86, and it was influenced by night conditions. These findings underscore the importance of modelling imperfect detection, especially for highly vagile and elusive organisms like bats. Our results demonstrate the effectiveness of using vegetation and landscape metrics derived from high-resolution remote sensing data to model species distribution in the context of biodiversity monitoring and conservation.

ORAL COMMUNICATION

30 years of detector-based bat counts in Europe

Matti MASING

In 1992, I started to use ultrasound detectors to study bats. One of the tasks was to develop an easy but efficient method to count bats. As a basis, I used a line-counting method described in 1952 to count amphibians and reptiles. Thus, in 1992–1994, the route counting method (RCM) to count bats using a bat detector was born. In 1994 this method was included in the Estonian National Environmental Monitoring Programme (NEMP) to count bats at selected bat monitoring stations (BMS) every year at the beginning of summer.
In 2000, the method was improved, as 5-min counting points were added to each counting line. Thus, two sub-methods (line counting, LC; and point counting, PC) were implemented in a study area during the same night. The cumulative effect of LC and PC made this improved method (RCM-2) maximum powerful, as no bat passing the detector during the night was missed.
RCM-2 has been in use for over 20 years now. During the 21st century, it has been successfully implemented in 16 European countries. This easy-to-use, yet efficient bat counting method has given fast results everywhere, often finding rare bat species hard to locate on the landscape. On some occasions, this method proved new bat species for the study area, which did not take more than only a few nights of fieldwork.
Both the experience and data from implementing RCM-2 can be used to develop or improve the European Bat Monitoring Network (EBMN).

ORAL COMMUNICATION

Bat Station at work

Matti MASING

If someone has learned a lot, then comes a day when it is time to implement what has been learned. This is the situation with out Bat Station, established in 2023 for fast learning and teaching of bats, their habitats and habits. In our days, the impact of man on natural and semi-natural habitats where bats live is enormous. At the same time, it is only possible to protect bats and their habitats efficiently on the basis of true knowledge of both. Here is where our station provides experience. We work fast, and we continue learning while we work. This has been our custom for decades, back to the 1970s and the 1980s. So, what does our Bat Station provide in connection with bats, bat protection and related knowledge? There are three main pillars on which we stand. First, good knowledge of bat habitats and bat habits, especially in the boreal zone of Europe, north of 55 n.l. Second, long experience with field methods in bat research. Among those, the most efficient automatic bat trap ever built, the BT-7433. Detector-based bat counts, using RCM-2 and similar methods (also, probably the best in the world); in which our team has experience in 16 European countries. And now, during the era of bat detectors, we are busy learning bat sounds, finding and implementing acoustical characters to identify European bats in flight.

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