Imperfect detection impacts on the performance of species distribution models

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Abstract: Species often remain undetected at sites where they are present. However, the impact of imperfect detection on species distribution models (SDMs) is not fully appreciated. We evaluate the influence of imperfect detection on the calibration and predictive discrimination of SDMs. We compare the performance of three types of SDMs: (1) a technique based on presence–absence data, (2) a technique based on presence–background data, and (3) a technique based on detection/ non-detection data that accounts for imperfect detection. We use simulations to evaluate the impacts of imperfect detection in SDMs in terms of how well they characterise the true spatial distribution. We study a range of occupancy and detection scenarios based on ecologically plausible environmental relationships and identify the circumstances in which imperfect detection affects model calibration and discrimination. We show that imperfect detection can substantially reduce the inferential and predictive accuracy of presence–absence and presence–background methods that do not account for detectability. While calibration is always affected, the influence on discrimination depends on the relationship of detectability and environmental variables. The performance of a model should be assessed with respect to its objectives. Comparative studies that assess the performance of an SDM by evaluating its ability to predict detections (e.g. Rota et al. 2011; Compte & Grenouillet 2013) rather than presences fail to reveal the benefits of accounting for detectability. We find that disregarding imperfect detection can have severe consequences for SDM performance, and hence for the estimation of species distributions. To date, this issue has been largely ignored in the SDM literature. Simultaneously modelling occupancy and detection does not necessarily require a greater sampling effort, but rather that data are collected and recorded so that they are informative about detectability. We recommend that consideration of imperfect detection become standard practice for species distribution modelling.

References

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