Animal Biotelemetry

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Erratum to: Does estimator choice influence our ability to detect changes in home-range size?

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Erratum to: Animal Biotelemetry (2015) 3:16 DOI 10.1186/s40317-015-0051-x

The original version of this article unfortunately contains mistakes. The last two paragraphs in Background were moved to make the Conclusion and this is not correct. Please find below the correct text for each section.

The correct Background is below:

Animals interact with conspecifics and their environment, leading to non-random patterns of space-use [1]. Several different analytical methods have been proposed for quantifying these patterns, including home-range estimation (e.g., [2, 3]), habitat and step selection models (e.g., [4, 5]), and Bayesian state-space models that fit a mixture of random walks to movement data (e.g., [6, 7]). Whereas the latter two approaches often require custom-written code and fine-tuning to fit a specific data set, a variety of off-the-shelf home-range estimators can be easily implemented in multiple software platforms (R, ArcGIS, etc.).

Because of their accessibility, home-range estimators are frequently used to compare space-use patterns for animals living in different landscapes (e.g., [8, 9]) or along spatial gradients (e.g., [10]). With the increase of fine-scale spatio-temporal data afforded by Global Positioning Technology (GPS), short-term (weekly, monthly) estimates of home-range size are now also commonly used to explore changes in space-use patterns over time (e.g., [3, 11, 12]).

When using home-range estimators to summarize space-use patterns, it is important not to conflate these statistics with the biological concept of an animal's home range [13–15], defined by Burt [16], as "That area traversed by an individual in its normal activities of food gathering, mating, and caring for young. Occasional sallies outside the area, perhaps exploratory in nature, should not be considered part of the home range." An animal's home range is arguably best thought of in terms of cognitive maps, a complex summary of various spatio-temporal utility surfaces representing different resources (e.g., food, shelter, escape routes, or mating and breeding areas), which the animal actively updates as it interacts with its environment [15, 17]. Home-range estimators, by contrast, provide simple, often static summaries of space-use in terms of a boundary on a map, an area, or a probability distribution of the relative time spent in different areas. An estimate of home-range size is best viewed as an index of space-use or movement cost to meet an individual's needs, a response measure that can be related to other measured covariates in order to gain insights into how animals interact with their environment or other organisms (e.g., habitat types and configurations, waterways, urban areas, or other GPS-tagged individuals).

An advantage of viewing home-range estimates as indices is that it emphasizes the need to start with an interesting and meaningful biological question or hypothesis, rather than viewing home-range estimation as an end in itself [13]. It also suggests that we need to think differently about comparative studies of home-range estimators. We should not only compare the ability of estimators to capture (or exclude) particular areas of space used (or not used) by an animal, but also increase emphasis on whether the estimator does a good job of capturing an important biological signal in the data that is relevant to an underlying question or hypothesis of interest. A biased estimator for home-range size may still prove useful if it does a good job of detecting *changes* in home-range size. For many research questions, this will mean that home-range size is often expected to be proportional to movement cost.

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The aim of this manuscript is to illustrate these points by investigating a property of common home-range estimators, the area, through a simulation study. We consider two different simulation scenarios capturing two broadly defined research questions. In the first scenario, we are interested in detecting changes in the amount of space used by an individual over time. In the second scenario, we are interested in comparing the amount of space used by different individuals living in landscapes with different amounts of favorable habitat. In both cases, we simulate animal movement using discrete time steps and calculate home ranges using different estimators, sampling rates, and analysis intervals (scenario 1 only; movement behavior did not change over time for scenario 2). In both cases, it is natural to ask, "What home-range estimator is most appropriate for detecting differences in the amount of space used (changes over time in scenario 1 or differences among landscapes with different amounts of habitat in scenario 2)." In addition, we ask "What analysis interval is most appropriate for exploring temporal space-use patterns?" (scenario 1 only). We explore these questions using simulated data, but we also consider GPS location data from a black bear (*Ursus americanus*) inhabiting northwestern Minnesota, USA, to illustrate the relevance of our simulation results, and method of estimator comparison to real-world data applications.

The correct Conclusion is below:

Our results suggest that for questions like the following: do male individuals require more space than females? Does latitude or elevation influence the space-use of a species?, or do individuals of a given species need more space in summer than in winter?, the choice of the estimator will likely be less important than emphasized in the literature while other decisions a researcher might make (e.g., sample size, sample rate, or analysis interval) are at least as important as the estimator choice. Yet, because different estimators give different absolute estimates of home-range size, it is still important, whenever possible, to use the same home-range estimator to analyze all location data. Further, given the differences in implementation of home-range estimators (e.g., variability in how KDE (lscv) is implemented [21]), it is also important to use the same software whenever possible. As a corollary, we strongly encourage researchers to archive raw location data (e.g., in archives like Movebank or dryad) to facilitate meta-analytic hypotheses testing of broad-scale ecological patterns.

Although some research questions may require absolute estimates of home-range size, most often, home-range estimates are used to explore changes in space-use patterns over time or space. In these cases, home-range estimators should be evaluated in terms of their ability to detect these patterns. More importantly, home-range estimation should be seen as a means to an end, i.e., estimators provide indices useful for addressing interesting biological questions or hypotheses—rather than as an end to itself [13].

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