Circular-Linear Copulae for Animal Movement Data

Animal movement is often modeled in discrete time, formulated in terms of steps taken between locations at regular time intervals. Steps are characterized by the distance between successive locations (step lengths) and changes in direction (turn angles). Animals commonly exhibit a mix of directed movements with large step lengths and turn angles near 0 when traveling between habitat patches and more wandering movements with small step lengths and uniform turn angles when foraging. Thus, step lengths and turn angles will typically be cross-correlated.

Most models of animal movement assume that step lengths and turn angles are independent, likely due to a lack of available alternatives. We show how circular-linear copulae that are symmetric in the circular dimension can be used to fit multivariate distributions that allow for correlated step lengths and turn angles.

We present and derive several new circular-linear copulae with this property and demonstrate how they are implemented in our new R-package cylcop to model animal movements in discrete time. We fit distributions with correlation structures described by these copulae to data collected on fishers (Pekania pennanti). With this approach, we are able to capture the inherent correlation in the data and provide a better fit than a model that assumes independence.

We see many opportunities to extend this approach and to integrate it into existing frameworks for modeling animal movement and habitat selection. For example, copulae could be used to more accurately sample available locations when conducting habitat-selection analyses.