

A point process to infer spatio-temporal interactions from camera trap data

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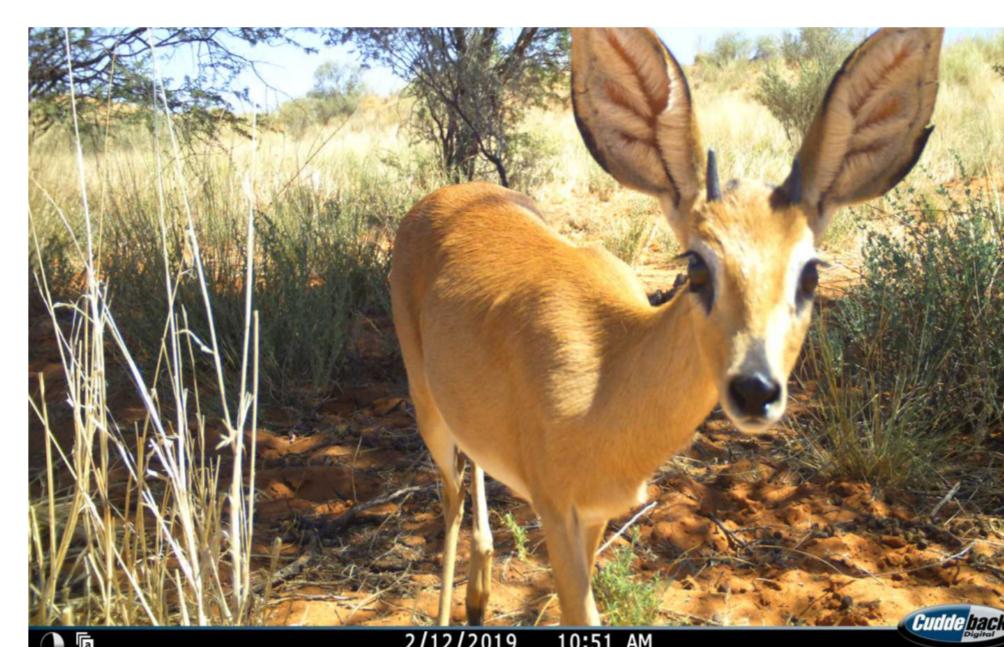
Context

Interactions

Interactions between species are central to many aspects of the functioning of natural systems. Notably, interactions influence species behavior, for instance their spatio-temporal distribution patterns.

Camera traps

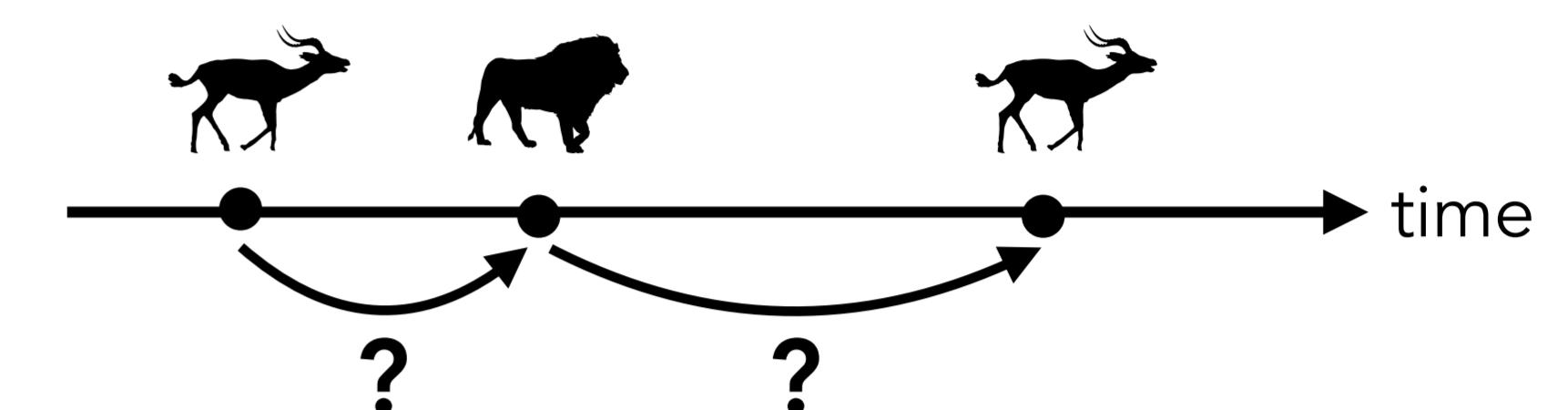
Camera traps are automated devices allowing to gather multiple species occurrence data continuously and in a non-invasive manner.



Camera trap picture of a steenbok
Picture: Snapshot Safari South Africa

Inferring interactions ?

Since camera traps give the precise time when species are seen, they can be used to see if some species avoid or attract each other, possibly due to underlying interactions.



Hawkes model (Hawkes 1971)

This model describes the occurrence of punctual events which influence each other. It has been used for various applications in several disciplines. Here, we will use the model of Lambert et al. (2018):

$$\lambda_i(t) = \left(\alpha_i + \sum_{j=1}^N \sum_{u \in t_j} f_{j \rightarrow i}(t - u) \right) +$$

For species i :

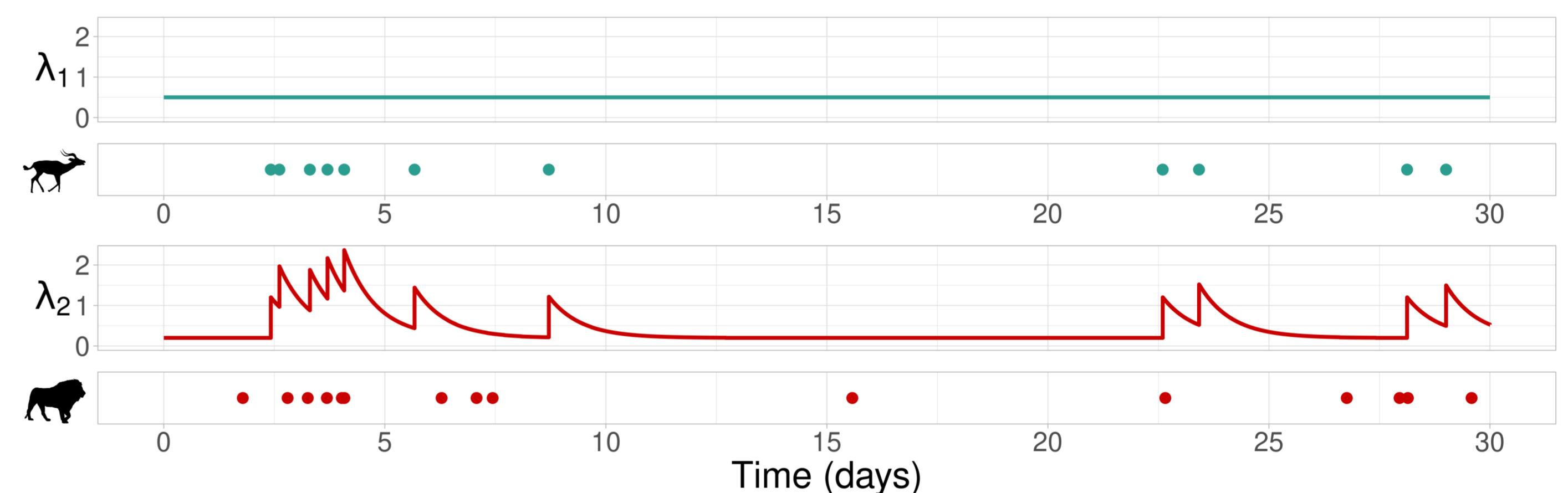
Intensity = expected count at time t

Spontaneous rate

Influence of previous species occurrences

Interaction function from species $j \rightarrow i$

Adjusting this model to camera trap data allows to infer which species attract or avoid each other.



Simulation of a Hawkes process with 2 species.

The points represent species occurrences and the curves λ_1 and λ_2 represent the intensity function (equation on the left).

Example: African savanna

Data

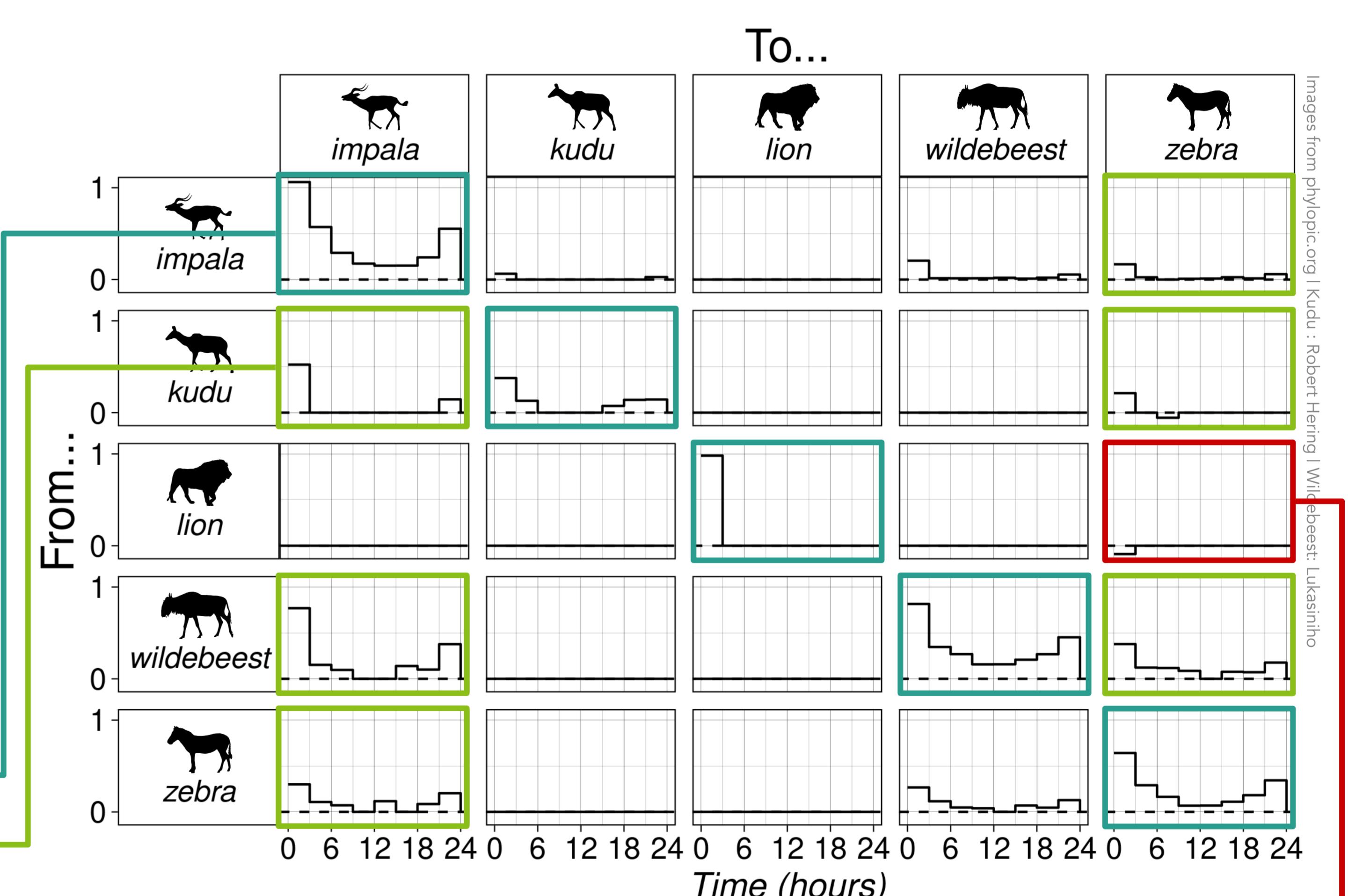
We adjusted this model to camera trap data collected with the Snapshot Safari program (Pardo et al. 2021) in South Africa. We focused on 5 species: impala, kudu, lion, blue wildebeest and Burchell's zebra.

Species occurrences were monitored in 5 sites, with 76 cameras in total, each of which was active 536 ± 227 days (sd). An independence filter of 60 min was applied.

Results

From these data, we inferred pairwise interaction functions between all species. The following patterns can be observed:

- Auto-atTRACTIONS
- Impala and zebra are attracted to all other herbivores species
- Zebra seems to avoid lion up to 3 hours after its occurrence
- Periodic patterns (e.g. impala-impala) → circadian rhythms?
- Some herbivore-herbivore interactions last up to 1 day → niche convergence?

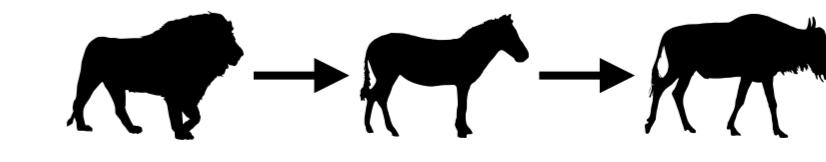
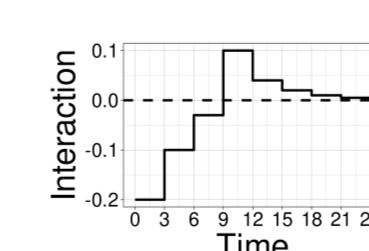


Pairwise interaction functions between species.

When a species attracts another, the interaction function is positive; when a species repels another, it is negative; when there is no interaction, it is null. Interactions are directed from row to column.

Conclusion & perspectives

- The Hawkes process provides directed interaction functions
- The multi-species framework takes indirect attraction/avoidance effects into account
- Perspectives: include covariates for the environment or the time of day



References

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