Modeling Situation-Specific Effects of Multiple Mortality on Social Network Structure in Griffon Vultures (*Gyps fulvus*)

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Research Question

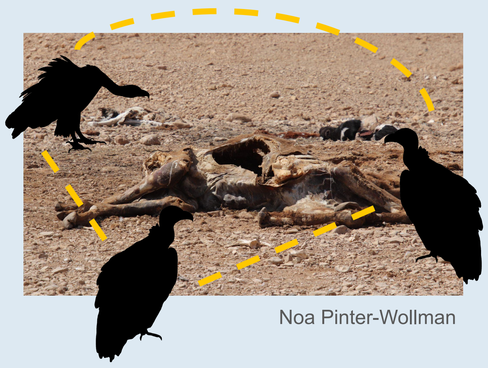
How long does it take for a **social network** to recover its structure after the **loss of several connected individuals?**

- How does recovery differ between **social situations**?

Background

Eurasian griffon vultures (*Gyps fulvus*) are **obligate scavengers** and **social foragers.**

Poisoned carcasses can kill many vultures quickly as they assemble to eat in groups. Poisoning is a major threat to griffon vultures.



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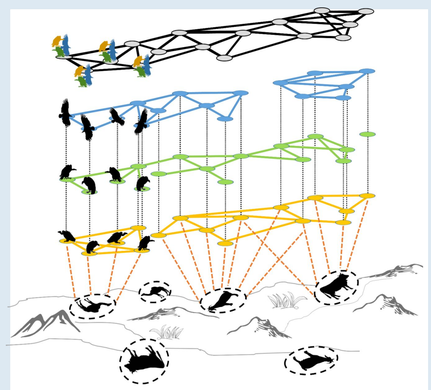


Fig. 1. Sharma et al. 2022

Social network analysis of GPS-tagged birds lets us study the population **social structure**. Networks differ between **situations** (co-flight, co-feeding, and co-roosting).

Modeling Approach

- Agent-based model: **Nodes** as vultures, **edges** as interactions (unweighted, undirected).

Baseline network dynamics:

- Edges added/removed based on two previous time steps, discrete time (Fig. 2a-b).

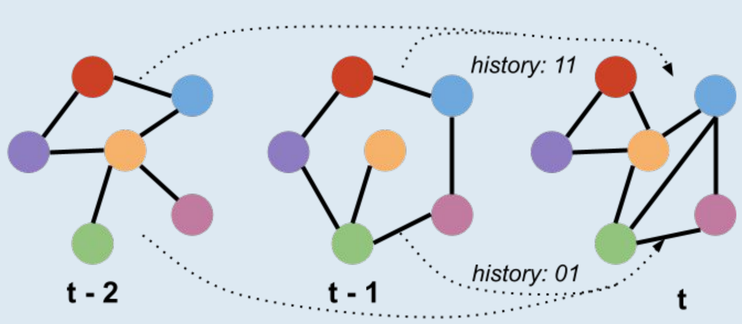


Fig. 2a. Edges are added and removed based on the two previous time steps.

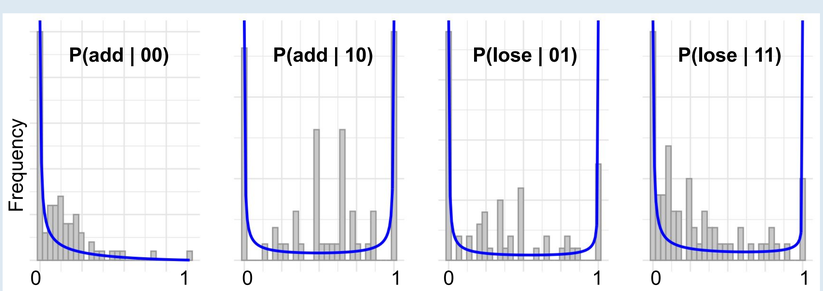


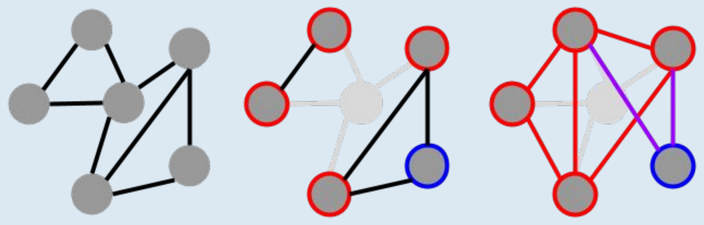
Fig. 2b. Probability distributions, from real feeding network data, for loss/gain of edges given their state 0/1 in the previous two timesteps.

Node removal and rewiring (Fig. 3)

- When node is lost, edges rewire.
- Higher probability of rewiring if mutually connected to the lost node (Farine 2021, "second-degree rewiring").
- Higher probability if history of connection.

Modeling Approach (Cont'd)

Fig. 3. Rewiring after loss of a single node.



A node and all of its edges are lost. Greater probability of forming/keeping edges between mutually "bereaved" nodes (red) than "non-bereaved" nodes (blue) (Fig. 3.)

Comparison to GPS Data

- Compared baseline model dynamics to GPS data from **36 tagged vultures** between 2020-10-01 and 2021-09-01. **Co-feeding** network only.
- Observed data has more isolated nodes, more seasonality than model output (Fig. 4).

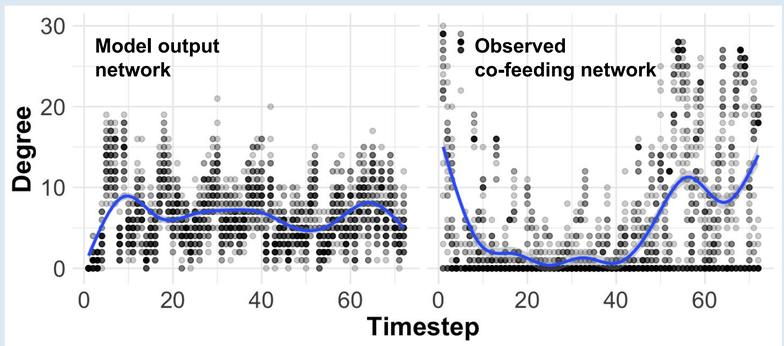


Fig. 4. Comparison of node degree: model output vs. observed co-feeding networks.

Comparison to GPS Data (Cont'd)

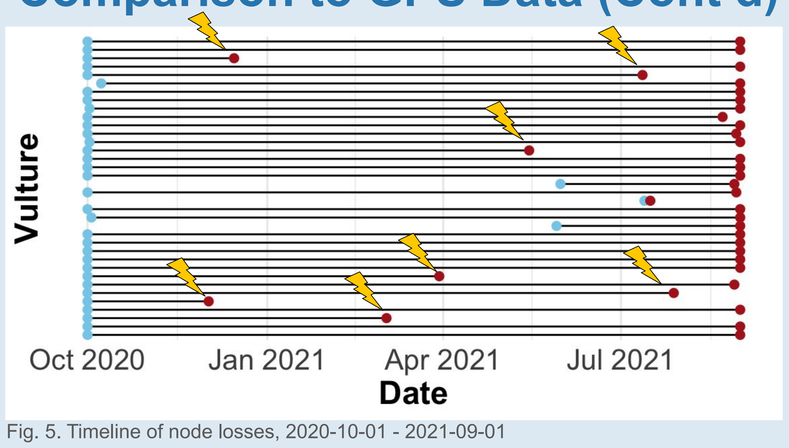


Fig. 5. Timeline of node losses, 2020-10-01 - 2021-09-01

- 7 single-node removals (Fig. 5).
- No evidence for second-degree rewiring (opposite?). Edge history matters (Fig. 6).

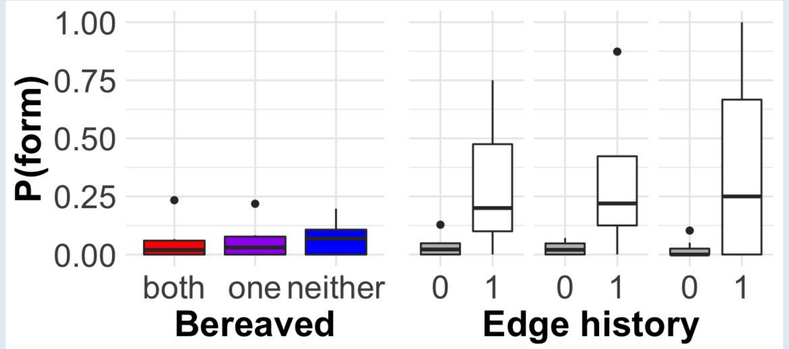


Fig. 6. Probability of forming an edge, given node status after loss and edge history.

Next Steps

1. Define rewiring for **simultaneous loss** of **multiple** connected nodes.
2. Further examine **loss in real data** for parameterization, including multiple mortality events (though data is limited).
3. **Refine** baseline model behavior to better capture real biology (e.g. Fig. 4).
4. Run model with multiple-node loss. Examine **recovery time** and resilience with different numbers of lost nodes.
   a. Measure density, degree distribution, transitivity.
5. Compare recovery time/resilience in different **behavioral situations** (flying, roosting) as well as overall aggregate network.

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More Info

https://kaijagahm.netlify.app/projects/2022-07-12-multiplemortality_vulturenetworks/