Social compensation strategies in response to individual loss in natural populations

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Extended Abstract

Societies across natural populations can be represented as social networks, whereby individuals are nodes and social interactions are edges. Social interactions in animal populations can therefore be measured, quantified and analysed with network analysis. Beyond intrinsic drivers such as disease and demography, animal populations face escalating pressures from climate change and anthropogenic activity, leading to population decline (1–3). Social interactions can compensate for the impact of individual loss on a population i.e. the "social buffering" hypothesis (4–7). Despite their central role, few studies have tested how animal social networks compensate for individual loss, which strategies are used, or how response might vary across the tree of life (8). Animals may respond through network reorganisation, known as 'rewiring', as shown in great tits (*Parus major*) and baboons (*Papio hamadryas*), where loss of individuals drives new associations and strengthen existing ones (9, 10). These social compensation strategies likely vary between species, influencing the extent to which network and individual properties are preserved during population decline. To address this research gap, we compare 399 real-world animal social networks to explore how different types of individual loss could affect social structure (11), and evaluate four different social compensation strategies to investigate how animal social structures may mitigate against individual loss of social associates as populations decline. By applying network science, animal social networks can act as case studies to understand resilience, robustness, and vulnerability in networks, with real-world direct impacts for population management and biodiversity.

Three removal methods were chosen representing the effects of natural disasters, culling and other natural loss on a population. Specifically, we consider random removal of individuals (as a potential representation of natural disasters). Complex networks may be more robust to random removals (12, 13). This provided a null comparison to centrality-based removal methods. Individual centrality in the network was calculated such that removal could be based on high to low (targeted culling) and low to high (natural loss or predation) centrality individuals. These methods mimicked 'targeted removal' regimes. Anthropogenic pressures often target higher centrality individuals, for example, in killer whales, historic hunting primarily targeted socially central juvenile females (13). Phenotypically biased trophy hunting, focusing on ornaments such as antlers, will target dominant individuals, which may therefore be more socially central (14).

Preliminary results indicate that while compensation strategies alter network structure, the specific method of compensation appears to have little effect. In contrast, removal methods influence both the magnitude and direction of structural change when no compensation occurs. Importantly compensation reduces these differences, suggesting that rewiring can buffer networks against the disruptive effects of different removal processes in real world animal social networks. These results illustrate the power of comparative network analysis in interdisciplinary work on social biological interaction networks, as it can reveal novel ecological and evolutionary insights in social systems (8). Future work will then look at associated biological traits and the spread of simple and complex contagions with removal and compensation.

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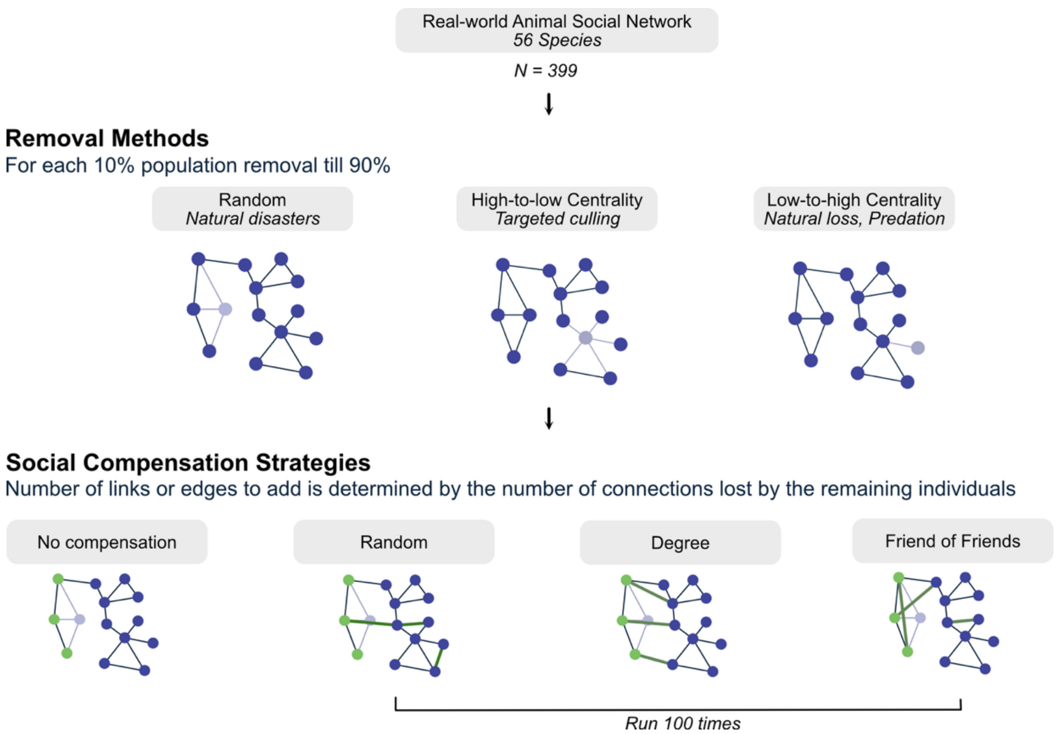

Figure 1. **Conceptual flow of methodology.** For each real-world animal social network (11), three removal methods were applied sequentially, removing 10% of the population. For each of these networks, four different social compensation strategies were applied. The number of edges add was determined by the number of edges lost by the remaining individuals.