Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: https://aejournals.org/

Original Research Paper

Social Wildlife Network Model for Analysing Animal Communication and Group Interaction Patterns

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Key Words

Animal communication, Social structure, Group interaction, Behavioural ecology, Sociality, Wildlife behaviour.

Abstract

The understanding of animal signalling and coordinating behaviour in social groups is one of the keys aims of behavioural ecology. In this paper, the Social Wildlife Network Model is introduced as an analytical framework that considers individuals as nodes and their communicative and behavioural interactions as connecting links, thus, allowing the analysis of group communication and interaction dynamics. Based on the existing principles of animal social network analysis, the model combines the behavioural observations of the individuals, the use of ethograms to code interactions, and the analysis of relational structures to quantify the intensity of associations between individuals, the frequency of their communication, and the positions they have within a group. This framework is proposed for conceptual application to three areas of animal social life: vocal and visual communication exchange, affiliative and aggressive interactions, and the structuring of group movement. Literature review showed that the use of network approaches allows discovering the non-random structuring of communication channels, the identification of individuals who have a disproportionately great influence on information exchange, and uncovering the way how the structure of the group and environmental factors affect interaction dynamics. Social Wildlife Network Model provides animal researchers with a standardized biologically founded method for quantifying sociality.

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Received: 25th May, 2026; Revised: 6th June, 2026; Accepted: 8th June, 2026; Available Online: 07th August, 2026
(DOI): 10.70102/AEJ.2026.18.3s.92

Introduction

However, few, if any, animals in group living behave as isolated individuals. For instance, from herd vigilance in ungulates to collective foraging in cetaceans, the success of individual animal is often related to its role and behaviour within a larger social context (Farine & Whitehead, 2015). Since behavioural ecologists have always been looking for techniques that could help in capturing the relational aspect of animal behaviour and not just counting their interactions, social network analysis has emerged in order to explain how individuals are interrelated via communication and behavioural interactions (Snijders et al., 2017). The social network approach, used in relation to non-human animals, provides a way of describing group-level patterns arising out of many pairwise interactions between group members (Sosa et al., 2021).

Effective communication is crucial within these interactions. Sounds, gestures, smells, and physical contact are the means by which information is exchanged between the participants; the routes by which these signals pass is seldom constant throughout a group (Hasenjager et al., 2021). Some participants are central in this respect, passing on and receiving information more often than others, whereas those who are peripheral have less exposure to the exchange of information within the group. The understanding of this system is directly relevant in order to understand the process by which behaviour can be learned, as well as stress responses or alarms.

In this paper, the Social Wildlife Network Model, a new conceptual model designed specifically for use in animal science, will be introduced as a tool for structuring observed behavioural data so that it may be used to characterize pathways of communication and group interaction. While a description of individual behaviour in an ethogram may be useful, this model focuses on the structure of the connections between the individuals, where each animal represents a node in which social positioning may be understood within the context of the larger group. The goal of this paper is to explain the model conceptually and describe how it is used.

Key Contributions

- A model that involves the use of social networks to analyze animal communication and group behaviours.
- Combines behavioural data and social network analysis to determine association, centrality, and group cohesion measures.
- Assists with studies on wildlife behaviours and welfare issues through analysis of the social structure.

The rest of the paper is structured as follows. Section 2 outlines the conceptual framework of the Social Wildlife Network Model. Section 3 discusses the methods for gathering behavioural data, while Section 4 outlines how the method is applied to patterns of animal communication. Section 5 covers group interactions and cohesion analyses, Section 6 offers the discussion section, and Section 7 concludes the paper.

Conceptual Basis of the Social Wildlife Network Model

The Social Wildlife Network Model is built upon three assumptions regarding behaviour that have been derived from previous research on sociality in animals. The first assumption is that individual animals within a group are considered as distinct units of analysis, which can be reliably identified through repeated sampling. The second assumption is that interactions between two animals, regardless of whether they are communicatory, affiliative, or agonistic, can be considered as discrete behavioural events involving a distinct sender and receiver, or as a mutual association such as co-feeding and co-resting (Sosa et al., 2021).

In this case, each individual animal becomes a node, while each observed interaction like a contact call, allogrooming session, threat display, or any form of synchronised movements is denoted by a link between two nodes involved in that interaction. The number of times and time period for which the interactions occur and their direction influence the strength and orientation of the link. Repeated observations over many sampling periods make it possible to see this as a stable representation of the organisation of social groupings within that group.

Three descriptive features are crucial for the framework. Association frequency describes the frequency and consistency of the interaction between two people in relation to the time of observation. Centrality of position denotes the degree to which the person is linked directly or indirectly with other people in the group, thus separating very connected people from peripheral ones. Group cohesion denotes the density and pattern of interconnections in the group; it shows if the interconnections occur evenly or only in some parts of people, for example, kin groups or age-sex categories (Gelardi et al., 2020).

Behavioural Data Collection Approach

Use of the Social Wildlife Network Model requires behavioural sampling that adheres to conventional ethological techniques. These include focal animal sampling, scan sampling, and all occurrence records of pre-specified interaction types. An ethogram that is designed according to the particular species under study identifies what behaviours need to be recorded. These may be discriminated based on various factors such as whether they are contact vocalizations or alarm calls, or affiliative contacts or displacement behaviours.

Observation takes place in different contexts depending on when the subjects are foraging, resting, or travelling so that there is no sampling bias for certain behavioural states. It is important to identify the individuals by using either their markings, tags, or simply getting familiar with the study population because the model relies on observing interactions among known individuals, not the anonymous behavioural observations. The effort to observe interactions is standardized for individuals to make sure that the difference in number of observations does not result from unequal sampling efforts.

The interaction data are then arranged into a relational database which provides information about the type, number, and direction of interactions between each possible pair of individuals. These data form the basis for the description of association, centrality, and cohesion as explained above without having to use specialized statistics software.

Application to Animal Communication Patterns

One application of the Social Wildlife Network Model relates to the nature of the communicative interaction within the group. Communication through vocalization in animals like songbirds, primates, and cetaceans is characterized by non-randomness in that some individuals make more calls and responses to other individuals compared to others (Snijders et al., 2017). Mapping the call-and-response interactions as directed links from the sender to the receiver enables identification of the individuals within the group who initiate vocal communication and those who only respond.

This structuring is of behavioural importance. In the case of species whose members depend on vocal communication in order to stay together while moving around or foraging, those that have high communicative centrality are likely to assume an important function in coordinating the movements of the group or warning other members against predator attacks. On the other hand, members that have low communicative centrality are likely to face the danger of being left behind and not getting enough information on food and dangers. Visual, postural, and olfactory communication can also be included in this structure of relations.

Furthermore, the model allows for comparative analysis between different contexts, for instance, whether communicative structures vary during states of tranquillity or alarm, or whether they vary depending on whether the birds are breeding or not. This enables the determination of whether the communication networks remain constant or variable, contingent on the environment.

Application to Group Interaction and Cohesion Patterns

Moreover, beyond mere communication, the Social Wildlife Network Model offers a way of mapping out more general patterns of social interaction, involving affiliative behaviours, such as allogrooming and proximity maintaining, as well as agonistic behaviours like displacement and threat display. It can help identify sub-networks within the group based on interactions that cannot be revealed simply by behavioural frequency counts, such as preferences for kinship, age, or reproductive similarity.

In addition to that, group cohesion in collective activities like group foraging, vigilance, and movement can be explained using interaction density and interaction distribution within the group. Groups which are characterized by dense and evenly distributed interactions tend to coordinate their collective actions more effectively while groups which have clustered or broken up interactions might have less effective coordination, response delay to external stimuli,

or a higher probability of breaking off into smaller subgroups. This is especially true of the species where social stability plays an important role in reproductive success and survival of offspring.

When used longitudinally, the model will also help to study how interaction structure changes due to demographic events such as birth, death, addition, or subtraction of individuals.

Discussion

The Social Wildlife Network Model provides an organised method for animal scientists to interpret behavioural data as a way of describing the social structure within groups. The most valuable aspect of the model does not arise from the creation of any novel behavioural categories; instead, it is the organisation of interaction data in a relationship framework which uncovers patterns unseen through traditional frequency analysis. This relational approach is in line with existing literature on sociality in animals, wherein it has been shown that social position, not interaction frequency alone, determines factors like access to information and exposure to stress.

Relevance of the model can be observed in many different fields of animal science. Welfare testing, for example, can use such a model in order to detect peripheral or isolated individuals within a captive population, who may suffer from chronic stress or resource exclusion problems. In the field of conservation biology, knowledge about communication patterns and cohesion of a group may assist in making decisions concerning group translocations or reintroductions. Social learning experiments can also benefit from mapping communicative centrality within a population in order to find individuals responsible for new skills propagation.

Some of these limitations need to be noted. It is necessary to have enough effort in observing to be able to get patterns of interaction. Also, it is possible that certain species communicate very seldom or very secretly, and thus more time will be required for sampling. Furthermore, structures of interaction are not always stable through time, and one has to be careful when extrapolating from short-term observations to social organization as a whole. However, despite these limitations, the proposed framework offers an important tool to animal scientists.

Conclusion

Social Wildlife Network Model is an analytical and empirical model which describes animal communication and group dynamics as a social network that is based on existing knowledge about animal behaviour and sociality gained through behavioural ecology. Using nodes (animals) and links between them (their communication/behaviour), the model makes it possible to systematically analyze association intensity, positional centrality and group cohesion of various species under different conditions. The framework can be applied to studies of animal communication and welfare, as well as to conservation management practices. Thus, it serves as a handy tool for animal scientists trying to comprehend how individual behaviour affects the group behaviour as a whole and vice versa. Further studies involving the use

of this framework can demonstrate how generalizable the patterns described by it are.

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