

**THE ORIGINS OF COMMUNAL ROOSTING BEHAVIOR IN BIRDS**

MSc. research proposal

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# **Chapter 1: Movement ecology and wildlife foraging behavior**

*Movement ecology and bird foraging behavior*

Despite long-standing interest in the factors that shape animal foraging behavior, it is still poorly understood how internal traits and external conditions jointly shape avian foraging movement (Mallon et al. 2020). Specifically, bird foraging behavior has been through direct observations. Because such methods are highly time-consuming, these studies have addressed the foraging behavior of specific taxa only (e.g., Smith et al. 2012), but research done on overarching questions aimed at unravelling the underpinning drivers of avian foraging ecology - especially across taxa - is not.

With the advance of tracking technology, however, different approaches can be used to make inferences on foraging behavior. For example, in mammals GPS data have been used to determine foraging based on velocities of movement (see Owen-Smith et al. 2012). Furthermore, using long-term data allows us to make predictions of important feeding grounds, especially for territorial species. Another study done with storks (*Ciconia ciconia*) confer information on the feeding areas during their life cycle and estimated the frequency of landfill use by the studied populations (Flack et al. 2016) using tracking data. Alternatively, a research paper on Andean Condors by Perrig et al. (2020) used GPS locations to identify probable foraging areas based on distance from roosting sites, velocity values and time of the day. There is a need to generate foundations on the types of movement associated to foraging behavior, especially given that the data are becoming more readily available.

Though individuals have many needs beyond nutrition (e.g., finding reproductive partners, sleeping, etc.), foraging is likely a key aspect of movement given that energy acquisition is essential for all heterotrophic species, which ultimately drives all other life processes. Hence, foraging ecology might be crucial to understand the mechanisms underpinning animal behavior. Given the vital importance of foraging, I will focus on my thesis on this aspect of ecology. In this opening chapter, I aim to review the current state of knowledge on potential drivers affecting foraging behavior of birds, and possible gaps that remain to be addressed to guide my work.

*Predictability of resources and foraging behavior*

To defend a feeding territory implies that there are benefits of doing so, one of them being energetic rewards (Ord 2021). Hence, it is expected that individuals with higher energetic demands (e.g., apex predators) will be more territorial than species in lower trophic guilds, all else being equal. Species with very specific niches and scarce or scattered food availability will also be more prone to defend territories because competition for these resources is likely to be stronger. As such, the greater the diet breadth of species, the less territorial they would be. However, when resources are unpredictable in the landscape, defending a feeding territory is no longer reasonable, and this is the case for many scavengers. Many scavenger species are large in size (vultures, ravens) which translates to high energetic demands, and yet they rely on unpredictable food patches, which naturally, cannot lead to territorial behavior (Grant 1993). Interestingly, many scavenger species forage in groups, leading to wonder if there are any benefits to this social behavior given the nature of their unpredictable food sources.

*Social structure and foraging behavior*

Evidence of social learning is growing across the animal kingdom (Aikens et al. 2022) with several studies looking at social behavior during migration. The benefits of social behavior, however, do not apply to migrating species alone. It has been discussed in the literature that one possible benefit from breeding in colonies is enhanced efficiency in exploiting an unevenly distributed food supply (Fisher 1954), which is supported by findings in Brewer’s Blackbird *Euphagus cyanocephalus* (Horn 1968). In addition, there is evidence to suggest that non-breeding sites like communal roosts do indeed act as information centers where individuals share information on foraging sites (Ward & Zahavi 1973, Wright et al. 2003). Thus, the sociality of communal roosting can be correlated to dispersion for foraging (Ward & Zahavi 1973), Here, vultures are an interesting system for several reasons. First, their unique feeding habits, since they are the only terrestrial vertebrate that is an obligate carrion consumer (van Overveld et al. 2020), second, because both New World Vultures and Old World Vultures – two independent lineages- converged to similar foraging habits (Van Overveld et al. 2022), and third, most- if not all- vulture species present some degree of social behavior with shared communal roosts among individuals.

*Memory and foraging behavior*

To navigate the landscape successfully, animals use cues in their environments like odor, sound, location and attributes in the landscape to guide their movement (e.g., Berberi et al. 2023). The process of acquiring this information, processing it and use it to make decisions is referred to as learning (Dukas, 2017,), and the term used for information retention is called memory (Rolls, 2014). This acquisition of knowledge is then used to evaluate whether to execute specific actions. For instance, an individual may decide whether or not to access a foraging area based on an assessment of the costs and benefits of doing so. Repeating this process and assessing the decision based on these costs or benefits suggest a learning process. Only recently has the field of movement ecology increased consideration of learning as part of animal decision-making when navigating the landscape (Fagan et al., 2013). For example, a study in blue whales showed that they rely highly on memory for migration and foraging areas (Abrahms et al. 2019). It is therefore reasonable to suggest that foraging is partially driven by learning processes as well. A classic example is that of feeding stations for vultures in Africa and Europe. For many vulture species that are in peril, supplementary feeding stations have been implemented to reduce poisoning threats. Once a group of individuals finds a feeding station, they will come back to use it frequently, given that the food is reliably there. This is a clear example of a memory process in foraging behavior. However, in a more complex scenario, with natural food availability, learning processes may function differently as food sources are usually scattered in the landscape, thus, animals might need to remember not one but many potential feeding grounds. One question arises, though: how does memory affect foraging efficiency for those species that feed on unpredictable food sources? If the food cannot be predicted, is memory all that relevant in finding them? Here, it can be argued that for scavengers that exhibit communal roosting behavior, short-term memory plays a role when finding and then sharing information with other individuals. Exploring the relationship between these two variables could open the door for further research questions in terms of the role of communal roosting in foraging success of a population, which ultimately has conservation implications.

*The unique nature of avian foraging ecology*

A relevant question remains unanswered – why are birds an interesting study system to answer the research questions here proposed? The answer has both ecological and pragmatic rationales. First, this behavior has been widely observed in birds (as opposed to other taxa where the behavior is not as persistent). Accordingly, many species of birds forage in groups, either by hunting or scavenging together, with this feature being more frequently seen among some groups in particular (e.g., corvids, vultures). Among the discussed benefits of sociality in the literature, a common consensus is that when doing so, individuals can be more efficient at finding food sources, which is the focus of this research. Although there are a few hypotheses to understand the origin of CRB, it is in birds where the behavior is more persistent across different groups (e.g., taxonomic groups, trophic levels, types of foraging). Thus, this group provides a comprehensive dataset to test and tease apart these hypotheses.

From a pragmatic perspective, there are extensive datasets existing for birds and systematized data. These reasons provide a unique opportunity to answer my proposed research questions and identify trends at the taxa level. Furthermore, if this idea can be further tested with movement data, at the moment birds are the taxa with more tracking data and for longer periods.

**Thesis aims and structure**

The overall aim of my thesis is to discuss drivers of communal roosting behavior and the potential implications on foraging efficiency in land birds.

*Chapter 1* will include a literature review on movement ecology of wildlife, with particular focus on bird foraging behavior. *Chapter 2* will be focused on understanding variables that affect the prevalence of communal roosting behavior (CRB) in birds. *Chapter 3* will use the previous chapters to highlight the value of sociality for foraging efficiency through the lens of Andean Condor (*Vultur gryphus*) conservation. *Chapter 4* describes the project timeline as well as my progress to date.

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