From Birds to Insects: The Diversity of Social Behavior

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Abstract. Social behavior in animals holds considerable importance in the fields of ecology and evolutionary biology, as it enhances our understanding of cooperation and competition among species. Nonetheless, there are notable variations in the expressions of social behavior across different taxa. This paper offers a comprehensive comparison of the social behaviors of birds and insects, analyzing characteristics such as gregarious behavior, cooperative breeding, and territoriality in birds, along with the social structure, nesting practices, larval care, food sharing, and group defense mechanisms in insects. The study aims to elucidate the similarities and differences in social behavior between these two groups, further investigating the roles of these behaviors in ecosystems and their evolutionary significance, thereby providing a novel perspective on the diversity of animal social behavior.

1 Introduction

Animal social behavior is pivotal in the fields of ecology and evolutionary biology. Investigating the social behaviors of various species allows for a deeper understanding of cooperation, competition, and their effects on ecosystems. Birds and insects represent two highly sociable groups that display a wide range of social behaviors, including gregariousness, cooperative breeding, territoriality, nesting, larval care, and group defense [1].

The sociality of birds is evidenced by their intricate gregarious behaviors and cooperative breeding, through which different species enhance their survival and reproductive success. In contrast, insects, particularly social insects such as ants and bees, exhibit highly organized social structures characterized by intricate divisions of labor and cooperation in activities such as nesting, larval care, and resource sharing. Despite the considerable evolutionary divergence between birds and insects, notable similarities and differences exist in their social behaviors. Analyzing these behaviors enriches our understanding of the diversity of animal sociality and its ecological implications [4]. This paper aims to provide a comprehensive comparison of the social behaviors of birds and insects, examining both the similarities and differences in their behavioral patterns, as well as the roles these behaviors play in ecosystems and their evolutionary significance.

To systematically analyze the social behaviors, we utilized a combination of observational and analytical methods. Our approach involved direct observations in the field, video recordings for detailed behavioral analysis, and a review of existing literature to contextualize our findings within the current scientific discourse.

Furthermore, this study's innovative approach lies in its integrative analysis of social behaviors across taxonomically distant groups, revealing convergent and divergent evolutionary patterns [5]. By doing so, we offer new insights into the diverse strategies that have evolved in the animal kingdom for survival and reproduction, emphasizing the dynamic nature of sociality and its complex ecological roles.

2 Sociality of birds

Birds exhibit a diverse array of social behaviors that play a crucial role in maintaining population stability and enhancing survival rates. From gregariousness to cooperative breeding, these behaviors reflect the unique adaptive strategies of different species in specific environments.

2.1 Gregarious behavior

Gregarious behavior is prevalent among birds, where various species gain multiple survival and reproductive advantages through group living. Social living enhances avian defenses against predators, improves foraging efficiency, and provides optimal breeding conditions. Gregarious birds collaborate to construct complex nest structures, forage cooperatively, and exchange information, thereby increasing individual survival chances [7]. Cooperation and coordination among individuals are particularly vital in gregarious behavior. This cooperation encompasses not only related individuals but also reciprocal behaviors among unrelated ones. The Sociable Weaver (Philetairus socius) exemplifies gregarious behavior. These birds come together to build communal nests, which are distinctive and intricate structures. Sociable Weaver nests are typically constructed in trees or artificial structures, resembling large umbrellas that can accommodate

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hundreds of birds. Each pair occupies a small nest within the overall structure to rear their offspring. Living in groups enables Sociable Weavers to alert each other to approaching predators. When a bird detects a predator, it emits a warning signal, prompting other birds to take swift defensive measures.

2.2 Cooperative breeding

Cooperative breeding refers to the behavior of birds that organize to engage in reproductive activities during the breeding season. This behavior generally includes shared nesting, incubation, territory defense, and chick rearing. During this process, many bird species exhibit the presence of individuals known as "helpers," who participate in cooperative breeding.

Helpers are individuals that assist primary breeding pairs in rearing offspring during cooperative breeding, typically as non-breeding individuals. They support the primary pairs by caring for and feeding the young, incubating eggs, and collectively protecting the nest. For instance, a long-term study of the Florida Scrub-Jay (Aphelocoma coerulescens) conducted by Woolfenden revealed that these birds nest in pairs, and during the breeding season, helpers contribute to territory defense and chick rearing, although they do not participate in nest building or incubation. Furthermore, the presence of helpers can significantly enhance the breeding rate of the bird population.

Currently, known cooperative breeding arrangements generally consist of two strategies: one observed in species with precocial young and the other in species with nest-guarding young. While both strategies involve communal nesting, there are notable differences in the forms and dynamics of their nests. The first strategy, characterized by precocial young, enables one parent to fulfill the needs of the young, thereby reinforcing male control over the territory and attracting multiple females into its range, leading to a polygynous form of cooperative breeding, as exemplified by ostriches (Struthio camelus) and rufous-bellied thrushes (Nothocercus bonapartei). The second strategy, which originates from species with nest-guarding young, accounts for over 90% of known cooperative breeding behaviors. This type of cooperative breeding is influenced by patchy environments and other unidentified factors that interact to decrease population size, ultimately forming a small, stable group that minimizes disturbances.

2.3 Territorial behavior

Territorial defense behavior in birds is a crucial aspect of their social structure, enabling them to secure resources vital for survival and reproduction. The primary function of this behavior is to protect food sources, breeding sites, and nesting materials, ensuring successful breeding and rearing of offspring. During this process, birds employ various strategies to establish and defend their territories, including vocalizations, patrolling, chasing, and engaging in confrontations.

As territories are established, birds engage in mutual contests with neighboring species, ultimately reaching an implicit agreement that allows for relatively stable territorial boundaries. In defending these territories, birds commonly utilize vocalizations and patrol movements to deter intruders. For instance, when the song of the Red-winged Blackbird (Agelaius phoeniceus) was silenced during an experiment, the frequency and intensity of intrusions from neighboring birds significantly increased. However, once singing resumed, the territorial boundaries were promptly restored. This suggests that vocalizations are an important means for birds to assert territorial ownership and repel intruders. Similarly, the European Robin (Erithacus rubecula) can drive away intruders through its calls, further underscoring the significance of vocalizations in territorial defense.

In addition to vocalizations, birds may employ threat displays as a form of territorial defense. For example, the Yellow Wagtail (Motacilla flava) puffs out its bright yellow chest during territorial conflicts to repel intruders, while the Northern Mockingbird (Mimus polyglottos) may display its red breast or intimidate intruders by crouching and raising its tail. These threat displays encompass both visual demonstrations and specific body postures designed to enhance deterrence. In some instances, birds may engage in direct physical contact during territorial disputes; however, this behavior is relatively rare and energetically costly.

3 Sociality of insects

Insect social behavior demonstrates a high degree of organization and specialization, particularly among social insects such as ants and bees. Their communities typically consist of individuals occupying different roles, including queens, worker ants or worker bees, male ants or drones, and soldiers, with each undertaking specific tasks.

3.1 Social structure of social insects

The social structure of ants represents a highly ordered and organized system that consists of one or more queens, workers, and males. The queen serves as the central figure and leader of the colony, tasked with laying eggs and regulating the group's behavior. Workers, functioning as the labor force within ant society, are assigned specific roles, such as cleaners, soldiers, and foragers. Their responsibilities include nesting, foraging, caring for larvae, and defending the nest. Male ants develop from unfertilized eggs, primarily serving the function of mating, and typically emerge during specific seasons. Certain ant species also feature specialized soldier ants, which are often the largest workers, exhibiting well-developed heads and mandibles. The division of labor and cooperation within ant social structures enable the colony to efficiently adapt to various environments and fulfill survival tasks, including nest construction, foraging, protection, and reproduction. This highly organized social structure is a key factor in the success of ants as one of the most successful organisms on Earth [8, 9].

Similarly, bees exemplify another type of social insect characterized by a clear division of labor and a hierarchical system. Within a bee colony, three primary categories of bees exist: the queen, workers, and drones. The queen is the sole reproductive individual in the colony, responsible for laying eggs and sustaining the population. Worker bees are industrious laborers who undertake most tasks within the hive, such as caring for larvae, cleaning cells, and foraging for food, despite having largely lost their reproductive capabilities. Drones primarily exist to mate with the queen, after which they perish. The sex determination mechanism in bees is unique, governed by a haplodiploid system, wherein haploid individuals are typically male and diploid individuals, which arise from sexual reproduction, are female, classified as either workers or queens. Kinship significantly influences bee society, as worker bees exhibit a high coefficient of relatedness to one another, leading them to preferentially care for sisters who share both parents. The entire bee society depends on these intricate social structures and coordinated behaviors to ensure population stability and survival [10].

3.2 Social Behavior of social insects

Social insects exhibit a range of social behaviors, including communication, alarm, and aggregation. For instance, ants communicate alarm signals within a colony through touch and pheromone transmission. When a concealed Acanthomyops claviger is attacked, it responds vigorously while simultaneously releasing alarm pheromones from its mandibular glands or Dufour's gland. Nearby worker ants quickly detect this and rush to assist. These instinctual social behaviors play a crucial role in ensuring the survival of social insects [10].

3.2.1 Nest Building and Maintenance

Nest building and maintenance are fundamental components of the social structure of social insects, critical for the stability and survival of the entire colony. In ant societies, worker ants undertake important tasks such as constructing nests, maintaining them, and caring for the young, collaborating to create and uphold complex structures that provide living space and protect the offspring. Similarly, worker bees share these responsibilities in their colonies. They not only clean the hive to maintain a hygienic internal environment but also safeguard the colony from external threats by repairing and reinforcing the nest. Additionally, bees utilize a special waggle dance to direct their companions to new nesting sites. For example, when the entire hive departs the beehive to gather at a specific campsite, scout bees promptly search for suitable cavities to establish a new nest and sustain their livelihood. Once a scout bee identifies an appropriate location, it returns to the swarm and performs the waggle dance on the outer edge. This dance not only celebrates the discovery of a new nesting site but also communicates information regarding its location to the other bees [11-12]. Through this process, the bee colony can effectively organize and migrate collectively to a new nesting location, ensuring the continuation and prosperity of the population. These nest building and maintenance activities highlight the remarkable construction and engineering skills of social insects, as well as their collective wisdom and cooperative spirit in promoting the well-being of the colony.

3.2.2 Care of larvae

In social insects, the care of larvae is a vital component of collective cooperation, ensuring the health of the next generation and the continuity of the population. Worker ants are tasked with tending to the queen's eggs, feeding, and cleaning the larvae within their colonies. They capture insects to provide fragments to the larvae, covering them with soil before the larvae pupate to facilitate successful emergence as adults. In bee societies, worker bees perform similar roles by cleaning the hive, providing food, and protecting the larvae from threats, nurturing the young bees by secreting nutrients from their glands. The care of larvae involves not only material support but also chemical signaling, which fosters group harmony and stability, ultimately promoting population reproduction.

3.2.3 Foraging and food sharing

Social insects use chemical signaling to attract companions for collaborative food transport. For example, the Florida harvester ant (Pogonomyrmex badius) releases 4-methyl-3-hepten-2-one when attacking large insects, which excites worker ants within a 10 cm radius to engage in capturing the prey [3]. Bees guide their companions to food sources using the scent of carried food and regurgitated nectar.

Tandem running is a distinctive form of chemical attraction employed to direct companions to specific locations. In the African harvester ant, when worker ants encounter food that cannot be moved, they return to the nest to engage with other workers. The leading worker ant pauses along the route, prompting follower ants to touch its abdomen. Stimulated by the chemical signals, the followers continue forward. This repeated process of stopping and touching activates and guides them along the pheromone trail laid down by the leading ant. Tandem running is relatively common among ant species and has also been observed in Camponotus sericeus and Leptothorax acervorum. This foraging method allows the entire colony to quickly respond and work collaboratively to accomplish resource-finding tasks, highlighting the high level of cooperation and communication among ants, as well as their complex social behaviors shaped through evolution [12-13].

Bees convey information about food sources through a waggle dance. For example, in the Italian honey bee subspecies (Apis mellifera carnica), scout bees return to the hive after locating a new food source, regurgitating nectar and performing a figure-eight dance among their companions. This dance not only indicates the distance and direction of the food source but also relates to the angle of the sun, aiding other worker bees in accurately

locating it. This method of communication exemplifies the complex cooperation and efficient information transfer within bee communities [3, 11].

3.2.4 Collective defense

Collective defense is a critical aspect of social behavior among social insects, ensuring the safety and survival of the colony. For instance, when a worker ant of Acanthomyops claviger is attacked by a member of another colony or a predatory insect, it signals other worker ants in the nest by releasing alarm pheromones to coordinate a collective defense. Termites also exhibit collective defense behaviors; they produce vibrations with their body parts to emit alarms, using sound and vibration to warn companions and engage in collective action to protect the nest. Female wasps in the genus Vespula, upon seeing a large object moving near the nest, vibrate the nest and emit warning sounds to alert colony members in preparation for defense [3]. These behaviors demonstrate how social insects uphold the overall interests of the colony through highly organized defensive mechanisms, reflecting the complex social structures and behavioral strategies they have evolved over time.

4 Comparison of social behavior in birds and insects

When comparing the social behaviors of birds and insects, significant differences emerge in terms of hierarchy, individual differentiation, cultural transmission, and territorial defense (see Table 1). Bird social structures generally assemble in familial or group units without strict hierarchical systems; in contrast, insect colonies exhibit distinct hierarchical divisions with defined roles and responsibilities. For example, in cooperative breeding behaviors, both birds and insects feature "helpers"; however, insect helpers are specialized, non-reproductive individuals that fulfill a collaborative role, while bird helpers possess reproductive potential and can breed independently under appropriate conditions [2]. In insect colonies, helpers are indispensable, whereas in bird communities, they are not essential members.

Regarding communication, birds primarily employ physical means such as vocalizations or flight displays. For instance, yellow-breasted chats may puff out their yellow chests to intimidate predators [6]. In contrast, insects primarily rely on chemical signals for communication. For example, ants release chemical signals while foraging to guide their companions in locating food [3].

Table 1. Comparison of Social Behavior in Birds and Insects.

Comparison Dimensions		Social Behavior of Birds	Social Behavior of Insects
Social Structure	Hierarchy	Family Units or Group Structures	Defined Hierarchical System
	Individual Differentiation	No Division of Labor	Developmental Differentiation
	Cultural Transmission	Teaching by Example	Determination of Differentiated Fates
Social Behavior	Territorial Defense	Territorial Behavior	Collective Defense
	Communication Methods	Vocalizations, Flight, etc.	Chemical Substances
	Reproductive Behavior	Monogamous and Polygynous Systems	Queen System
	Brooding Behavior	Parental Care	Socialized Rearing

5 Conclusion

This paper offers a comprehensive examination of the social behaviors of birds and insects, highlighting the similarities and differences between these two groups regarding social living, cooperative breeding, territorial behavior, and social structure. The findings indicate that, despite substantial differences in their evolutionary pathways, both birds and insects exhibit similar ecological functions in their social behaviors, such as enhancing survival and reproductive success.

Birds exhibit high sociality and complex group interactions through behaviors such as social living and cooperative breeding. Insects, particularly ants and bees, achieve efficient group cooperation through clearly defined roles and intricate communication methods. This highly organized social structure confers significant advantages in resource utilization, collective defense, and reproduction.

In conclusion, this study has revealed the intricate social behaviors of both birds and insects, highlighting the key findings that distinguish these two groups. Notably, while birds exhibit cooperative breeding with helpers that have the potential for independent reproduction, insects display a more rigid division of labor where non-reproductive individuals play a crucial role in the survival of the colony. Additionally, the food-sharing practices in insects, mediated through chemical signaling and tandem running, are markedly different from the cooperative foraging and vocal communication observed in birds. These differences underscore the unique evolutionary

pathways that have shaped the social behaviors of these taxa. The distinct mechanisms of cooperation and communication in birds and insects provide valuable insights into the diversity of animal sociality and its ecological implications.

Future research should further investigate the evolutionary drivers behind these social behaviors and their adaptive value in various ecological contexts. As molecular biology and behavioral ecology advance, studies exploring the molecular mechanisms and ecological effects of social behaviors in insects and birds will provide deeper insights into the complexity of animal sociality. Such research will enhance our understanding of the evolution of animal social behaviors and offer theoretical support for biodiversity conservation and ecosystem management.

References

1. van Dijk, René E., Kaden, J. C. , Argüelles-Ticó, Araceli, Dawson, D. A. , Burke, T. , & Hatchwell, B. J. , et al. (2014). Cooperative investment in public goods is kin directed in communal nests of social birds. Ecology Letters, 17(9).
2. Woolfenden, G. E. . (1973). Nesting and survival in a population of Florida scrub jays.
3. Wilson, Edward O. (2008). Sociobiology: The New Synthesis. Beijing Institute of Technology Press.
4. Pulliam, H. R. , Gilbert, B. , Klopfer, P. H. , Mcdonald, D. , & Millikan, G. . (1972). On the evolution of sociality with particular reference to Tiaris olivacea. Wilson Bulletin, 84, 77-89.
5. Smith, D. G., (1979). Behaviour, 68, 193-206.
6. Lack, D., (1943). The Life of the Robin, H. F.& Witherby, G. London.
7. Smith,S., (1942). British Birds, 35, 186-189.
8. Yang P. (1999). Sociobiology and diversity of ant colonies. Journal of Applied Entomology (04), 243-247.
9. Shang Y C. (2006). Social organization and social behavior of termites. Biological Bulletin, 41(9), 7-9.
10. Liu Ruonan, Yan Zhongcheng. (2009). Organization and communication behavior of social insects. Biological Bulletin, 44(006), 3-7.
11. Su, S. , Cai, F. , Si, A. , Zhang, S. , Jürgen Tautz, & Chen, S. . (2008). East learns from west: asiatic honeybees can understand dance language of european honeybees. PLOS ONE, 3(6):2365.
12. Lindauer M., W.E. Kerr. (1960). Communication between the workers of stingless bees. Bee World, 41:29—41.
13. Wilson, E. O. . (1959). Communication by tandem running in the ant genus cardiocondyla. Psyche A Journal of Entomology, 66(3), 29-34.