CHAPTER 30

Behavioral Ecology: Patterns and Trends in Animal Social Interactions

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SUMMARY

The emergence of ecology, specifically behavioral ecology represents a crucial shift in the understanding of the complex relationship between organisms and their environments. This scientific discipline gained prominence in the mid-20th century, concentrating on the study of how animal behavior evolves as a response to ecological concerns. Through careful observations and experiments, researchers revealed the adaptive approaches employed by species to survive and reproduce. The integration of evolutionary principles and ecological dynamics gave rise to a significant comprehension of animal interactions, emphasizing the role of behavior in regulating population dynamics. Patterns along with trends in animal social connections reveal substantial insights into the complications of the communication and cooperation in distinct species. From hierarchical structural configuration in primate communities to complex mating rituals between different birds, these patterns highlight the evolutionary significance of social behavior. Observable trends frequently comprise cooperation for resource acquisition and formation of territories. Such patterns help us to understand the adaptive behaviors that structure social life, and thus the contingencies that enter into the fitness of a population. Therefore, this chapter explores the patterns and trends in animal social interactions.

INTRODUCTION

Behavioral ecology is a scientific discipline that explores the interactions between an organism's behavior and its environment, aiming to understand the adaptive significance of behavior in the context of natural selection. This field plays an indispensable role in examining the complex relationships between ecology as well as ethology, connecting both disciplines to provide a comprehensive understanding of how animals behave in their natural habitats (Nettle et al., 2013).

Basically, behavioral ecology signifies the study of animal behavior in the broader framework of ecological processes. Furthermore, this discipline explores the fundamental questions about why animals behave the way they and how these behaviors play a key role in their survival and reproduction. The primary focus of this field revolves around exploring the adaptive significance of behaviors, aiming to explain the evolutionary forces that govern as well as maintain them (Carter et al., 2013; Akbar & Ijaz, 2024; Hayat et al, 2024). One of the foundational principles of behavioral ecology is the concept of natural selection. This principle postulates that behaviors enhancing an organism's fitness, its ability to survive and reproduce will be favored over time. Consequently, the behaviors exhibited by individuals in a population are often the result of evolutionary processes, improved by countless generations to optimize survival in their specific ecological niche.

One of the most important natures of behavioral ecology is highlighted by its integration of ecological as well as ethological perspectives. However, ecological factors such as resource availability, the pressure from predators as well as environmental conditions have a significant impact on an organism's behavior (Sng et al., 2018). For instance, an animal's searching behavior may be shaped by the distribution of food resources in its habitat. On the other hand, the study of animal behavior provides an angle to observe and interpret the complicated details of how animals interact with each other and their environment (Owen-Smith et al., 2010).

Through the lens of disciplines that encompass behavioral ecology, it provides a holistic depiction of the interactions between an organism and its environment, illustrating how ecological pressures act to select for the evolution of behaviors that maximize an individual's chances of survival and reproduction whether it be locating food, avoiding predators, seeking partners or nursing young (Schmidt et al., 2010). The coupling of ecology and behavior captures the intricate ways in which behavioral approaches and lifeways evolve through time, to account for the diversity of behavioral profiles that exist in animals (Schmidt et al., 2010).

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This is because behavioral ecology is not only informative, particularly when considered alongside other strategies to understanding the natural ecosystem. It is also far more than just a theoretical curiosity in the field of science. It has substantial applications in certain areas as diverse as conservation, animal welfare as well as sustainable development. Therefore, this chapter provides patterns as well as trends that modulate animal social interactions, providing a closer understanding at how these dynamics influence the ecological equilibrium.

HIERARCHY AND DOMINANCE

The rules by which members of a group negotiate their associations with other members of the group, organize the consumption of resources, and manage access to mates or territory are called social hierarchies. Different kinds of networks may appear from the growing hierarchy of relationships between members of a social organization, some of which could be significantly extra complicated. A fundamental property of all social hierarchies is the dominance, or the capacity of an organization or group member to execute authority or control over the other animals. This behavior could manifest in various ways, ranging from overt dominance or physical aggressiveness to more precise subtle social signaling or communication among different animals. Subordinate animals often experience restricted access as well as resource limits, whereas dominant animals typically get more access to resources along with greater mating prospects. One of the primary strategies used to modulate authority is aggression behavior. This may manifest as open battle or extensive submissive intimidation. The result of these aggressive interactions determines the carrier's standing in the social hierarchal organization in a variety of animal species. The winner of a battle advances up the ladder, revealing those who are under them and obtaining access to resources if they are at the top of the hierarchy (Garandeau & Cillessen, 2006).

In addition to displays, ritualized actions that function as non-physical cues of authority can also be used to identify dominance. Exaggerated stances, vocalizations, or gestures that communicate dominance without requiring direct physical contact are examples of these behaviors. These demonstrations occasionally help to lower the possible expenses of direct conflict and offer a less dangerous way for people to gauge one other's strength and determination (Liénard & Boyer, 2006). Beyond overt manifestations of animosity, social signaling is essential to establishing and preserving dominance. Animals use a range of indicators, such as hormonal signals, body language, and vocalizations, to convey to other members of their group what social rank they have. Animals utilize these signals as a kind of language to negotiate the intricate web of social interactions inside the hierarchy (Bar-Tal et al., 2007). While the concept of supremacy might evoke images of power struggles as well as conflict, its existence serves essential functions in social groups. Supremacy hierarchies aid in reducing the conflict over resources by providing a structured system for resource allocation. In many cases, the presence of a clear hierarchy decreases the need for constant physical confrontations, contributing to group constancy.

Moreover, dominant can play a key role in reproductive success. Dominant individuals often have increased access to mates as well as resources, enhancing their chances of passing on their genes to the next generation. This aspect of dominance is a driving force in the evolutionary processes that normalize social structures in species. Social hierarchies as well as dominance is observed across a wide range of species, each with its exclusive strategies as well as mechanisms. In wolf packs, for instance, dominance is often established through physical confrontations as well as submissive postures. Birds may use complex vocalizations as well as courtship displays to gain access to partners and nesting locations (Austin et al., 2021). Dominance hierarchies affect the roles and responsibilities within the colony, even in social insects like ants and bees (de Silva et al., 2020). Furthermore, Table 1 provides an overview of different animals that display hierarchy and dominance.

COMMUNICATION AND SIGNALING

One of the most obvious forms of animal communication is vocalization. Across species, animals produce an extensive range of sounds that convey specific meanings. From the melodic songs of birds to the haunting sounds of wolves, vocalizations serve as remarkable function in the animal kingdom (Seyfarth & Cheney, 2017).

For instance, bird songs are often related to mate attraction as well as territory defense. Male birds use their melodies sound not only to serenade potential mates but also to establish and defend their breeding territories from rival males. The richness as well as intricacy of these songs may carry certain information about the health condition of the singer, genetic fitness as well as territorial boundaries. Similar to this, marine animals incorporating whales as well as dolphins use a variety of sounds i.e., clicks, whistles as well as pulses, to communicate with one another in the aquatic environment. These underwater cues are indispensable for locating prey, coordinating organizational activities, and modulating social bonds within their pods (Pénitot et al., 2021).

In contradiction to vocalizations, body language plays an indispensable function in animal communication. Gestures, expressional postures as well as actions deliver valuable insights into an animal’s goals, emotional status, and social condition. For example, the tail of the dogs is often utilized to convey excitement or enjoyment. On the other hand, defensive posture conveys obedience or maybe fear condition (Fröhlich et al., 2019). Animals with substantial social interactions including monkeys, possesses the capability to navigate the difficulties of organizations dynamic configuration via a complicated language of facial expressions, different postures as well as gestures of the body (Roberts & Roberts, 2020).

In the kingdom of insects, bees are capable of performing complicated dance routines to communicate the different locations of nutritional resources for their fellow hive members (Grüter & Czaczkes, 2019). When evaluated in the context of olfactory communication, chemical signals provide a more complicated mode of communication than vocalizations or body languages. Different animals create molecules known as pheromones, which are used by animals

of the same species to transfer information. These chemical signals are required for mating, establishing territory as well as forming social bonds (Snijders & Naguib, 2017).

Ants use pheromones to send out a variety of information i.e., trail markings that point partners in the direction of nutritional resources. When an ant leaves a trail of pheromones behind when it locates certain food resources (Adams et al., 2020), which effectively draws other ants to join it in its hunting attempt (Fig 1). Approximately all of the mammalian species, particularly big cats and canids, mark their territory by means of scent. For example, wolves employ urine to mark borders and alert other packs when they are in the targeted area. Scent marking is a similar method used by domestic cats to mark their territory and convey message about their reproductive condition. Animals coordinate their combined activities as well as their individual interactions with members of the species. For social animals to coordinate their movements, organize their hunting techniques, and preserve group consistency, effective communication is indispensable (Demartsev et al., 2023).

Animals may coordinate their organizational activities in addition to speaking to each other independently. Social animals require to communicate well in order to coordinate their movements, organize their hunting plans, and preserve organizational cohesion within their group (Herbert-Read, 2016). Fish in schools display remarkably synchronized swimming behaviors, responding to minute cues from other members. Effective communication is established by the group's synchronized swimming, which allows them to locate food sources, evade predators, and move through difficult environmental stresses (Chivers et al., 2016).

Alarm calls, recognized vocalizations, and particular body language signs are employed to warn group members of potentially dangerous conditions (Mattila et al., 2021). The group flees or takes covert action when they recognize the threat that these noises represent. Meerkats are small mammals that live in communal groups. They take it a step further and choose certain individuals as sentinels, whose primary duty is to warn the community of impending danger and keep a watch out for prospective predators (Collier et al., 2017).

In a manner similar to this, when predators or other risks are around, ants use certain alarm pheromones to notify other members of their colony. In reaction to the chemical signals' rapid spread, ants organize a concerted defense response to save the colony (Adams et al., 2020). Dominance hierarchies often rely on a complex language of signals to establish as well as maintain the order of power among individuals. Aggressive shows, submissive postures, and subtle cues communicate the hierarchical structure as well as help to avoid unnecessary conflict (Mitchell et al., 2023).

In wolf packs, for example, dominant individuals may assert their status through confident body language, vocalizations, as well as direct eye contact. Subordinate individuals, in turn, exhibit passive behaviors, such as letting down their body and avoiding direct eye contact, to convey deference and avoid confrontation (van der Borg et al., 2015). Among primates, grooming assists as both a social bonding activity as well as a means of reinforcing social hierarchies. Higher-ranking individuals receive more grooming from subordinates, reinforcing the group's social structure and maintaining relations in the community (Wubs et al., 2018).

COOPERATION AND ALTRUISM

Cooperation serves as a foundation of social interactions and it demonstrates in a variety of ways across the animal kingdom. Whether it's hunting in packs, protecting territories, or increasing offspring collectively, species engage in cooperative behaviors to improve their chances of survival as well as reproductive success (Prounis & Ophir, 2020). A classic example of collaboration is observed in social insects, such as honeybees and ants. In a beehive, workers collaborate consistently to forage for food, build and sustain the hive, and protect the queen and her offspring. The division of labor in the colony make sure the efficient utilization of resources, give to the success of the hive (Jandt & Gordon, 2016).

In mammals, particularly between carnivores, collaborative hunting is a common strategy. Wolves, for example, hunt in packs, leveraging their collective strength and cooperation to bring down larger prey. By working with each other, individuals can access more considerable food sources than they could alone, providing a clear benefit in the challenging environment of survival (Elbroch et al., 2017). Collaborative behaviors also increase to the avian realm, with birds forming associations for mutual protection and breeding success. V-formations during migration, as seen in geese (Fig 2), exemplify how birds decrease wind resistance and conserve energy by taking turns leading the group. This cooperative effort allows them to cover wide distances more efficiently.

While collaboration involves individuals working together for mutual advantage, altruism takes the concept a step further by encompassing self-sacrificing behaviors that benefit others at a cost to oneself. In the kingdom of social animals, altruistic acts are especially exciting, challenging traditional notions of individual self-preservation (Tornero et al., 2018). One of the most important examples of altruism is observed in certain social insects such as honeybees. Worker bees in a hive exhibit selfless conduct when they sting an invader in order to defend the colony. But this action has a severe price: the bee eventually perishes and loses its stinger. One worker bee's sacrifice spreads the greater benefit by protecting the hive from any dangers (Mullen & Thompson, 2015). In the kingdom of mammals, meerkats show altruistic behaviors in their social structure. Sentinel duty is assigned to some individuals in these tiny carnivores, who keep an eye out for potential predators while the rest of the group forages for food. To keep the group secure, the sentinels forgo their own foraging chances and assume the danger of predation (Duncan et al., 2019).

The visible paradox of altruism in nature has been a focal point of evolutionary studies. Kin selection, a concept introduced by biologist W.D. Hamilton, give a framework for understanding how altruistic behaviors can evolve. The idea is rooted in the concept that individuals may exhibit self-sacrificing behaviors if it benefits their close genetic relatives,

thereby promoting the transmission of shared genes (Birch & Okasha, 2015).

This phenomenon is obvious in the social insects brought up earlier. In a beehive, workers are more closely associated to their sisters (with whom they share about 75% of their genes) than to their own offspring. By protecting the hive and supporting the queen's reproduction, worker bees indirectly insure the continuation of their shared genetic material (Galbraith et al., 2016). In the animal kingdom, kin selection is a driving force behind many examples of altruism. Prairie dogs, for example, issue warning calls to make aware their relatives of approaching predators. While this vocalization may fascinate the attention of the predator, the act of warning benefits the prairie dog's kin selection behavior, enhancing the likelihood of survival for relatives who share a significant part of their genes (Socias-Martínez & Kappeler, 2019).

Reciprocal altruism is another evolutionary theory that sheds light on evidently selfless behaviors. This form of altruism involves individuals providing encouragement to others with the expectation of receiving reciprocal advantages in the future. The collaborative exchange of favors forms the basis for strong relationships in a group (Shultziner & Dattner, 2016). One of the classic examples of reciprocal altruism is present in vampire bats. These bats engage in reciprocal food sharing, regurgitating blood to share with group members who have been unsuccessful in existing a meal. Over time, individuals take turns benefiting from this collaborative behavior, ensuring that each bat has a chance to receive assistance when needed (Carter et al., 2020).

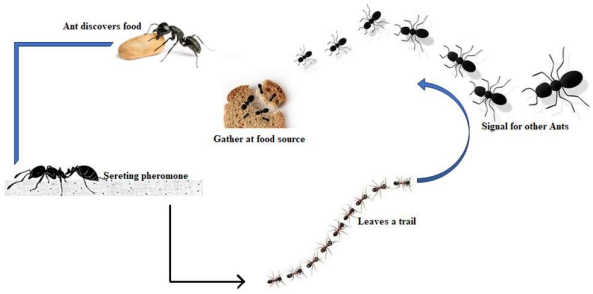

Fig 1. Communication and signaling in ants

Fig 2. 'V' formation of geese to reduce wind resistance and conserve energy

Primates, particularly chimpanzees, show behaviors that align with reciprocal altruism. Individuals are arrested in grooming rituals, removing parasites and forming social bonds. The act of grooming, while providing immediate advantages to the individual receiving the service, also establishes and sustains social associations in the group (Van Leeuwen et al., 2021). The principles of collaboration and altruism are not restricted to the non-human animal kingdom. In humans, these behaviors are obvious in complex ways that increase beyond genetic relatedness. Human societies are identified by intricate social networks, when individuals engage in collaborative endeavors and altruistic acts to strengthen social bonds and foster a sense of community (Decety et al., 2016). From a young age, humans show a tendency for collaboration and altruism. Children, for example, often engage in cooperative play, share resources, other help others in need. These behaviors, noticed early in development, lay the foundation for the complex social interactions that distinguish human societies (Silk & House, 2016).

Altruism in humans also expands to acts of kindness and philanthropy that go beyond immediate social circles. Individuals give charitable causes, volunteer their time, and engage in altruistic behaviors that benefit strangers as well as communities at large scale (Barman, 2017). This wide expression of altruism underscores the complexity of human social dynamics and the interaction between individual well-being and the greater good. Moreover, human societies exhibit cultural evolution, where collaborative behaviors and altruistic standards are transmitted across generations. Cultural practices that promote collaboration, reciprocity and altruism give to the cohesion as well as resilience of human communities (Kaniasty, 2020).

TERRITORIALITY

Territories are specific geographic areas that animals claim and protect against intruders. These areas are distributed as a valuable resource base, providing access to critical elements necessary for an individual's survival and reproductive success. The establishment as well as protection of territories are deeply fixed in the evolutionary strategies of numerous species (Kamath & Wesner, 2020).

One of the primary functions of territorial behavior is resource dividing among individuals in a population to reduce direct competition. By defining specific areas as their own, animals produce a structured environment where every individual has exclusive access to a part of the available resources such as food, mates, or suitable nesting sites (Kronfeld-Schor & Dayan, 2003). Territoriality serves as a built-in check on population density, keeping it within sustainable bounds. Without this process, unchecked competition for resources might result in overexploitation and increased stress, which would be detrimental to the population's overall health and fitness (Rose & Cowan, 2001).

Table 1. Overview of animals that display hierarchy and dominance.

Animal	Social Structure	Dominance Behavior	Examples
Lions	Pride with a dominant male	Dominant male asserts control	In a lion pride, the dominant male typically leads.
Chickens	Pecking order	Aggressive pecking for hierarchy	Chickens establish a pecking order for resources.
Wolves	Pack structure	Alpha wolf leads	Wolves exhibit a hierarchical structure with an alpha wolf.
Elephants	Herd with matriarch	Matriarchal dominance	Elephants often have a matriarch leading the herd.
Hyenas	Clan structure	Female dominance	In hyena clans, females are often dominant over males.

Table 2. Different animals that display parental care behavior

Animal	Parental Behavior	Offspring Interaction	Examples
Penguins	Shared incubation and feeding	Alternating roles in caring for chicks	Emperor penguins share incubation duties and care for chicks.
Elephants	Extended parental care	Calves stay with the mother for years	Elephants display long-term parental care.
Birds of Prey	Provisioning food	Hunting and delivering food to the nest	Birds of prey actively hunt and provide food to offspring.
Wolves	Pack cooperation	Cooperative rearing of pups	Wolf packs cooperate in raising and protecting their young.
Dolphins	Pod support	Cooperative care and protection	Dolphins exhibit cooperative care within their pods.

Animals claim territory that is plentiful in food sources, creating a consistent as well as exclusive food source. By decreasing rivalry with neighboring animals, this tactical placement not only safeguards a suitable food supply for the territorial animals but also helps in the prevention of starvation (Hinsch & Komdeur, 2017). Red foxes for instance have places that include meadows, woodlands as well as urban areas, among other types of habitats. These areas provide substantial access to a variety of nutritional resources, including insects, birds as well as small animals including birds (Kimber et al., 2020).

Furthermore, numerous animals use their territory to attract partners and initiate breeding colonies (Potvin et al., 2015). During the mating season, numerous bird species, particular songbirds exhibit territorial behavior. In order to attract females, males often defend certain territory employing elaborate songs, violent actions and various displays. By enhancing the probability of effective reproduction, the possession of a premium nesting location in a defended habitat helps to preserve the animal's genetic heritage (Demko & Mennill, 2018).

In addition to this, birds frequently invest a plethora of time and energy in building nests, and the availability of a safe and resource-rich nesting area is indispensable to the survival of the offspring (Hope et al., 2018). Seabirds that breed in colonies such as terns as well as gulls, exhibit territorial behavior in crowded nesting sites. Each couple risks out and defends a particular territory, guaranteeing informal access to food as well as other resources while minimizing the possibility of nest predators (Scopel & Diamond, 2017).

PARENTAL CARE

In many animals, parents dedicate time as well as energy to protecting their offspring against various predators, unfavorable weather as well as certain looming dangers (Grigoryeva et al., 2017). Furthermore, Table 2 provides an overview of different animals that display parental care actions. For example, in the animal kingdom of birds, raising along with protecting nests is a substantial aspect of parental care (Enos et al., 2023). Furthermore, amphibian's offspring may involve protecting their eggs that are placed in aquatic conditions. Besides, certain frogs preserve their eggs and make them moist to keep them from drying out (Schulte et al., 2020).

Parental care often involves more than just providing safety—it often involves providing nourishment. Many animals go to great lengths to guarantee that their offspring are fed well during the formative phases (Lucas et al., 2018). Mammals, characterized by viviparity, often engage in nursing as a prime form of parental care. Mother mammals produce milk, a rich source of nutrients, which they provide to their offspring. The act of nursing establishes a close bond between parents as well as offspring while ensuring the young receive the essential nutrients required for growth as well as development (Blackburn, 2015).

In the avian world, feeding performances take various forms. Birds may spew up partially digested food to feed their chicks, or they may actively quest to provide a consistent supply of nutrition. The delicate method of feeding involves not only the relocation of nutrients but also the transmission of decisive skills necessary for independent foraging.

Furthermore, mentoring, a behavior commonly associated with mammals, plays a substantial role in parental care. Parents invest time as well as attention in scrubbing, grooming, and maintaining the hygiene of their children. This not only contributes to the physical well-being of the young but also fosters communal bonding (Lovrić et al., 2020).

Among primates, grooming formalities serve as a form of parental care. In addition to keeping their children clean and free of parasites, parents properly groom their children. This conduct strengthens social ties within the family and gives the kids a sense of security and comfort (Simone-Finstrom, 2017; Kessler, 2020). Mammals, particularly those having long parent-child care periods, dynamically teach their young how to locate their food, environment as well as engage with the other members of the social group. Elephants, are well known for having intricate social systems, frequently teach their offsprings by assisting them in navigating the problems of the surrounding environment (Feldman, 2016; Uomini et al., 2020). Moreover, certain birds also exhibit informative behaviors. Parents are essential in teaching their children the complexities of vocalizations in the kingdom of songbirds. Intricate song transmission is frequently a taught practice that highlights the value of parental supervision in obtaining required assistance (Pouyat et al., 2015; Bartoszeck et al., 2018).

CONCLUSION

In conclusion this chapter provides a comprehensive overview of the noticeable connections between environmental science as well as behavior. It explores the evolutionary significance of behaviors designed by natural selection, emphasizing the integration of environmental as well as ethological perspectives. The discussion on hierarchy as well as dominance, communication as well as signaling, cooperation as well as altruism, territoriality, as well as parental care highlights the diverse strategies employed by animals to navigate their surroundings, ensure survival, as well as contribute to the environmental balance. This exploration not only enhances our understanding of animal behavior but also underscores the practical applications of negotiating ecology in various fields.

REFERENCES

Adams RM, RL Wells, SP Yanoviak et al., 2020. Interspecific eavesdropping on ant chemical communication. Frontiers in Ecology and Evolution 8:24. https://doi.org/10.3389/fevo.2020.00024

Akbar A & MU Ijaz, 2024. Pharmacotherapeutic potential of ginkgetin against polystyrene microplastics-instigated testicular toxicity in rats: A biochemical, spermatological, and histopathological assessment. Environmental Science and Pollution Research 31:9031-44. https://doi.org/10.1007/s11356-023-31662-7

Austin VI, AH Dalziell, NE Langmore et al., 2021. Avian vocalisations: The female perspective. Biological Reviews 96:1484-503. https://doi.org/10.1111/brv.12713

Barman E, 2017. The social bases of philanthropy. Annual Review of Sociology 43:271-90. https://doi.org/10.1146/annurev-soc-060116-053524

Bar-Tal D, E Halperin & J De Rivera, 2007. Collective emotions in conflict situations: Societal implications. Journal of Social Issues 63:441-60. https://doi.org/10.1111/j.1540-4560.2007.00518.x

Bartoszeck AB, W Vandrovieski, V Tratch et al., 2018. What do Brazilian school children know about birds in their country? European Journal of Educational Research 7:485-99. https://doi.org/10.12973/eu-jer.7.3.485

Birch J & S Okasha, 2015. Kin selection and its critics. BioScience 65:22-32. https://doi.org/10.1093/biosci/biu196

Blackburn DG, 2015. Evolution of vertebrate viviparity and specializations for fetal nutrition: A quantitative and qualitative analysis. Journal of Morphology 276:961-90. https://doi.org/10.1002/jmor.20272

Carter AJ, WE Feeney, HH Marshall et al., 2013. Animal personality: What are behavioural ecologists measuring? Biological Reviews 88:465-75. https://doi.org/10.1111/brv.12007

Carter GG, DR Farine, RJ Crisp et al., 2020. Development of new food-sharing relationships in vampire bats. Current Biology 30:1275-9. https://doi.org/10.1016/j.cub.2020.01.055

Chivers DP, MI McCormick, BJ Allan et al., 2016. At odds with the group: Changes in lateralization and escape performance reveal conformity and conflict in fish schools. Proceedings of the Royal Society B 283:20161127. https://doi.org/10.1098/rspb.2016.1127

Collier K, AN Radford, SW Townsend et al., 2017. Wild dwarf mongooses produce general alert and predator-specific alarm calls. Behavioral Ecology 28:1293-301. https://doi.org/10.1093/beheco/arx091

de Silva RC, A Prato, CA Oi et al., 2020. Dominance hierarchy, ovarian activity and cuticular hydrocarbons in the primitively eusocial wasp *Mischocyttarus cerberus* (Vespidae, Polistinae, Mischocyttarini). Journal of Chemical Ecology 46:835-44. https://doi.org/10.1007/s10886-020-01206-1

Decety J, IB Bartal, F Uzefovsky et al., 2016. Empathy as a driver of prosocial behaviour: Highly conserved neurobehavioural mechanisms across species. Philosophical Transactions of the Royal Society B 371:20150077. https://doi.org/10.1098/rstb.2015.0077

Demartsev V, AS Gersick, FH Jensen et al., 2023 Signalling in groups: New tools for the integration of animal communication and collective movement. Methods in Ecology and Evolution 14:1852-63. https://doi.org/10.1111/2041-210X.13939

Demko AD & DJ Mennill, 2018. Male and female signaling behavior varies seasonally during territorial interactions in a tropical songbird. Behavioral Ecology and Sociobiology 72:1-3. https://doi.org/10.1007/s00265-018-2495-5

Duncan C, D Gaynor, T Clutton-Brock et al., 2019. The evolution of indiscriminate altruism in a cooperatively breeding mammal. The American Naturalist 193:841-51. https://doi.org/10.1086/703113

Elbroch LM, M Levy, M Lubell et al., 2016. Adaptive social strategies in a solitary carnivore. Science Advances 3:1701218. https://doi.org/10.1126/sciadv.1701218

Enos JK, EB Smith, MP Ward et al., 20236. Increasing perceived predation risk through playbacks reduces red-winged blackbird abundance in agriculture late in the breeding season. Ornithological Applications 125:034. https://doi.org/10.1093/ornithapp/duad034

Feldman R, 2016. The neurobiology of mammalian parenting and the biosocial context of human caregiving. Hormones and Behavior 77:3-17. https://doi.org/10.1016/j.yhbeh.2015.10.001

Fröhlich M, C Sievers, SW Townsend et al., 2019. Multimodal communication and language origins: Integrating gestures and vocalizations. Biological Reviews 94:1809-29. https://doi.org/10.1111/brv.12535

Galbraith DA, SD Kocher, T Glenn et al., 2016. Testing the kinship theory of intragenomic conflict in honeybees (*Apis mellifera*). Proceedings of the National Academy of Sciences 113:1020-5. https://doi.org/10.1073/pnas.1516636113

Garandeau CF & AH Cillessen, 2006. From indirect aggression to invisible aggression: A conceptual view on bullying and peer group manipulation. Aggression and Violent Behavior 11:612-25. https://doi.org/10.1016/j.avb.2005.08.005

Grigoryeva A, 2017. Own gender, sibling's gender, parent's gender: The division of elderly parent care among adult children. American Sociological Review 82:116-46. https://doi.org/10.1177/0003122416686521

Grüter C & TJ Czaczkes, 2019. Communication in social insects and how it is shaped by individual experience. Animal Behaviour 151:207-15. https://doi.org/10.1016/j.anbehav.2019.01.027

Hayat MF, M Zohaib, MU Ijaz et al., 2024. Ameliorative potential of eriocitrin against cadmium instigated hepatotoxicity in rats via regulating Nrf2/keap1 pathway. Journal of Trace Elements in Medicine and Biology 84:127445. https://doi.org/10.1016/j.jtemb.2024.127445

Herbert-Read JE, 2016. Understanding how animal groups achieve coordinated movement. Journal of Experimental Biology 219:2971-83. https://doi.org/10.1242/jeb.129411

Hinsch M & J Komdeur, 2017. What do territory owners defend against? Proceedings of the Royal Society B 284:20162356. https://doi.org/10.1098/rspb.2016.2356

Hope SF, RA Kennamer, IT Moore et al., 2018. Incubation temperature influences the behavioral traits of a young precocial bird. Journal of Experimental Zoology 329:191-202. https://doi.org/10.1002/jez.2176

Jandt JM & DM Gordon. The behavioral ecology of variation in social insects. Current Opinion in Insect Science 15:40-4. https://doi.org/10.1016/j.cois.2016.02.012

Kamath A & AB Wesner, 2020. Animal territoriality, property and access: a collaborative exchange between animal behaviour and the social sciences. Animal Behaviour 164:233-9. https://doi.org/10.1016/j.anbehav.2019.12.009

Kaniasty K, 2020. Social support, interpersonal, and community dynamics following disasters caused by natural hazards. Current Opinion in Psychology 32:105-9. https://doi.org/10.1016/j.copsyc.2019.07.026

Kessler SE, 2020. Why care: Complex evolutionary history of human healthcare networks. Frontiers in Psychology 11:199. https://doi.org/10.3389/fpsyg.2020.00199

Kimber O, BL Gilby, CJ Henderson et al., 2020. The fox and the beach: Coastal landscape topography and urbanisation predict the distribution of carnivores at the edge of the sea. Global Ecology and Conservation 23:01071. https://doi.org/10.1016/j.gecco.2020.e01071

Kronfeld-Schor N & T Dayan, 2003. Partitioning of time as an ecological resource. Annual Review of Ecology, Evolution, and Systematics 34:153-81. https://doi.org/10.1146/annurev.ecolsys.34.011802.132435

Liénard P & P Boyer, 2006. Whence collective rituals? A cultural selection model of ritualized behavior. American Anthropologist 108:814-27. https://doi.org/10.1525/aa.2006.108.4.814

Lovrić R, N Farčić, Š Mikšić et al., 2020. Parental perception of changes in basic life needs of children with disabilities after six months of therapeutic horseback riding: A qualitative study. International Journal of Environmental Research and Public Health 17:1213. https://doi.org/10.3390/ijerph17041213

Lucas JE, LM Richter & B Daelmans, 2018. Care for Child Development: an intervention in support of responsive caregiving and early child development. Child: Care, Health and Development 44:41-9. https://doi.org/10.1111/cch.12544

Mattila HR, HG Kernen, GW Otis et al., 2021. Giant hornet (*Vespa soror*) attacks trigger frenetic antipredator signalling in honeybee (*Apis cerana*) colonies. Royal Society Open Science 8:211215. https://doi.org/10.1098/rsos.211215

Mitchell LJ, F Cortesi, NJ Marshall et al., 2023. Higher ultraviolet skin reflectance signals submissiveness in the anemonefish, *Amphiprion akindynos*. Behavioral Ecology 34:19-32. https://doi.org/10.1093/beheco/arac089

Mullen EK & GJ Thompson, 2015. Understanding honeybee worker self-sacrifice: A conceptual-empirical framework. Advances in Insect Physiology 48:325-54. https://doi.org/10.1016/bs.aiip.2014.12.002

Nettle D, MA Gibson, DW Lawson et al., 2013. Human behavioral ecology: current research and future prospects. Behavioral Ecology 24:1031-40. https://doi.org/10.1093/beheco/ars222

Owen-Smith N, JM Fryxell & EH Merrill, 2010. Foraging theory upscaled: The behavioural ecology of herbivore movement. Philosophical Transactions of the Royal Society B 365:2267-78. https://doi.org/10.1098/rstb.2010.0095

Pénitot A, D Schwarz, P Nguyen et al., 2021. Bidirectional interactions with humpback whale singer using concrete sound elements. Frontiers in Psychology 12:654314. https://doi.org/10.3389/fpsyg.2021.654314

Potvin DA, PW Crawford, SA MacDougall-Shackleton et al., 2015. Song repertoire size, not territory location, predicts reproductive success and territory tenure in a migratory songbird. Canadian Journal of Zoology 93:627-33. https://doi.org/10.1139/cjz-2015-0039

Pouyat RV, ID Yesilonis, M Dombos et al., 2015. A global comparison of surface soil characteristics across five cities: A test of the urban ecosystem convergence hypothesis. Soil Science 18:136-45. https://doi.org/10.1097/SS.0000000000000125

Prounis GS & AG Ophir, 2020. One cranium, two brains not yet introduced: Distinct but complementary views of the social brain. Neuroscience and Biobehavioral Reviews 108:231-45. https://doi.org/10.1016/j.neubiorev.2019.11.011

Roberts AI & SG Roberts, 2020. Communicative roots of complex sociality and cognition. Biological Reviews 95:51-73. https://doi.org/10.1111/brv.12553

Rose KA, JH Cowan Jr, KO Winemiller et al., 2001. Compensatory density dependence in fish populations: Importance, controversy, understanding and prognosis. Fish and Fisheries 2:293-327. https://doi.org/10.1046/j.1467-2960.2001.00056.x

Schmidt KA, SR Dall & JA Van Gils, 2010. The ecology of information: an overview on the ecological significance of making informed decisions. Oikos 119:304-16. https://doi.org/10.1111/j.1600-0706.2009.17573.x

Schulte LM, E Ringler, B Rojas et al., 2020. Developments in amphibian parental care research: History, present advances, and future perspectives. Herpetological Monographs 34:71-97. https://doi.org/10.1655/HERPMONOGRAPHS-D-19-00002.1

Scopel LC & AW Diamond, 2017. The case for lethal control of gulls on seabird colonies. The Journal of Wildlife Management 81:572-80. https://doi.org/10.1002/jwmg.21233

Seyfarth RM & DL Cheney, 2017. The origin of meaning in animal signals. Animal Behaviour 124:339-46. https://doi.org/10.1016/j.anbehav.2016.05.020

Shultziner D & A Dattner, 2016. The merits of self-handicap: The handicap principle as an explanation of altruism compared to reciprocal altruism. Cogent Biology 2:1140857. https://doi.org/10.1080/23312025.2016.1140857

Silk JB & BR House, 2016. The evolution of altruistic social preferences in human groups. Philosophical Transactions of the Royal Society B 371:20150097. https://doi.org/10.1098/rstb.2015.0097

Simone-Finstrom M, 2017. Social immunity and the superorganism: Behavioral defenses protecting honey bee colonies from pathogens and parasites. Bee World 94:21-9. https://doi.org/10.1080/0005772X.2017.1307800

Sng O, SL Neuberg, ME Varnum et al., 2018. The behavioral ecology of cultural psychological variation. Psychological review 125:714. https://doi.org/10.1037/rev0000104

Snijders L & M Naguib, 2017. Communication in animal social networks: a missing link? In: Advances in the Study of Behavior (Naguib M, J podos, LW simmons et al., eds): 49: 297-359. https://doi.org/10.1016/bs.asb.2017.02.004

Socias-Martínez L & PM Kappeler, 2019. Catalyzing transitions to sociality: Ecology builds on parental care. Frontiers in Ecology and Evolution 7:160. https://doi.org/10.3389/fevo.2019.00160

Tornero E, JF Sánchez-Romera, JJ Morosoli et al., 2018. Altruistic behavior among twins: Willingness to fight and self-sacrifice for their closest relatives. Human Nature 29:1-2. https://doi.org/10.1007/s12110-017-9304-0

Uomini N, J Fairlie, RD Gray et al., 2020. Extended parenting and the evolution of cognition. Philosophical Transactions of the Royal Society B 375:20190495. https://doi.org/10.1098/rstb.2019.0495

van der Borg JAM, MB Schilder, CM Vinke et al., 2015. Dominance in domestic dogs: A quantitative analysis of its behavioural measures. PLOS One 10:0133978. https://doi.org/10.1371/journal.pone.0133978

Van Leeuwen EJ, SE DeTroy, SP Kaufhold et al., 2021. Chimpanzees behave prosocially in a group-specific manner. Science Advances 7:7982. https://doi.org/10.1126/sciadv.abc7982

Wubs M, R Bshary, L Lehmann, 2018. A reinforcement learning model for grooming up the hierarchy in primates. Animal Behaviour 138:165-85. https://doi.org/10.1016/j.anbehav.2018.02.014