Reproductive Altruism in Honey Bees: A Theory to Understand Social Evolution

Simran Bhatia[1], Priyanka Rani[1]* and Vaishali
Ph.D. Students, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P., India
*Corresponding Author: priyankabhargava019@gmail.com

Source: Galbraith D. A. (2015)

Altruism refers to the selfless concern for the well-being and welfare of others, often at the expense of one's own interests or benefits. It involves acts of kindness, compassion, and generosity towards others without expecting anything in return. Altruistic behaviour can be observed across various species, including humans and animals. It can manifest in different forms, such as helping others in need, sharing resources, and sacrificing personal interests for the greater good. Similarly, reproductive altruism is a phenomenon observed in honey bees where certain individuals forgo their own reproductive opportunities to assist in the reproduction of their relatives. In a honey bee colony, there are three main types of bees: the queen, drones, and workers. The queen is the reproductive female in the colony and her primary role is to lay eggs. Drones are the male bees whose sole purpose is to mate with queens from other colonies. Workers are the sterile females who perform various tasks within the colony, including foraging, nursing the brood, and defending the hive. Honey bees demonstrate this idea as their entire social structure is based on preserving the community rather than the individual. Honey bees are classically considered one of the most selfless organisms, but it is not fair to say that all honey bees in a colony benefit equally from their social structure. Only female worker honey bees are truly selfless in a colony, as they do not reproduce and instead, invest their energy into the wellbeing of the colony. Workers in a honey bee colony exhibit reproductive altruism by suppressing their own reproduction and helping the queen to rear her offspring. They do not mate and do not lay eggs. This behaviour is known as worker sterility. It's important to note that the altruistic behaviour of worker bees in relation to egg-laying is just one aspect of their complex social structure and behaviour. Honey bees exhibit a wide range of cooperative behaviours within the colony, including food sharing, brood care, and defense, all of which contribute to the survival and success of the hive as a whole.

Altruism in egg-lying worker bees

Altruism is a concept that refers to selfless concern for the well-being and welfare of others. In the context of egg-lying worker bees, there are certain aspects of their behaviour that can be considered altruistic. In a honey bee colony, workers

engage in policing behaviour, selectively destroying eggs laid by other workers to maintain the queen's reproductive monopoly. However, in some rare cases, worker bees may lay eggs. This behaviour is known as "worker policing." When a worker bee lays an egg, it is usually an unfertilized egg that develops into a male bee or drone. Drones are the male bees whose primary purpose is to mate with the queen. The presence of worker-laid eggs can be detrimental to the colony because the resources needed to raise drones are wasted. The worker-laid eggs divert resources away from the production of worker bees, which are essential for the survival and functioning of the colony. Therefore, worker bees have developed mechanisms to suppress and remove worker-laid eggs in order to maintain the efficiency of the colony. In this context, the behaviour of worker bees can be seen as altruistic. By removing worker-laid eggs, they are sacrificing their potential reproductive opportunities to benefit the overall well-being and productivity of the colony. This behaviour can be considered selfless, as it helps maintain the harmony and functionality of the honey bee colony. This reproductive division of labour is a key characteristic of social insect colonies, including honey bees. Honey bee worker sterility is a result of complex social interactions and physiological factors. The queen produces a pheromone called queen mandibular pheromone (QMP), which inhibits the development of workers' ovaries and suppresses their reproductive capabilities. This behaviour is essential for the colony's survival and growth.

Source: Getty images

"Kin Selection Theory" and "Selfish Gene Theory"

Honey bees, despite their social hierarchy based on selflessness, still follow the "Selfish Gene theory". They exhibit altruism, which means they preform selfless actions that benefit others while decreasing their own fitness. This can lead to a worker honey bee foraging for food and providing it to the rest of the colony, benefiting other members of the population while reducing their own fitness. Kin selection, on the other hand, suggests that honey bees increase the inclusive fitness of the population by increasing the inclusive fitness of the population. This means that the genes of close family members are just as important as an organism's own genes for passing on, as they are not trying to benefit themselves but rather ensure the survival of their genes.

One prominent explanation is kin selection or inclusive fitness theory, proposed by biologist Hamilton (1963). According to this theory, individuals may exhibit altruistic behaviours towards their close relatives because they share genetic material. By helping relatives survive and reproduce, individuals indirectly promote the transmission of their own genes, even if they themselves do not directly reproduce. Queller (2003) model predicted that under queen less conditions in a honey bee colony, patrigenes promote selfish behaviour, while matrigenes promote altruistic behaviour, according to Galbraith (2015). Galbraith et al. (2016) investigated kin selection by examining the social behaviour of worker honey bees, which are all female. They found that the genes the workers

inherit from their queen (matrigenes) direct worker bees' altruistic behaviour, forgoing production of their own offspring to help rear their siblings. When the queen dies, the workers can begin to selfishly compete with one another to lay eggs. The genes they inherit from their different fathers (patrigenes) direct this behaviour.

Factors affecting altruism

Altruism in honey bees, specifically in the context of their social organization and division of labour, is primarily influenced by various factors. Some key factors that affect altruistic behaviour in honey bees are:

Genetic Relatedness: Honey bees exhibit a eusocial structure, characterized by a reproductive division of labour, where only a few individuals (queens) reproduce, while the majority (workers) help raise the brood and maintain the colony. The workers are often more closely related to their sisters than they would be to their own offspring. This high genetic relatedness enhances the evolutionary benefits of altruistic behaviour, as workers can increase the representation of their shared genes in future generations by supporting the reproduction of the queen.

Kin Selection: Altruism in honey bees can be explained by kin selection theory. Since workers are more closely related to their sisters, they can enhance their inclusive fitness by helping the queen produce more offspring. By doing so, they indirectly pass on a portion of their genetic material to the next generation, promoting the survival and reproductive success of their kin.

Chemical Signaling: Honey bees rely on chemical signals, specifically pheromones, to coordinate their activities and communicate within the colony. The queen bee produces pheromones that help regulate worker behaviour, suppress worker reproduction, and maintain colony cohesion. These chemical signals play a crucial role in shaping altruistic behaviour by influencing the workers' response to the queen's needs and the overall division of labour within the colony.

Environmental Conditions: The environment can also impact altruistic behaviour in honey bees. Factors such as resource availability, seasonality, and colony size can influence the division of labour and the extent of altruistic acts. For example, during times of abundant food resources, worker bees may allocate more resources toward the growth and reproduction of the colony, exhibiting heightened altruistic behaviour.

Age and Task Specialization: Honey bee workers transition through different tasks as they age, starting with tasks inside the hive, such as nursing brood, and progressing to tasks outside the hive, such as foraging for nectar and pollen. The allocation of workers to specific tasks is influenced by age-related physiological changes, pheromonal cues, and colony needs. Task specialization ensures efficient resource utilization within the colony and enhances the overall survival and productivity of the colony.

These factors interact and shape the altruistic behaviour observed in honey bees, contributing to the success and sustainability of their highly organized social structure.

Altruism as social evolution in honey bees

Altruism in honey bees is a prime example of social evolution, as it involves the evolution of traits that benefit the colony as a whole, even at the expense of individual reproduction. Social evolution refers to the process by which traits or behaviours that enhance the fitness of a social group or community are favoured by natural selection. In honey bee colonies, the reproductive division of labour is a key aspect of social evolution. The

majority of individuals in the colony, known as workers, forego their own reproduction and instead support the reproduction of a few individuals, particularly the queen. This altruistic behaviour benefits the colony as a whole, ensuring the survival and reproductive success of the queen and the overall productivity of the colony.

Genetic relatedness, therefore, plays a crucial role in the evolution of altruism in honey bees. The workers' sacrifice of their own reproductive potential is offset by the inclusive fitness benefits gained through the reproductive success of their genetically related sisters. Additionally, the social structure and organization of honey bee colonies, facilitated by pheromonal communication, division of labour, and cooperation, further promote the evolution of altruism. Through the coordinated efforts of individuals within the colony, resources are efficiently gathered, brood is cared for, and the survival of the colony is maximized. Overall, the social evolution of altruism in honey bees is driven by the inclusive fitness benefits gained through kin selection and the complex social structure that promotes cooperation and division of labour within the colony. These evolutionary mechanisms have led to the development of highly organized and successful honey bee societies.

Conclusion

In conclusion, reproductive altruism in honey bees is a remarkable phenomenon that demonstrates the intricacies of social evolution. The division of labour within a honey bee colony, where the majority of individuals (workers) forego their own reproduction to support the reproduction of a few individuals (queens), highlights the benefits of altruistic behaviour for the survival and productivity of the entire colony. This altruism is driven by the workers' high genetic relatedness to their sisters, promoting the propagation of their shared genes through indirect fitness benefits. The chemical signaling, environmental conditions, and task specialization further contribute to the development and maintenance of reproductive altruism in honey bees. The study of reproductive altruism in honey bees provides valuable insights into the evolution of social systems and cooperative behaviours, highlighting the intricate balance between individual and group fitness. By understanding the factors influencing reproductive altruism in honey bees, we gain a deeper understanding of the fascinating dynamics of social organization and cooperation in the natural world.

References

Galbraith DA. 2015. Epigenetic mechanisms mediating conflicts within social insect colonies.

Galbraith DA, Kocher SD, Glenn T, Albert I, Hunt GJ, Strassmann JE, Queller DC and Grozinger CM. 2016. Testing the kinship theory of intragenomic conflict in honey bees (Apis mellifera). *Proceedings of the National Academy of Sciences*, 113(4), pp.1020-1025.

Hamilton WD. 1963. The evolution of altruistic behaviour. *Am. Nat.* 97, 354–356.

Queller DC. 2003. Theory of genomic imprinting conflict in social insects. *BMC Evolutionary Biology*, 3(1), pp.1-23.

* * * * * * * * * * * * *