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**Selfish Genetics within Selfless Honey Bees**

        The emergence of life on Earth is estimated to have begun 3.8 billion years ago. Since then, all organisms have developed from simple organic molecules into the vastly complex creatures that exist today. Even though all organisms have diverged from one another, each having their unique set of characteristics, one thing still remains the same for all life-genes. An organism’s genes are the instructions that direct the structure, processes, and behaviors they exhibit. The goal of any organism’s genes is to survive for future generation of that species. Genes are selected within a population over time to increase that organism’s individual fitness. In order to increase one's fitness, being selfish may seem like the best way to go about it; however, this is not the case, as many organisms are selfless and express characteristics that decrease their own fitness. 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. Drones and queens are selfish in a colony because drones are always able to pass on one hundred percent of their genes and queens reproduce freely and do not contribute to the colony. Understanding which members of a population are selfless or selfish in honey bees can be used to help understand the social structures of organisms that share the same selfless behaviors, such as humans.

The behavior and reasoning for most biological processes is based on an organism’s genes. Organisms which are selfish and acquire the most nutrients, mates, and resources are likely to be the most fit in a population, meaning they have the highest chance of reproducing. The selfishness exhibited by an organism is not to benefit themselves, but rather benefit the survival of its genes. This idea is called Selfish Gene theory (Taylor). Honey bees on the surface may seem like they do not follow this as their entire social hierarchy is based on selflessness. Honey bees still follow the Selfish Gene theory as they express both altruism and kin selection.

Worker honey bees exhibit altruism, meaning they preform selfless actions that benefit another while decreasing their own fitness, by means of dividing labor and not reproducing (Seeley 20). When a worker honey bee forages for food and gives it to the rest of the colony, they are benefiting the other members of the population by providing food. This can hurt themselves as they spend energy foraging for food and possibly put themselves in harm's way. Kin selection is the idea that instead of an organism trying to increase their own fitness, they increase the inclusive fitness of the population (Seeley 22). This means that the genes of close family members are just as important as an organism's own genes for passing on because an organism is not trying to benefit themselves, but rather ensure the survival of their genes. Honey bees that express altruism and follow kin selection are trying to ensure the survival of the genes in a population rather than each member's own genetics, thus still following the Selfish Gene theory.

Genetics can be thought of as the language that connects all organisms together. All organisms contain the same molecules that make up DNA, with the only difference being the length and order of those molecules. Organisms differ in how they receive DNA from their parents. Honey bees reproduce sexually but vary in how drones, workers, and queen bees are produced. Female Honey bees contain 32 chromosomes and reproduce in a way that is similar to most of other reproducing animals (Lattorff and Moritz 642). Once a honey bee egg cell is fertilized by a sperm cell, it contains all 32 chromosomes, making it a diploid organism. Sixteen chromosomes come from an egg cell and pair up with each matching chromosome carried in the sperm cell. When a cell like an egg and sperm cell contains half the amount of genetic material, they are then considered haploid.

Drones, which are fully developed male honey bees, come from unfertilized eggs, making them haploid. Drones are considered haplodiploid, as they contain half the normal genetic material in a population (Lattorff and Moritz 642). Since drones arise from an unfertilized egg, they contain only genes from the queen bee. The only purpose of a drone in a colony is for reproduction. They do not provide any labor in a colony like worker bees. Being used only for reproduction and being haploid, a drone will always pass on all of its genetic material when reproducing. Since 16 chromosome come from a male and 16 chromosome come from a female for fertilization, a male gives all 16 of its chromosome making, it the most fit organism in honey bees, as one hundred percent of their genetic information will always be passed on.

Worker honey bees are sterile in colonies with a queen honey bee. Since worker honey bees do not reproduce in normal colony conditions, they have a fitness of zero, since their genetic information is not normally passed down. Drones, when compared to worker bees, are selfish, as they do not contribute to the colonie’s well being and are able to pass all of their genetic material. This is why when honey bees are referred to as selfless, drones should be excluded, since they work only to benefit their own genetics.

Queen honey bees, along with drones, are selfish in a hive and do not exhibit altruism. When a queen bee reproduces, a small fraction of her offspring develop into queen bees, depending on the environmental conditions. These daughter queens are of little value to the queen, as they lack the ability to produce wax, brood food, and pheromones for alarms that worker honey bees have and do not participate in hive activities, such as cleaning cells, tending the young and gathering food (Seeley 28). These queen daughters selfishly take up resources in the colony without giving anything back.

Even though workers do not reproduce in a colony and are considered sterile, workers still contain ovaries. These ovaries remain underdeveloped because the queen releases pheromones, like 9-oxo-decenoic acid, that suppress the development of worker’s ovaries (Lattorff and Moritz 646). Worker honey bees that are not continuously exposed to this pheromone will begin to develop ovaries and produce unfertilized male offspring because workers do not contain the necessary reproductive parts to mate. If workers can reproduce on their own, then why not reproduce in order to pass on their genes? Even though a queen honey bee emits pheromones to prevent this, occasionally honeybees will reproduce and these eggs are eaten by nursing worker honey bees. When worker honey bees are left without a queen, they are known to reproduce in place of the queen.

Queenless colonies are not regularly maintained by the pheromones given off by the queen. In a study done between scientists at the University of Illinois and Macquarie University, they tested whether or not altruism would persist by worker honey bees in queenless colonies. They predicted that due to kin selection, the degree of altruism should decrease because the relatedness between worker honey bees and their sister offspring is less than the relatedness to daughters of a queen. Having the majority of a population consisting of workers all being closely related is why kin selection works in favor of each member’s population genetics. But once workers start reproducing more, the genetic relatedness of the colony becomes more spread out. By examining both the foraging behavior and ovary activity, the study was able to determine that the level of altruism did not change significantly from normal queen colonies.

        The study examined honey bees’ foraging behavior along with their level of ovary activity. It was predicted that workers should prioritize raising their offspring over colony tasks as it offers a direct increase in fitness since worker honey bees are more related to their offspring then they are to their sisters.  The study took both forager and non forager honey bees from a queenless colony and dissected them to assess their level of ovary activity. When doing this, the study showed that there was no difference found between the ovary levels of honey bees that foraged and did not forage. This data shows that honey bees show the same level of altruism when raising their offspring. Honey bees still contribute to the wellbeing of the colony while producing offspring (Naeger et al. 1576). This data from the experiment further justifies that worker honey bees are truly selfless within a colony, even when they are able to reproduce and create offspring that can pass on their genes.

        Many organisms demonstrate some degree of altruism, but no single organism, except for humans, performs selfless acts purely for another organism’s benefit because altruism is a method of selflessly preserving an organism’s genes, and therefore holds some selfish intentions in it. Worker honey bees shown in the previous experiment, even when having the option to benefit themselves by raising their own kin, will continue to work towards the greater good of the colony, therefore showing true altruism.

The importance of narrowing down the statement that all honey bees are selfless to only worker honey bees can be applied to understanding and identifying members of a population that deviate from the normal. Researching this in honey bees can gives us a model for how we can predict other organisms to behave. Establishing models in biology is critical because many biological processes tend to repeat themselves if they are successful. The honey bee’s social system is successful and has occurred on its own several times throughout evolutionary history. This system is called eusociality. This system of organization contains altruism, reproductive division of labor, multiple generations living together, and cooperative brood care, meaning other members in a population take care of a mother’s offspring (Lattorff and Moritz 641). Developing a thorough understanding of eusociality in honey bees allows scientists to make predictions on behaviors of other organisms that demonstrate eusociality.

Eusociality, when considered in its general form, can be applied to humans. A family can consist of multiple generations living in a house together. Many households have shown reproductive division of labor, even though this is not the case for all families, where one person will take care of the children and while the other parent works. Families can include multiple generations living together in a house and can consist of members that are not reproducing, including children, who are to young to reproduce but old enough to help out with the family, people who are hired to help in a house, and women who are post menopausal that cannot bare children anymore but still help raise them. Most importantly, humans demonstrate extreme levels of altruism when selflessly helping people who we do not share our genetics with and not expecting anything in return. Studying honey bees and understanding their genetics not only helps understand other animals who show eusociality, but it also allows us to understand human behavior and social structure.

Not only can studying honey bees help to understand human social structure, but it is also important for our existence. Honey bees are a predominant pollinator and ensure the survival of crops. Without pollination from honey bees, crops would not be able to reproduce and yield the amount of food as they do now because of this society today relies on preserving honey bees. Even though agriculture today relies on honey bee pollination, humans are a danger to them. Humans have led to the near extinction of many organisms; honey bees are not safe from the increased use of pesticides and pollution. In order to protect honey bees from anthropogenic sources of pollution, understanding their behaviors and social structure can allow us to modify our pesticide practices in order to protect honey bees better.

Selfish Gene theory, which explains the behavior of honey bees, can also be applied to humans. Humans both demonstrate eusociality and altruism, similarly to honey bees, but at the same time are also selfish when using pesticides that pollute our environment and hurt other organisms, like honey bees. In examining and breaking down who is truly selfless in a population, it can be applied to how humans interact with each other. The human population just like honey bees contains selfish individuals, like queen bees that do not contribute to the wellbeing of the colony and reproduce freely, and drones who are able to pass on one hundred percent of their genetic information. In future research, humans should examine how the selfless behaviors exhibited by honey bees can be used in human society in order to preserve our selfless actions instead of our selfish ones.

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