

Eusociality

A simple yet effective organizing system in the animal society



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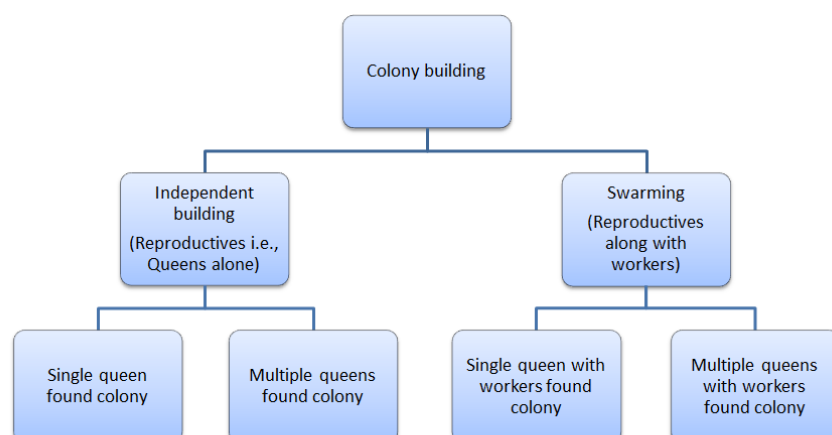
Overview

The general assumption is that humans are the most social beings in the animal society and are capable of building complex organizing systems. Well, there are other animal species that have a higher degree of organization and their organizing systems are more structured and granular as compared to the human society. Eusociality is the highest level of organization of animal sociality. Eusocial species is any colonial animal species that lives in multigenerational family collections in which the majority of individuals cooperate to assist relatively few or sometimes even a single reproductive member. Examples of eusocial animals are bees, ants, termites, wasps etc.

What Is Being Organized?

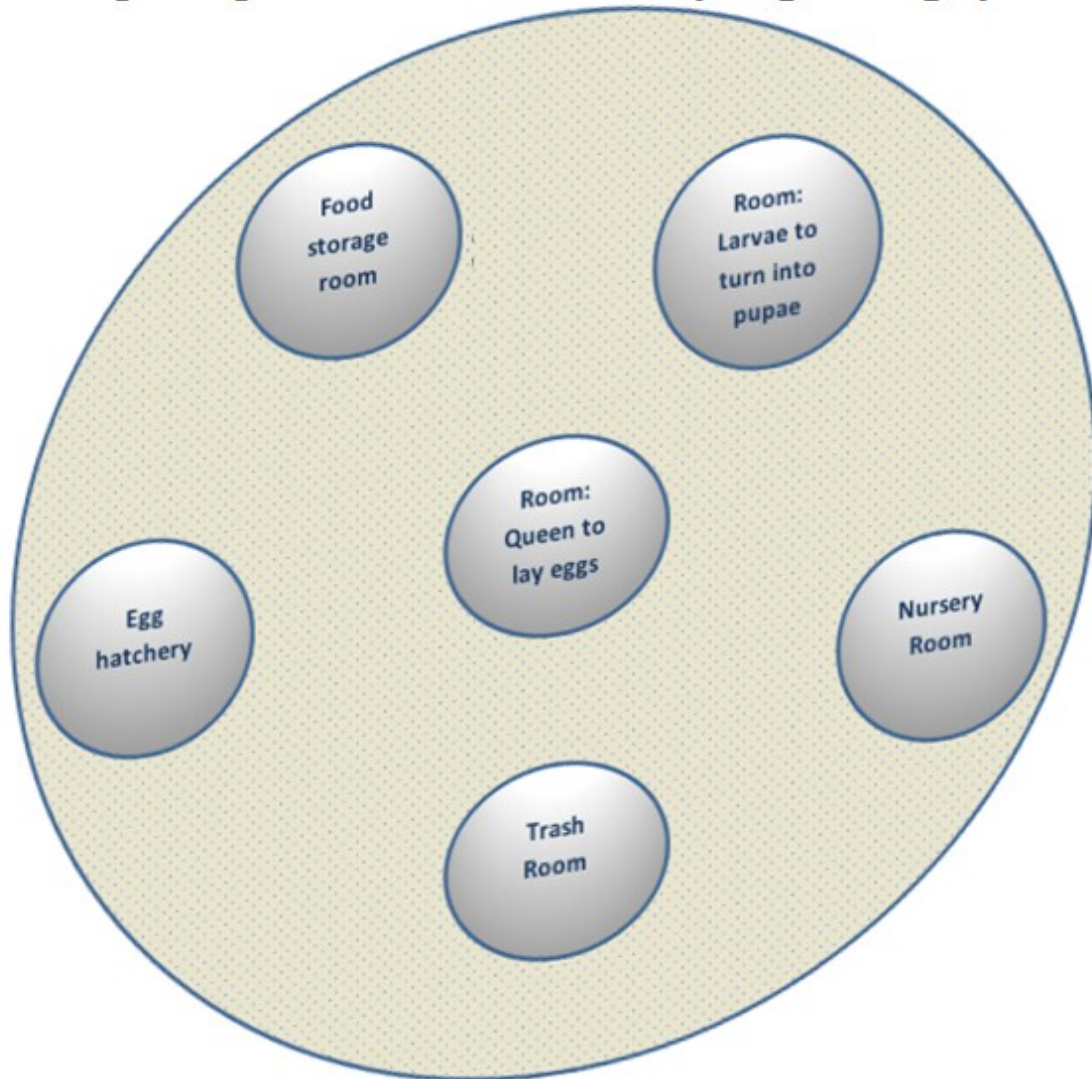
The organizing systems are the colonies of eusocial species consisting of parents, offsprings, siblings and extended families. The primary resources in the colony organizing system is the workforce, consisting of the animals or insects i.e., ants, bees, etc. These primary resources form intentional communities and act as agents to build colonies and also organize themselves in a flat organization structure to ensure the growth of their colony. A colony can thus be called a self-organizing system. Another main resource in these organizing systems is the food that is stored in the colony for the survival of the primary resources.

This intentional arrangement of eusocial species has been able to create value by optimizing and standardizing the principles of its operations and devising an organizing system that is simple and flat yet extremely effective where every primary resource also acts as an agent and strives towards the maintenance and expansion of the system i.e., growth of their species thus leading to creation of more colony organizing systems.



Ways of creation of a colony organizing system

A simple representation of a colony organizing system



There are multiple entrances into the colony and tunnels interconnecting the various rooms

Why Is It Being Organized?

The primary reason behind the design of this organizing system is in order to provide themselves with protection and an environment suitable for proliferation. Another important factor is that these resources, ants, bees and other eusocial species are inept individually and they are capable of solving complex organizational problems when working as a collection of resources. When highly orderly and optimal arrangements emerge from local interactions among ants, bees and other eusocial species, it is called “swarm intelligence.”

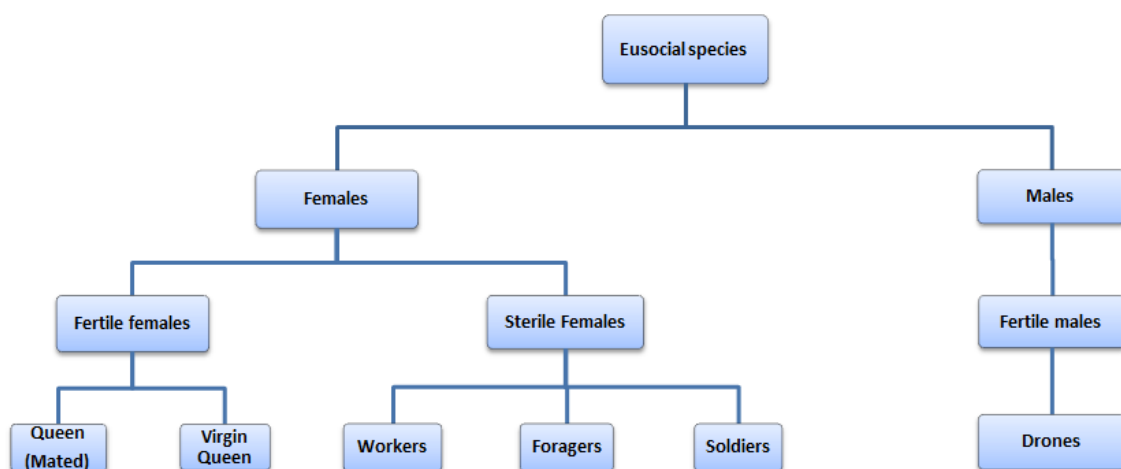
A colony organizing system can solve problems unthinkable for individual resources, such as finding the shortest path to the best sources of food, allocating workers to perform different

tasks, or defending a territory from predators. As individuals, ants or bees might be tiny dummies, but as colonies they respond quickly and effectively to their environment. The colonies themselves have a complex structure which can only be attained by working as a collection of resources. [An example of a complex ant colony: <https://youtu.be/d0e-q5MHwNQ> : Timestamps 0:48 to 2:12 and 2:47 to 2:55]

How Much Is It Being Organized?

The colony organizing system is well-defined, structured and ecologically sustainable. There are three main organizing principles of eusociality that distinguishes it from organizing amongst other animals. On a high level, they are i) cooperative brood care where the individuals often feed and care for offsprings that are not their own, ii) overlapping generations within a colony of adults where the older generation trains the younger generation to maintain colonies and iii) presence of a definite caste system and excellent division of labour into reproductive and non-reproductive groups.

The categorization system in a eusocial animal colony is a caste system and the different castes can be considered as institutional categories as there are specific standards that enable classification of these animals into castes. The various castes, mainly, queen, drone and worker are determined using intrinsic properties such as anatomical or morphological properties of the resources i.e., the gender of the resource, body size, whether it is fertile or sterile, has wings or not etc. These intrinsic properties in turn influence the extrinsic property that is the functional capabilities of the resource.



Taxonomy of a eusocial species

When Is It Being Organized?

The colony in itself is an emergent organizing system where the resources collectively build, maintain and improve the structure as new requirements arise. The organizing of the resources within the colonies happens mostly “on the way in”. Each resource at birth is classified into different categories – the castes.

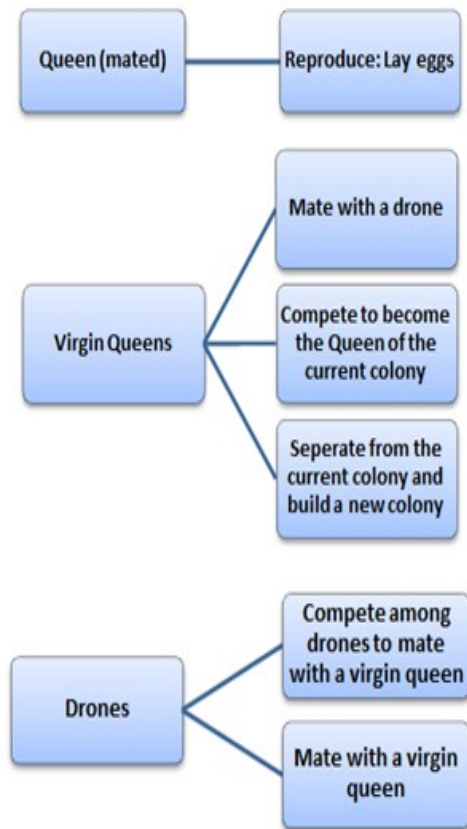
There are some exceptions to this rule. For example, in some ant colonies there are two categories under sterile females, workers and soldiers. If there is a resource crunch in the workers category, ants from the soldiers category are moved into the workers category.

How (or by Whom) Is It Organized?

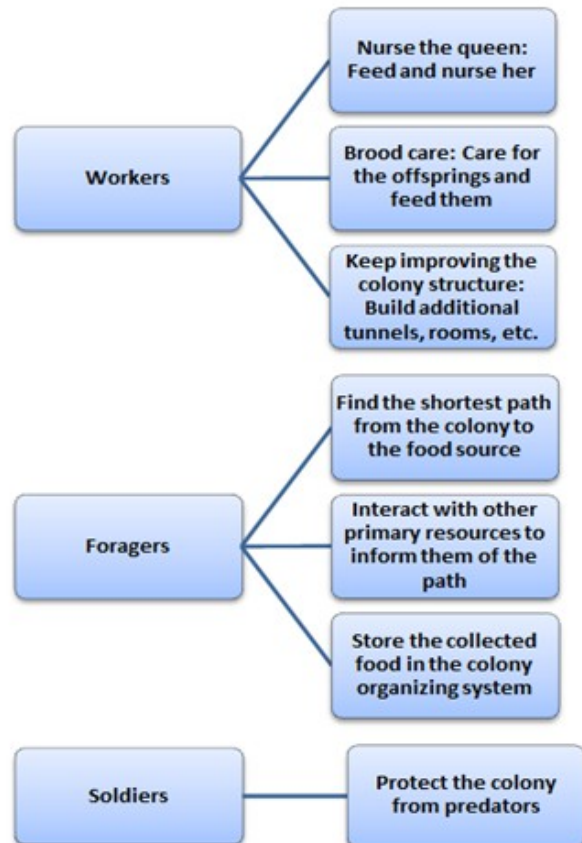
The key to the success of a colony is its flat organization structure, continuous evolution and the fact that there is no top-down intentionality in its creation. It emerges over time via collective behaviour without central control where decisions are made by primary resources (bees or ants) that act as agents and they intentionally create traces. The colony and its path systems are thus an emergent organization where ants and bees follow and reinforce the paths taken by their predecessors.

Further, the classification of resources into castes is determined by the resource properties. A fertile winged female who has mated is the Queen of the colony, fertile winged females who have not mated are virgin queens and are competitors for the Queen position in the future, a fertile winged male is a drone, and sterile females with no wings are workers, soldiers and foragers. Most of the interactions within the colony are by the sterile females who collect and store food resources, perform brood care, nurse the queen, maintain and improve the colony, and protect it from predators. The only interaction of a drone is mating with a virgin queen and that of a mated queen is laying eggs.

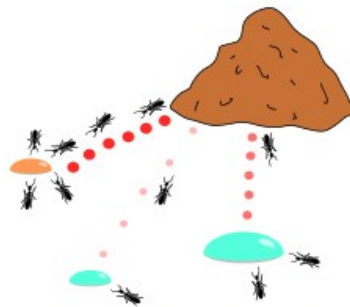
Reproductive labour



Non-reproductive labour



Various interactions supported by the colony organizing system



Interactions among ants using path trails from colony to indicate the nearest source of food



round dance



waggle dance

Interactions among bees at the entrance of the colony using dance to indicate the nearest source of food

Where Is It Being Organized?

The physical location where the eusocial species decide to build a colony system is carefully chosen by taking various factors into consideration: climatic conditions, safety from predators, room for storing food and potentially expanding the colony, etc.

For example, when investigating a potential site for new colony system, bees carefully check the cavity to ensure it meets certain specifications. The cavity must be large enough to hold a volume of not less than about six and a half gallons. It must have a small entrance that has a maximum diameter of about one and a half inches that lies near the base to facilitate waste removal. Finally, it should be south facing for warmth and lie high enough off the ground to protect against predators.

Other considerations

Eusocial species are being studied at large to understand how their organizing principles can be incorporated in global organizations and businesses run by humans to create flat organizing systems and achieve success rates of the same magnitude as these animals do in their colonies. Also, there are complex algorithms, namely, ant colony optimization and bee colony optimization that are created by studying the organizing principles and interactions of the ants and bees within and outside their colonies. The applications of these algorithms are in water resource management, travelling salesman problem, traffic sensors location problem on highways, spam host detection, network design, etc. It is fascinating to learn that the organizing principles of eusocial species are helpful in solving such complex issues of human society.

The evolution of the categorization and classification structure of the colony organizing system among eusocial species

In the colony organizing system of eusocial species, some animals are sterile. They don't have the capability to pass on their genes to the next generation. How did these categories evolve in these species and persist? According to Darwin's theory, since these animals do not breed, their fitness should be zero and any genes causing such a condition should be eliminated from the population immediately.

Haplodiploidy determines the sex in all members of the insects such as bees, ants, etc. In this system, sex is determined by the number of sets of chromosomes an individual receives. An offspring formed from the union of a sperm and an egg (fertilized egg) develops as a female and an unfertilized egg develops as a male. This means that males do not have fathers and have only half the number of chromosomes that a female has and hence are haploid.

The haplodiploid sex-determination system has a lot of peculiarities. The most important one is that the relatedness between the sisters of worker species in a colony system is 0.75. This means that relationship among worker sisters is significantly more as compared to siblings in other sex determination systems which are diploid. It is this point which drives the kin selection theory of how eusociality evolved.

	Mother	Father	Daughter	Son	Sister	Brother
Haplodiploid						
Female	50%	50%	50%	50%	75%	25%
Male	100%	0%	100%	0%	50%	50%
Diploid						
Female	50%	50%	50%	50%	50%	50%
Male	50%	50%	50%	50%	50%	50%

Table: Shared gene proportions in sex-determination systems

The worker sisters sharing nearly 75% of the genes are termed as "supersisters". If they reproduce, they would share only half of their genome with their offspring. Thus, they can pass on more genes by caring for sisters than they would by having their own offspring. This unusual situation explains why eusociality evolved among ants and bees and there was division of labour into reproductive and non-reproductive groups.

In a colony with a single breeder, the queen, and many workers, the evolutionary stability is achieved by each individual resource investing all their energy in helping the collection. This helps explain why some of the castes in eusocial species give up their reproductive capability and strive towards the expansion of the colony system.