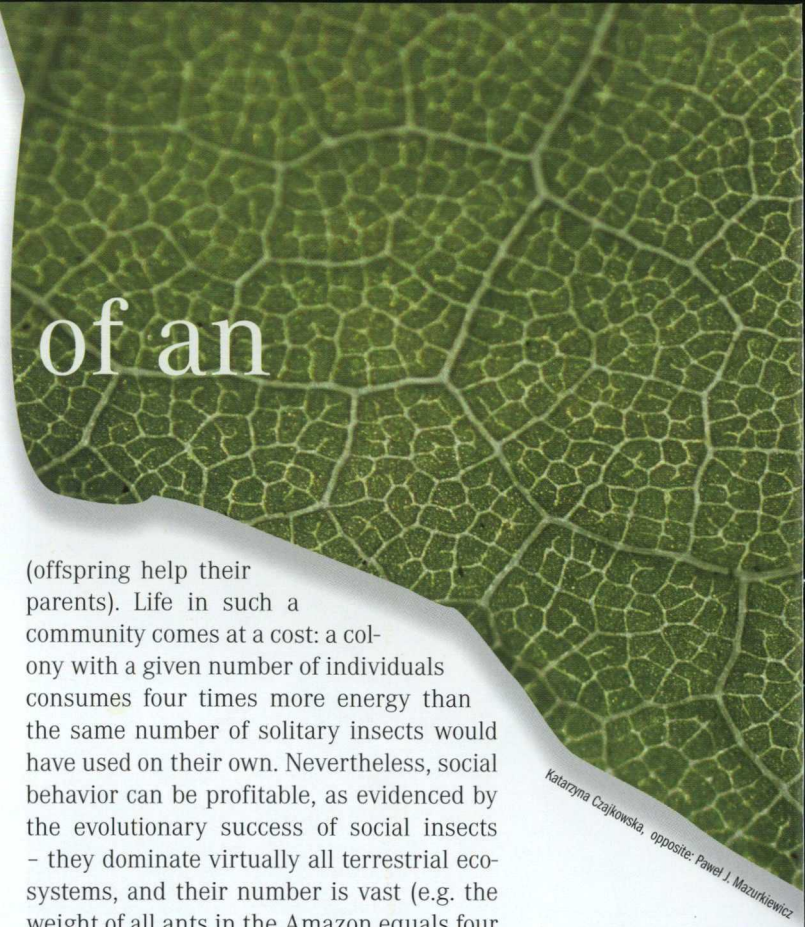
Eusocial insects

The Social Life of an Individual Ant

PAWEŁ J. MAZURKIEWICZ
College of Inter-faculty Individual Studies in Mathematics and Natural Sciences
University of Warsaw

Paweł J. Mazurkiewicz, a psychologist and biologist, is pursuing an interdisciplinary doctoral thesis at the Laboratory of Ethology, Department of Neurophysiology, Nencki Institute of Experimental Biology, Polish Academy of Sciences, and at the Department of Animal Physiology, Faculty of Biology, University of Warsaw. He is examining the factors influencing the development of aggressive behavior in ants. He is the winner of the Foundation for Polish Science SKILLS-eNgage competition and popularizes ethological studies among school children and university students.



Katarzyna Czajkowska, opposite: Paweł J. Mazurkiewicz

Termites, wasps, bees, certain aphids, thrips, beetles... and of course ants. Some species of the rich and diverse world of insects, rather than living alone, have instead developed communities of various kinds. But should a group of such eusocial insects, ranging in size from a few hundreds to many millions of individuals, still be considered a set of distinct individuals, or rather a kind of superorganism?

There is no strict dichotomy between solitary insects and social insects. Depending on the degree of social structure, various intermediate forms can be distinguished, including "subsocial" insects, which only care for their offspring (e.g. some cockroaches). The most advanced form of social life has been attained by the truly social (or "eusocial") insects. They are distinguished by three factors: 1) individuals from the same colony cooperate in the care of offspring, 2) there is a reproductive division of labor based on infertile or less fertile individuals performing duties for the brood of more prolific individuals, and 3) the colonies host individuals from different generations (offspring help their parents). Life in such a community comes at a cost: a colony with a given number of individuals consumes four times more energy than the same number of solitary insects would have used on their own. Nevertheless, social behavior can be profitable, as evidenced by the evolutionary success of social insects – they dominate virtually all terrestrial ecosystems, and their number is vast (e.g. the weight of all ants in the Amazon equals four times the weight of all vertebrate animals living there).

Labor

One of the main pillars of eusocial communities is cooperation based on division of labor in colonies. More fertile individuals (queens and males) live together with less fertile individuals (workers), who care for the brood and perform various other tasks. The manner in which jobs are assigned is not accidental. Some ants are polymorphic, which means that there is a significant difference in body size and proportions among workers of the same colony. Workers belong to different "morphological castes" and are highly suited to performing specific functions. For example, workers with large extended heads and strong mandibles are called "soldiers" and are specialized in performing defensive functions. In most species, however, workers are monomorphic, i.e. they do not differ significantly from each other in terms of size and proportions of various parts of the body. However, in both polymorphic and monomorphic species, duties in the colony are substantially affected by the worker's age.

In the course of development of ant and other social insect workers we can notice specific changes in their behavior. Young workers – "nurses" – engage in duties within the nest, such as caring for offspring or the queen, and it is not until they get older that

From a lonesome ant to the heart of a new colony: this young queen ant of the carpenter ant species *Camponotus herculaneus* is surrounded by the first generation of her worker-daughters. In time, they will increase in number. This is an early stage in an experimental colony at the Laboratory of Ethology, Nencki Institute of Experimental Biology, Polish Academy of Sciences

they proceed to fulfill more dangerous tasks outside the nest, such as collecting food or nesting material. At that moment they are referred to as "foragers." The oldest workers defend territory, fight wars, and act as scouts.

Interestingly, the course of behavioral development in social insects can be strongly modified by the social context: the process of transition between certain stages may be accelerated, delayed or even reversed, i.e. old foragers may return to acting as nurses. This process has best been studied mostly in honeybees.

A society of such insects thus seems to constitute a precisely functioning superorganism. However, in many ant species a significant proportion of workers do not actually do any work, a fact that calls into question the sense of the phrase "busy as an ant."

Sacrifice

There are cases where single individuals – workers or queens – act in an unconventional way, deviating from the behavior of the general population. There are spectacular examples documenting how single individuals were able to sacrifice their lives for their colony. Every evening the nests of *Forelius pusillus* ants must be closed from the outside to protect the ants from cold and predators. This task is taken on by the oldest individuals in the colony. By closing the nest, those old workers are in fact committing suicide, because they have no chance of survival outside the nest. In fact, they are not only protecting their community, but also saving work of other workers, because in a few days they would probably have been dead anyway and it would be necessary to carry them to the waste area. It is difficult to say whether these ants are making some kind of conscious decision (how could they possibly be able to foresee the consequences of their actions?) or whether their behavior simply results from the physiological modifications occurring in aged workers.

Another case of such behavior is seen in carpenter ants of the species *Camponotus saundersi*. When faced with overwhelming numbers of enemy workers, they can tense

the muscles around a container of poisonous substance inside their bodies and explode, splattering the surrounding enemies with it. In this way, one "suicide bomber" ant can kill dozens of aggressors. Termites of the species *Neocapritermes taracua* behave similarly during fights against ants.

In these cases we are dealing with a situation when one ant dies, so that many of its fellows can survive. But sometimes the altruistic actions of one ant may focus on helping another, single worker. This would seem to run counter to the economy of the colony, where a single worker is like a single cell in the overall organism. A team at the Laboratory of Ethology of the Nencki Institute of Experimental Biology has studied ant rescue behavior, i.e. ants assisting single individuals who find themselves in a dangerous situation. In 2002, Wojciech Czechowski, Ewa J. Godzińska and Marek Kozłowski released a study which triggered great worldwide interest in this issue. They found that when an ant fell into the funnel of an antlion larva - an insect that feeds on ants - in many cases other workers would actually come to its rescue and try to get it out of the trap.

Solitariness

It is frequently assumed that all species of ants are social insects. This raises the question of how an individual worker will function when separated from the colony. Total solitude is certainly highly stressful for ants, as it significantly shortens the lifespan of even young workers. Interestingly, the presence of even one more worker significantly prolongs it. Research on solitariness in ants conducted at the Laboratory of Ethology clearly shows that in the vast majority of cases a solitary worker is indeed much like a cell separated from its parent body.

However, there is a certain moment in the life of individual ants, when they have only themselves to rely on, and it is not only their own life that matters. This applies to queen ants in the period after their mating flight, when fertilized queens land on the earth, lose their wings, and start searching for a place for themselves. In species that form polygynous nests (those in which many queens coexist), some of the queens may return to their home nest, while others may be adopted by other nests of the same species. A young queen might also be adopted by an orphaned colony, even if it belongs to a different species. However, in cases where a queen finds a new colony, she must choose an appropriate location, lay eggs, and care for the first larvae and pupae, which only after some time will turn into workers, able to take over the responsibilities of caring for offspring and for their queen, who becomes dependent on their care.

Another interesting case of solitariness can be found in certain species that do not produce workers at all. As an example, *Anergates atratulus*, ant species found in Poland, only has queens and males. However, even these ants cannot live without the presence of other ants. The queen of *A. atratulus* is a social parasite that lives in the nests of ants of the genus *Tetramorium* and takes advantage of their "hospitality."

Autonomy

In view of these findings, it seems fair to conclude that ants are individuals partially deprived of a separate, autonomous identity, with limited self-existence when separated from the colony. However, treating anthills as a superorganism - something more than just the sum of individuals - does not rule out looking at each worker as a separate, independent entity. Intriguingly, individual differences have been noted in the behavior of workers, e.g. not all of them will make efforts to rescue their fellows in danger. Similarly, only some foragers will revert to being nurses. We do not yet know what gives rise to such differences. ■

Further reading:

Godzińska E.J. (2007). Owady społeczne: mity i fakty [Social Insects: Myths and Facts]. *Kosmos 56*, 371-381.

Hölldobler B., Wilson E.O. (1994). *Journey to the Ants: A Story of Scientific Exploration*. Belknap.

Hölldobler B., Wilson E.O. (2009). *The superorganism*. New York: W.W. Norton.

Tofilski A. (2008). Mechanizmy współdziałania i rozwiązywania konfliktów u owadów społecznych [Mechanisms of Collaboration and Conflict-Resolution in Social Animals]. *Kosmos 57*, 343-350.

Wnuk A., Godzińska E.J. (2006). Wpływ izolacji społecznej na fizjologię i zachowanie się mrówek [The Impact of Social Isolation on the Physiology and Behavior of Ants]. *Kosmos 55*, 177-196.