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BIOSEMIOTIC DIMENSIONS OF COLONIAL ANIMALS

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Colonial animals form a functional entity which frequently behaves like a superorganism. In the case in which the individuals of a colony are physically related among them, their morphofunctional differentiation may occur, so that some of them become compatible with the organs of some pluricellular individuals. Morpho-functional differentiation occurs, too, within colonies in which the individuals are not physically connected among them. Thus, in the case of social insects (ants, white ants, bees, wasps, etc.), the colonies are differentiated into castes while, for a much more extended labour division, the phenomenon of polyetism (within which the individuals – according, to their age -, develop certain activities) is also to be observed.
Individuals' morpho-functional differentiation and the coordination of their activities within the colonies cannot be developed without a permanent dialogue. In our opinion, the semiotic dialogue is an essential condition of colonial life, contributing to the understanding of colonial animals' semiotic dimensions.

Introduction

According to **Edward O. Wilson** (1980), "the term of colony refers to the fact that its members are either physically united or differentiated in reproductive and sterile castes, which have both characteristics".

Consequently, a colony may be formed, too, of not physically related among them individuals. However, their differentiation and the formation of some castes are necessary. The society thus formed may be so well organized that it behaves like a superorganism. In such situation, social insects represent real colonies; they may form a society that works as a superorganism. However, what should one mean by social or eusocial animals? Citing again **Edward O. Wilson,** social organisms are characterized by the common possession of three characteristics, as follows:

"- individuals of the same species cooperate in taking care of the nestlings;

- a productive labour division is working, involving more or less sterile individuals, that act on behalf of the nest fecund partners;

- a superposition's of at least two generations of the life stages is to be noticed, capable of contributing to the colony's activities, so that the progeny helps the parents during a certain period of their life".

To such conditions there respond the social insects belonging to the groups of ants, white ants, bees and some of the wasps.

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In these cases, the colonies generated by a queen (sometimes, even a small group of queens) – are divided into castes, that any be of workers and/or soldiers. In superior ants, a temporary polyetism, similar to that of ants had been developed (i.e., the workers execute works according to their age, in the absence of any morphological differentiations).

In heteronomous colonial animals, where the individuals are physically united among them, individuals' differentiation is so ample that no similarity is possible. They play different, well-established parts, behaving like organs of a whole organism or superorganism.

In the case of hydrozoa and syphonophoa, no castes are present, although the individuals – differentiated as to the presence or absence of the reproduction function - depend on one another along their life cycle, all depending by the whole, the whole depending on each individual. Labour division being perfectly achieved, all individuals participate to the realization of the whole's programs.

Social animals form a functional whole. From the moment in which several individuals are associating for living together, they should participate to the accomplishment of the whole's programs (i.e., to the optimum functioning of the society). Labour division requires individuals' morphofunctional differentiation. The fact that, compulsorily, the reproduction function is not fulfilled by all individuals any more, induces a first differentiation, solved – apparently, in the simplest possible manner – by the modification of the somatic formula. From the beginning, two categories of individuals are differentiated within the society: the reproductive and the sterile ones. The latter ones should execute different works. If the activities are so much differentiated among them that not all individuals are capable to execute them, then morphofunctional differentiations occur. The soldiers or the fighters – that should necessarily be stronger – will be bigger and provided with more efficient weapons (very strong mandibles, the head proportional to the mandibles and to the effort required from their part). If the workers' charges are different, then their dimensions are also different, even if they belong to the same family. For example, in the *Formicoxenus nitidulus* species, besides the male, female and semifemale (semiworker), other 4 categories of workers – with dimensions varying between 1.5 and 3 – are present. If some living reservoirs are needed for food, then some of the workers will fulfill this function. They will have an enormous belly. In the *Proformica nasuta* species – which is a mellipherous species – the honey deposited by a worker may feed some hundreds of working ants for almost a week.

If the works to be executed are not so difficult that they may be made by any worker, then these should not be differentiated – either morphologically or by their dimensions. Nevertheless, as already mentioned, the phenomenon of polyetism appears. The workers perform successive works, as a function of their age. If, nevertheless, under certain circumstances, the fulfillment of activities – already passed beyond by some workers – is required, they will return and will execute the respective works.

The castes and the polyetism open large perspectives in work's distribution, while specialization on a certain direction becomes almost a profession. In the absence of some specialized professionals, a society cannot work properly. The above-mentioned aspects lead to the differentiation of some individuals from heteronomons colonies – where the partners are physically linked among them -, which act as organs. Individuals' differentiation within the social organisms is similar to the existence of organs.

If crawfishes and scorpions have strong claws, for both attack and defense, in social insects such organs are represented by soldiers' caste. They assure protection, they are mobile, coordinating their actions so that to defend the colony. If the target refers to the food reservoirs – that should not be altered or lost, remaining yet available to the workers – then such "organs" do appear. The honey-bearing ants fulfill ideally the double function of reservoir and fodders. In the case of *Myrmecocystus chortideorum*, the foddering ant has such an enormous belly, that it cannot move anymore. It hangs on the ceiling, distributing food to the others. On one side, these foddering ants are fed, on the other, they feed other workers.

Labour division covers all the necessities in the colony. A careful analysis of a colony's life would evidence no fissure in its functioning. More than that, its organization is so perfect that the relations among castes and between the forms of polyetism are balanced as a function of the colony's condition. A certain type of relations occurs in "peace" times, and another one when a predatory expedition is prepared, or when, in the colony's life, major modifications – induced by certain factors – are produced.

How do such things happen? Which are the mechanisms permitting such an organization and functioning? For a thorough understanding of the situation, a semiotic analysis of colonies' organization - that is, of the social life's organization – should be necessarily developed. In the absence of the communication among individuals, and also in the absence of coordination – according to the program of the whole – no association among individuals is possible.

Biosemiotic dimensions of insect colonies

As biologists, the authors of the study understand perfectly that one cannot talk of life, of the existence of a living being, in the absence of its communication with the peristasis, with the cosmic ocean. Communication is developing exclusively through signals, no matter which their origin is. They are emitted by certain structures, being received and dechiphered by other structures.

The branch of science that studies the signals and their deciphering in the living structures is biosemiotics. That is to say that biosemiotics studies the function of signals and of symbols in the human and non-human communication.

Jacob von Uexküll introduced the notion of umwelt, for defining the universe that surrounds us, in the form we perceive it. Consequently, each being has an **Umwelt** of its own, as each one should perceive one's universe. For entering the umwelt, an object should be first discovered and then some of its characteristic should be grasped.

Starting from the ideas of **Uexküll, Konrad Lorenz** created a new science, ethology – i.e., the science of behavior. **A. Sebeok** observed that each animal dialogize with the environment, considering that ethology "is nothing also but a special case of semiotics"; consequently, he created the term of zoosemiotics.

Biosemiotics found out that communication is present at all levels in nature or, one of life's characteristic is exactly the capacity of emitting and deciphering signals. In its simplest form, the semiotic discourse appeared concomitantly with the process that generated living beings.

This means that the individuals of a species do not live insolatedly, but, on the contrary, in a tight semiotic interaction; in their turn, the species are also existing within such an interaction. It is therefore quite normal that the signals transmitted by an individual or by a species to be received and interpreted by other individuals or other species. In this way, an ecosemiotic discourse – with vital significance for both individuals and species – may be developed.

Jesper Hoffmeyer draws the attention – in presenting his principles on biosemiotics – that "it is the signals, and not the molecules, that represent basic units in the study of life". There results from here that it is mainly not the structure, but the signal's quality and significance that is of major importance in vital phenomena.

Organisms represent pattern builders. They form their models as a function of the extent to which they know reality. They emit and receive patterns with a certain significance for their whole life. The pattern does not represent a sum of structures, but a complex of signals with vital significance, present in the organism.

The same **Jesper Hoffmeyer** asserts that "the living organism is a swarm"; this law of **Hoffmeyer** is capital for underst anding the structure and functionality of pluricellular organisms and, consequently, of colonial structures. The pluricellular organism is not simply a sum of cells.

These cells are tightly connected among them, and are reciprocally informing one another. They communicate, take actions and unite their efforts for assuring functioning of the whole. The same holds time for the individuals in a colony, be they physically united among them or not.

Cells' or – in the case of complex organisms – individuals' differentiation granted their high capacity of transmitting and receiving information (in a biosemiotic dialogue), so that the whole organism manipulates as large as possible parts of the environment – in both space and time – thus favourizing – according to the ideas of **Uexkül –** the largement of the so-called Umwelt.

The connection among the individuals of a colony may be accomplished through a multitude of signals, that may be of chemical, tactile, visual, acoustic, electrical etc., nature.

It is not impossible that the feromones – acting as chemical substances involved in the communication among the individuals of the same species – had been the first signals utilized by the living structures. Feromones should have circulated among procaryotes' ancestral cells. From the moment in which the first pluricell - organisms – characteristic for metazoa - started to be formed, the hormones substituted feromones in the establishment of intercellular links. Form the moment in which the first photosensible formations appeared, the communication means became larger and larger.

The acoustic receivers provided new ways of communication, much more subtle and much richer. However, the appearance of a new signaling system does not automatically exclude the other ones, as no biosemiotic system of communication is obsolete. Thus, chemical communication in the living structures is universal. More than that, chemical communication is applicable, as well, among different species, especially among those involved in a symbiotic living together.

W.L. Brown and **Thomas Eisner** proposed the term of alomones, for defining interspecific chemical signals. The chemical substances may be transmitted in all media, in either dark or light, in the vicinity or at considerable distances. It is accepted the idea that less than a microorganism of a feromone may persist as a signal for hour or days, over distances of hundreds or thousands meters. Their synthesis is quite a simple process, while their spreading raises no problems.

Once more, feromones act ideally in the communication among microorganisms, too. Nevertheless, it is known that each signal should be received and decoded. Each signal represents a piece of information, which may have vital functions. That is why, some special receivers are needed, once known that such signals are not addressing all living beings; on the contrary, they are selective, even strictly selective.

One of the shortcomings characterizing chemical communication is its slow propagation rate. Instead, its persistence in the environment is considerable. Feromones cannot be modulated in frequencies, nor can they be variable in intensity and time. Instead, one and the same species may emit a multitude of feromones, as due to the numerous types of glands it possesses.

Some mammals have up to seven modalities of synthesizing and emitting feromones, while the bees and the ants may have more than 10 exocrine glands which emit feromones involved in social organization.

Thus, a bee possesses hypopharyngeal, labial, genal glands, the Nanasov, the Kaschevnikov gland, etc. Their functions are different, as follows: honey comb's cleaning, dissolution, digestion, honey comb's building, larvae feeding, queen's taking after, control of the colony, etc.

Chemical communication is supported by the tactile one. The latter is essential for colonial forms. Ants communicate easily among them simply by touching their antennae. The "password of crossed antennae" becomes extremely efficient in the inter/ individual relations, in different situations, such as: orientation, gathering, food signaling, signaling out of a peril, investigation, feeding, conciliation, parents-nestlings relations, etc. In the case of aphides, tactile communication causes the appearance of winged forms. Also, tactile communication is indispensable to gregarious locusts in organizing their migration. The quite numerous activities developed in an anthill and, equally, the activities of food gathering and processing are based on tactile communications.

Visual communication is operating, no doubt, only in conditions of light. However, the eyes of certain insects may be so highly perfected in a certain direction that orientation may be made by sun or by stars. Some ants may see the stars even in the daylight.

The communication possibilities among individuals are multiple. It goes beyond saying that any society formed of individuals is based on principles of communication and of dialogue among the partners. A colony is not a simple sum of individuals, it is a functional whole. Any structure is more than the sum of its component parts, as it acquires some additional characteristics, while its compounding clements loose some of their own characteristics. Being part of a colony, its individuals may loose part of their independence, coming to depend on both one another and on the whole structure.

They will obey the whole's program and will accomplish it to the extent to which they will succeed in communicating among them. How could one understand, then, the perfect coordination of all the activities developed by ants in their anthill? How could otherwise the fungus-cultivating ants of the *Atta* genus coordinate their actions and grow real fungus gardens, if not by communicating among them – on one side – and with the fungi – or the other? There is no mistake here. Ants do communicate with the fungi. Very difficult to explain, however, is the manner in which, besides labour division, their morphological differentiation occurs.

Ants of the *Atta* genus are considerably differentiated as a function of the mission they have to accomplish, namely:

- the big individuals, having the strongest mandibles, climb the trees and cut the leaves from the petiole, leaving them to fall down. These are the "cutting" ants;
- other ants – smaller than the first ones – with sharp and very biting mandibles, work on the ground, cutting up smaller or larger pieces, to be then transported to the anthill; these are the "tailor" ants;
- even smaller ants, but with long legs, carry to the anthill the pieces of cut up leaves. As the leaves they carry are bigger than them, covering their body during the transport, they are called "umbrella-carrying ants";
- the umbrella carriers, or the carrying ants, deliever the pieces of leaves to the chopping ants; provided with strong mandibles, they crumble the leaves, masticate them and then fertilize them with their own excrements, depositing the material in the substrate prepared for the fungus culture;
- the gardener-ants, which are even smaller, are extremely active. They impregnate the substrate with fungus spores and, when the fungi begin to grow, they cut them at the bottom, the resulting pieces (which are not eaten) being deposited on the substrate, to act as a fertilizer. The ants feed themselves with the juices imbiding at the level of the cuttings. Here, a callus is being formed, which creates some more or less spherical formations, known as "ants' turnip tops". These constitute the basic food of the fungus-cultivating ants. In most cases, the formation of turnip tops is synchronous with the hatching of a new larva generation. For assuring the reserve of spores, the reproducing females have special rooms at the level of their mandibles, where the fungus' spores are deposited.

As one may observe, a highly organized symbiotic mutualism operates here between ants and fungi.

Acromyrmex octospinosus cultivates fungi of the Leucopirine group. The culture is perfectly organized, functioning faultlessly. Sometimes, however, these fungus cultures are attacked by a parasite fungus, *Escovopsis* – from Ascomycotina. The damages may be, sometimes, considerable. To get rid of such parasite fungi, *Acromyrmex octospinosus* learned to cultivate bateria of the *Streptomyces* genus, known as secreting antibiotics, thus inhibiting the *Escovopsis* attack. This means that a superior type of symbiosis is created, for a biological combat of the fungus –which is actually only what humans nowadays do in the economically developed countries.

Symbiotic mutualism is largely occurring in the world of ants. It is known that ants grow aphides. They eat aphides' sweet excrements and, for having them, ants cultivate them and take care of them in a very special manner.

These aphides are also known as "cows" of the ants. The *Crematogaster lineolata* species protects the aphides by building around them shelters made of earth, while *Crematogaster pilosa* makes the shelters from a cellulose paste quite similar to the cardboard.

The ants of the *Oecophylla smaragdina* species grow some butterfly caterpillars of the Lycaenidae family, as they feed with secretions, occurring on the top of some special hairs. They do not only protect them and build shelters to them, but also take them to "pasture" on the trees' leaves, during the day, driving them back to the shelter in the evening.

All the above observations seem to belong to science fiction, however they are mere realities of the living world, that should be fully understood and explained. Two aspects are of prime importance here, namely: the semiotic dialogue developing among the members of the same family during labour division and in the activities coordination, and the semiotic dialogue among the species performing the symbiotic mutualism.

One should not insist on the fact that, in the absence of communication among partners, nothing will work. One should also go beyond the naïve interpretation according to which the behaviour of inferior (subhuman) beings is mechanical, instinctive, fastened in behavioural genetic schemes. The investigator discovers the cooperation among partners, the dialogue developing an exchange of – not only necessary but, sometimes, highly subtle – information. An ant calls her sisters when she discovers a new source of food, but not in any way, and not all of them. The pieces of information are provided in a precise manner, being called together only the number of ants corresponding to the amount of food discovered. Consequently, each action is highly adequate to its purpose. The circulating information are precise and suitable. Such a language is perhaps a bit too anthropomorphic, yet it is the only one that permits a correct judgement of the situation.

Even more subtle appears to us the relation among species within the phenomenon of symbiotic mutualism.

Fungus cultivation by the ants of the Atta genus, and not only, attained a hard-to-imagine perfection. The assimilation and improvement of the working techniques raised no special problems. They are simply learned and transmitted from one generation to another. The problem is elsewhere: wherefrom do ants know so precisely fungi's living requirements? How do they establish the optimum conditions of temperature, humidity and ventilation? Taking all risks, the authors assert that this is impossible in the absence of a semiotic dialogue among partners. Which are then the signals on the basis of which things advance? We do not know. They may be chemical, electrical or of other nature, yet the semiotic dialogue remains a "must". Even the simple positive answer which the partner gives in certain situation is a form of communication, as well.

A colony's functionality is based on the semiotic dialogue developed among the partners of the same family. The morphofunctional differentiation of the individuals in a colony (castes, polyetism) is performed through highly organized biological mechanisms. If, in the colonies in which its individuals are physically linked among them, the formation – at the expense of some members – of some so-called organs is a subsequent stage, one should accept that, in the colonies of social insects, too, a similar sort of "organs" – represented by different types of castes or polyetism forms, leading to the fulfillment of some indispensable functions for the realization of the colony's integrality – are differentiating.

In the absence of a semiotic dialogue among partners, nothing will happen. Consequently, the biosemiotic dimensions of the colonial structures are obvious.

Conclusions

Colonial animals form unitary, global structures, which are sometimes completed as a superorganism, no matter if its individuals are physically united or not among them. In the evolved forms, of the social animal colonies-type, a morphofunctional differentiation of the individuals is manifested, which permits labour division. This process may be accomplished, too, in the absence of individuals' morphofunctional differentiation, as the phenomenon of polyetism – in which the individuals perform, as depending on their age, successive functions – is installed. Labour division and the coordination of all the activities performed within the colony cannot be accomplished without a semiotic dialogue among partners. Its realization involves various types of signals (chemical, acoustic, visual, etc.).

The paper aims at providing some convincing explanations to the behaviour of the individuals forming a colony, as based on a biosemiotic-type dialogue, developed both among the colony's individuals, on one side, and among them and the representatives of other species, with which a symbiotic mutualism is realized, on the other.

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