THE SPECIES. BIOSEMIOTIC DIMENSIONS

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Abstracts. The investigations devoted to the pest-natural enemies complex found as active in the cabbage cultures of Romania favorized the discovery of a natural thesaurus highly illustrative for the way in which nature is developing under our eyes. For example, Brassica oleracea var. capitata L. is controlled, along its whole existence, by numerous phytophagous species occurring as a compact swarm surrounding it. Such phytophagous species are characterized by precise specializations of their nutrition ways, dividing the organs of the host plant so that to avoid too large superpositions. Along its evolution, each phytophagous species creates its own ecological niche, so that neither occupied nor free niches ever appear. In their turn, the phytophagous species are controlled by large swarms of entomophagous insects, the existence of which depends on one another. The assertion may be therefore made that a species may be actually represented as a swarm of swarms, living its life as part of the huge swarm represented by the integral biocoenosis. The present study aims at applying the 7th biosemiotic principle of Jasper Hoffmeyer, according to which any organism is a swarm of swarms. Consequently, analysis of species and of the biocoenotic complexes in the light of the above-mentioned principle may open new, fascinating perspectives for a better and thorough understanding of the living world.

Key words: producers, phytophagous species, zoophagous species, zoophagous species, swarms of swarms, parasitoids

Introduction

On June 7, 2007, which was a hot summer day, maybe the most torrid one in the last 50-60 years (following an almost non-existent winter, with neither snow nor low temperatures, as no one had seen in the last 100 years), we were controlling a cabbage culture at Agigea, the district of Constanţa, on the Black Sea shore.

The summer cabbage was well-grown, its heads already well-developed in some plants, or only in the process of forming - in others. The authors have been interested in the analysis of the pest complexes attacking cabbage for more than 40 years, so that they were quite surprised to observe an extremely high number of Plutella xylostella butterflies. On each cabbage head, tens of butterflies could be observed flying in swarms -
an impressive density of *Plutella xylostella* adults, innumerable swarms never seen before in any field we used to control, along the years, against pests and entomophagous species.

A careful controlling of the cabbage leaves evidenced numerous small, blacky granules gathered on their base. First, we did not understand what these granules might have been: actually, they were *Ceuthorhynchus quadridens* Panz. individuals, falling down in thanatosis. Without any exaggeration, 50-60 individuals, or even more could be observed on each plant in part.

Curiously, in the same place of the cabbage culture, yet in 2006, the presence of this species was hardly observable (only few individuals, the attack of which was negligible). This time (i.e., in 2007), the overwhelming presence and intensity of their attack was really surprising.

Once again, we remembered the invasion of swarms of swarms in the cabbage cultures of 2006.

As the last chemical treatment of the cabbage culture had been applied 3 weeks ago, the *Brevicoryne brassicae* L. colonies were freely installing on plants, covering almost completely their leaves, a careful and patient watching evidencing the presence of tens of parasitoid insect species on such colonies.

The experience we had got during the investigations devoted to the entomophagous complex of *Brevicoryne brassicae* permitted us to identify easily the presence of *Diaeretiella rapae*, of various *Charips* species, of *Asaphes* and *Pachyneuron*. Once again, the occurrence of the huge *B. brassicae* swarm on the cabbage, accompanied by a swarm of swarms, formed of parasitoid insects, took us by surprise.

The large swarms of *Pieris rapae* L. and – even if more rarely - of *P. brassicae* L. butterflies flying over the whole surface of the culture, surrounding us, created the illusion that the entire field was the scenery of a theatrical show, the main protagonists of which were: light, color and graceful movements.

As far as we were concerned, the cabbage culture was actually an authentic national thesaurus.

All passionate investigators interested in studying pest insects and their natural enemies know that the chance of finding out cultures over-attacked by phytophagous insects, over-controlled – in their turn – by entomophagous species, is extremely rare. For us, such a dream came true on June 7, 2007, at Agigea.

At first sight, everything seemed equally unreal and unaccountable… after which, we did try to find a possible explanation. Not far from “our” cabbage culture, we saw an already harvested rape (Brassica rapae var. oleifera D.C.) culture; without fail, many of its pests *Plutella xylostella*, *Ceuthorhynchus quadridens*, *Pieris*, *Brevicoryne* and the whole suite of entomophagous species, to be identified during subsequent analyses, had migrated to the cabbage field.

Another, even more plausible cause might have been the absence of a cold winter, the simply aberrant climatic conditions induced by the emerging global warming of the earth. Apart from the already mentioned national natural thesaurus (the cabbage culture described should have been preserved as an open-air museum, as a scientific evidence of the free manifestation of biodiversity in nature and, equally of nature’s - not man’s! – economy, we shall never forget the fascinating image of the swarms of swarms busily active within the larger swarm of the integral biocoenosis.

The metaphor is far from being casual and we did not use only accidentally, but as a most convincing expression of the biosemiotic thinking of Jasper Hoffemeyer,
The species. Biosemiotic dimensions

according to whom a living organism occurs as a large swarm of cellular swarms. Actually, this is the 7th of the biosemiotic principles elaborated by Hoffmeyer.

Our investigations supported the idea that any species is a swarm of swarms, living and developing inside the huge swarm of the integral biocoenosis – which is exactly the idea to be demonstrated in the following.

Discussion

In ecology, one of the main principles still working is that “everything depends on everything”, more precisely that the existence of each living being depends on all the other living organisms and on the whole life of the biosphere. The bio-geo-chemical ecological circuit is the proof that all substances are involved in a perpetual cycle, which will go on as long as life will continue on earth. The existence of trophic chains, with more or fewer links, is indicative of the inextricable circuit of matter and energy.

As unanimously known, life on our planet depends entirely on the existence of producers - especially plants, as well as other autotrophic organisms. Plants are photosynthesizing autotrophic organisms, which means that life on the Terra depends primarily on the Sun – yet not only. There also exist chemo-synthesizing autotrophic organisms, which do not need solar energy for the synthesis of organic substances, namely methano- and ferro-bacteria, and others.

However, there also exist photo-synthesizing bacteria species – in others words, plants and bacteria are autotrophic organisms which synthesize the organic substances starting from water, carbon and mineral salts.

Producers serve as food sources for (primary) phytophagous consumers, which transform the organic substance – of either vegetal of bacterial nature – into organic substance of animal nature. One and the same organic substance – of vegetal nature – may be transformed into a qualitatively different organic substance of animal nature. Rabbits eat cabbage: goats, snails, cabbage butterflies, cabbage flies and cabbage bugs eat cabbage, too, so that the same food is transformed into extremely different organic substances of animal nature. Primary (phytophagous) consumers may be eaten by zoophagous consumers belonging to different (secondary, tertiary, quaternary or top) orders. Primary consumers represent a real “industry” through their capacity to transform an organic substance of vegetal type into an organic substance of animal type. During their entire life, animals depend on producers. Both producers and consumers are born, live, grow, develop, get old and die.

Along their whole existence, they produce different organic substances, which they release in the environment, together with large amounts of undigested organic substances, i.e., excrements. All dead organic substances should be decomposed, i.e., mineralized and re-introduced into the bio-geo-chemical circuit. Decomposition of the organic substances of biogenic nature is performed by decomposing agents, mainly bacteria, as well as by fungi or some Protiste representatives.

Decomposers close the bio-geo-chemical circle, developing at planetary, zonal and even local level.

The already mentioned principle – everything depends on everything – is perfectly applicable, too, in the analysis of the complex interrelations developed between a species and all the other species present in the biocoenosis in which the former one lives.
Let us exemplify this on the *Brassica oleracea* var. *capita* L. species – known as a cultivated species, requiring therefore man’s protecting intervention in its competition with the spontaneous plants. The cabbage growing in the field may be attacked by weeds and herbs, known as far more vigorous and favoured in the struggle for space, water, mineral salts and light. If carefully looked after, the cabbage plants will soon show a proper development, their rounded leaves growing and gradually surrounding the forming cabbage head.

Inevitably however, their presence in the field draws the prompt attention of the phytophagous species always looking for host-plants capable of feeding them and, mainly, permitting egg deposition. Consequently, the *Plutella xylostella* (L.) females start to deposit their eggs on the developing buds of the cabbage plants. It is only 3-4 larvae of this species that may completely destroy the bud, thus affecting growing of the whole plant. *Plutella* produces several generations, yet only those developed on young plants of both summer and autumn cabbage are harmful. In the case of large, well-developed cabbages, with vigorous, extended leaves in their basal rosettes, the *Plutella* females deposit their eggs on the basal leaves which are not wrapping the head, so that, when the cabbage gets harvested, both larvae and pupae remain in the field, on the basal leaves. Such an extremely subtle adaptation is perfectly illustrating the “intelligence” of the species.

However, even more interesting is that, in a harvested cabbage culture, in which numerous vigorous leaves are still present and new buds – also vigorous – get formed, the *Plutella* female – as well as the *Pieris*, *Mamestra* and *Autographa* ones – do not deposit their eggs until the soil is not freshly tilled. Prior to this observation, we were happy to find out harvested, abandoned cabbage cultures, as we knew that, in the absence of any pest-killer treatments, we might trace either pests or their entomophagous complex. Is time, we came to understand that the insects attacking cabbage never deposit their eggs on harvested cabbage cultures, even if the leaves remained behind are still robust, with young, well-grown buds. Apparently, the females know that such plants will be soon destroyed, so they never put their newly emerging generations at stake.

In Romania, cabbage cultures constitute a proper target for more than 50 phytophagous species (Mustață, Gh., 1974), an exceedingly high number of pests, to which one should add bacteria and pathogenic fungi, the only possible observation to be made being that cabbage is controlled by a very large number of species (Cherry et col., 2004).

Actually, this should not surprise anybody. The great geneticist N. Vavilov found out that each species has its own birth place, defined by him as the “World Genetic Center” of the respective species. Here, in its birth place, the species comes into contact with all species occurring in its “native” biocoenosis; the relationships thus established are quite different: some are simply neutral, others are competitive, while others control its very existence (e.g., the relations with parasites, parasitoids or species of prey) or are controlled by it. Therefore, all these species evolve together, along a co-evolution process. The relations established among species are governed by some cybernetic principles, such as the self-regulation mechanisms, which do not allow the exponential development of a species and the elimination of others (Mustață Gh. et col., 2000).

Along the whole cycle of their life, the phytophagous species depend on the plants they prefer as their food. Let us assume that, on a desert island, there exist together some plant and the phytophagous insect that eats is leaves (or roots, or any other organ); it
goes without saying that the insect will not destroy all plants it attacks, which would cause – in the absence of any food – its own extinction. Consequently, some relationship – similar to that discovered by the great scientist Volterra – is therefore established between the predator and its victim, which might become permanent in the absence of the disturbing environmental factors, the action of which is known as inducing disequilibria. In such a cycle, declining and ascending periods may occur, in both predators and victims. More than that, the phytophagous species are attacked – in their turn – by zoophagous organisms. In the case here under investigation, the phytophagous insects are controlled by a predatory or by a parasitoid species. As the predator does not consume the whole population of phytophagous insects, some self-adjustable cycle is manifesting, too. In addition, the zoophagous species restricts the populations of the phytophagous one, thus assuring the existence of producers within certain limits. In this way, feed-back type loops – involved in the self-regulation mechanisms of the organisms – are formed (Fig. 1).

When zoophagous organisms of superior order are involved, the interrelations among species become increasingly complex (Mustață Gh. et col., 2001).

In the case of the *Plutella xylostella* species, an extremely high number (20-25) of species of primary parasitoides are active, their conjugated actions coming to restrict this pest up to 70-80, and even 90% its populations (Mustață Gh., 1973; Mustață Gh., M. Lăcătușu, 1973; M. Constantineanu, Gh. Mustață, 1973, 1974).

With a biosemiotic expression, the observation may be made that a swarm of parasitoid insects is actively controlling the populations of the *Plutella xylostella* species.

As evidenced in Fig. 2, some species act as secondary parasitoides, limiting the – beneficial for humans – action of the primary ones. All in all, this complex of parasitoides provides a self-regulation mechanism which prevents any possible exponential development of some species (Mustață Gh., Andriescu Ionel, 1972-1973; Mustață Gh., 1974-1975, Mustață Gh. et col., 2001, 2002, 2003).

Nevertheless, the *Brassica oleracea* var. capitata is not attacked exclusively by *Plutella xylostella*. As already mentioned, a whole complex of phytophagous insects is controlling the existence of this culture plant. Previous investigations of ours have been devoted to the action, quite different from one case to another, of the *Pieris brassicae* L., *P. rapae* L., *P. napi* L. and species (Ionescu, Gh. Mustață, 1976-1977; Gh. Mustață, 1978). Thus, the *Pieris brassicae* larvae, gregarious in their first stages, attack simultaneously the cabbage leaves; they consume the limb completely, leaving intact only the main nervures. The effect of such an attack is extremely serious for the plant, calling for a prompt chemical intervention from the part of producers.

In *P. rapae* and *P. napi*, the larvae are solitary, their presence on one and the same plant being much more reduced. The *Pieris brassicae* females deposit several groups of 20-60 eggs each, which means that between 100-300 larvae will be active on a single plant. In the relation established between the host plant and this species of
Lepidoptera pest, the same principles as those discussed for the preceding species are applicable – namely, these pests cannot completely destroy the host plants from some area, as this would jeopardize their own existence. More than that, in the environmental conditions of Romania, these pests are, in their turn, controlled by an impressive number of parasitoid insects (Fig. 3) (Mustăţă Gh., 1978, Mustăţă Gh., Nguyen Thi Thi, 1979). Primary parasitoids conjugate their action for restricting the pest populations within acceptable limits but, in their turn, they are controlled by a large number of secondary parasitoids. The trophic network specific to this complex occurs as a swarm of parasitoid insects developing a highly organized action within *Pieris* populations, impeding the exponential development of the species. Each *Pieris* species is accompanied by its own swarm of primary and secondary parasitoids and, because all these species belong to the same genus, many of the parasitoid species are common, which permits merging of the various trophic networks in only one, global network, occurring also as a swarm of parasitoid insect swarms (Mustăţă Gh., 1986; Mustăţă Gh. et col., 1986, 2000, 2005).

Although attacking the same host species, *Mamestra brassicae* L. is controlled by a complex of parasitoid species different from those of the *Pieris* and *Plutella* species. Special mention should be made of the fact that *Mamestra brassicae* L. is one of the most dangerous enemies of cabbage as its larvae – occurring in their last development stages – enter the head and destroy it on the whole.

*Mamestra brassicae*, too, is controlled by some parasitoid complex (Fig. 4), yet its attack is weaker. However, in some cabbage cultures, in some areas, in some years, the eggs of this species are parasitized by *Trichogramma evanescens* Westw., in ratios of 40-60% and even more. A wholly different swarm of parasitoid insects was identified during the investigations devoted to *Mamestra brassicae* (Mustăţă Gh., Mustăţă M., 2000), to which the complex of parasitoid insects traced out in the *Autographa gamma* L. (Mustăţă Gh., Gabriela Costea, 2000) populations should be also added.

A quite special case is represented by the *Brevicoryne brassicae* L. aphid, the colonies of which might sometimes compromise a cabbage culture, in the absence of any chemical treatments for their combat.

*The proliphicity of this aphid is huge – its colonies may completely cover the cabbage leaves. Let us imagine that, on a cabbage hectare attacked wholly by *Brevicoryne brassicae*, the density of its representatives on only one leaf varies between 50 and 200/cm², which is an inconceivable biomass. Let us also retain that, if the cabbage leaves are almost completely covered by this aphid, no place remains free for many of the other common pest species. Consequently, it may be concluded that a cabbage culture can be wholly destroyed by only one pest species, which actually happens in numerous cases, yet not always! The intensity of the attack may vary from one culture to another, from one region to another, from one period of time to another. One and the same plant species should face the aggression of the attack of numerous phytophagous species.*

*Brevicoryne brassicae* invades as a huge swarm, covering an entire cabbage culture. When the density of the virginogene aperous females attains a certain supportability threshold, a special program of reproduction - permitting the birth of winged virginogene organisms – is launched.

As these beings pass more easily from one plant to another and even from one culture to another, the sensation of swarm is created both really and metaphorically. Such a crazy multiplication may be explained by the occurrence of a disequilibrium in nature,
which prevents any control on these aphid populations from the part of the entomophagous species.

Previous investigations have put into evidence a quite high member of species of prey, the conjugated actions of which are oriented towards the reduction of such pest populations within reasonable limits (Fig. 5). Among them, mentioned should be made of the Syrphidae, Ionitidae, Chamaemyidae (Diptera), Coccinellidae (Coleoptera), Heteroptere, Neuroptere (Mustăţă Gh., 1986; Mustăţă Gh., Mustăţă M., 2001), species, which attack the B. brassicae colonies in June and July, considerably reducing their effects. However, in their turn, the predators may be controlled by some parasitoid species, which restricts their action – beneficial for human economy. Besides predatory insects, complexes of parasitoid insects are also occurring in the colonies of this aphid, appearing as a huge swarm acting inside a swarm of aphids.

As illustrated in Fig. 5, such a swarm performs a highly ordered action, primary, secondary, tertiary and even quaternary parasitoids – each one with a “mission” of its own – being here involved. The parasitoid species perform either conjugated or opposite actions, thus assuring a coherent and perfectly ordered development of the whole process. Within such a complex, the tertiary parasitoids (Asaphes vulgaris and Pachyneuron aphidis) may act as both secondary and tertiary agents – or even as quaternary ones, when the species are reciprocally parasitizing one another.

The multiple trophic valencies evidenced by these two species permit the creation of a special buffer system inside the biocoenotic complex. As a function of the biomass provided by their hosts, the species move more from one trophic level to another. Therefore, realization of such a buffer system assures the self-regulation mechanism of the biocoenotic complex (Mustăţă Gh. et col., 2000, 2001, 2007).

Study of these biocoenetic complexes permits a better understanding of the mechanisms assuring both self-regulation in nature and the natural equilibrium.

The entomophagous complex controlling the B. brassicae populations explains the application – by the authors of the present study – of the “swarm of swarms” concept, usually utilized in biosemiotics for explaining organisms’ working as an entity.

Prior to a more ample discussion on such aspects, the observation should be made that the great number of phytophagous species that attack a plant determines their specialization (feeding mode and organs upon which the attack is directed). In the case of cabbage, it is the leaves that assure the largest part of the biomass.

In seedy plants, besides other organs, a flowery stem is developed, that may be attacked by some phytophagous insects. Some species attack the leaves, others – the flowers or the fruit, seeds, stem and even root. Some species, such as Ceu thorhynchus pierorstigma Marsh attack the cabbage roots, thus provoking the formation of galls, in which the larvae are fed. Delia radicum L. (sin.: Delia brassicae Bche., Chortophila brassicae) attacks the roots, while Baris chlorizans attack the stems, the larvae digging large galleries, which considerably affect the host plant (Mustăţă Gh., 1978).

A careful investigation of the complex of entomophagous species controlling the Delia radicum populations put into evidence an extremely high number of parasitoid species, which conjugate their actions for reducing the populations of such a dangerous pest. Delia radicum has its characteristic parasitoids, not occurring in other species that attack the cabbage. The swarm of parasitoids which control the Delia radicum populations has its specific structure, each species occupying a precise position in the trophic network (Fig. 6) and building, along its evolution, an ecological niche of its own. Possibly, some
A thorough, monographic investigation of the *Brassica oleracea capitata* species should necessarily include the analysis of the complex of phytophagous species controlling the course of its existence, which will lead to the discovery of a swarm of phytophagous insects more or less specialized for attacking this plant.

The number of parasitoid species controlling some of the cabbage-attacking species is really impressive. As the phytophagous insects apparently form a swarm around the host plants, one might quite easily imagine the intense, busy activity of the swarms and swarms of parasitoid insects surrounding some phytophagous species (*Brevicoryne brassicae*, *Plutella xylostella*, *Pieris brassicae*, *Delia radicum*, etc.). In the opinion of the authors, such complexes of parasitoid insects, which control some pest insects, do form genuine biocoenotic complexes, defined by the same authors as parasitoid biocoenoses. Once accepting the term, one may also realize that these biocoenoses evidence characteristic, well-defined structures established along the geological time, i.e. during the evolution process, and that they work according to well-established laws.

In other words, such swarms of parasitoids do not act chaotically, their evolution following precise regulations.

Fig. 7 attempts at illustrating the swarm of swarms represented by *Brassica oleracea* var. *capitata*, together with the phytophagous species controlling its existence, and which are controlled – in their turn – by swarms of entomophagous species, reciprocally depending on one another. According to the authors of the present study, each complex of parasitoid species that controls a phytophagous species represents a parasitoid – type biocoenosis, which should be nevertheless viewed as part of the integral biocoenotic complex represented by the agrobiocoenosis – i.e., the cabbage culture.

There might be deduced from here that the species here under investigation, *Brassica oleracea* var. *capitata*, represent a swarm of swarms, which is but part of the larger swarm of the integral biocoenosis. For better illustrating the metaphorical expression of “swarm”, applied from a biosemiotic perspective, one should follow the trophic network established by the investigations developed in an endive (*Cichorium intybus* L. ssp. *sativum* (D.C.) Janchen var *foliosum* Hay) culture attacked by *Uroleucon cichorii* Koch. (Fig. 8) (Mustaţă Gh. et col., 1991, 2001).

The trophic network developed by the parasitoid species controlling the populations of this aphid is impressively huge, indeed, which might explain the extremely complex structure evidenced by the numerous species belonging to it. Again metaphorically, one may imagine an immense swarm, within which the species, divided into castes, perform specific functions, all contributing to the edification of an indestructible whole. Nothing is accidental or chaotic, each step is controlled by the interrelations established among species along millions and millions of years of their evolution.
As to the role played by tertiary parasitoids (Asaphes suspensus, A. vulgaris and Pachyneuron aphidis), they may act – as already mentioned – as secondary and quaternary ones, as well. Their larvae are ectoparasitary. One might deduce from here that they are younger parasitoid species, which have not found yet their perfect host. However, this would mean that a parasitoid species has a more advanced parasitary life, the fewer the number of its hosts is. Would it be possible that, millions of years later, these species will restrict their action exclusively to some hosts and will occupy a fixed position inside the trophic network? Maybe yes, maybe no. According to the authors, involved here is rather the realization – within these biocoenotic complexes – of a buffer system capable of granting a highly functional self-regulation mechanism.

Now, which might be the conclusions to be possibly drawn from the analyses performed?

A strict observation – extended over more than 30 years – of the parasitoid complexes of some pest species permitted a first estimation on the large number of parasitoids which act together for restricting the development of some pest species (Pieris brassicae, Pieris rapae, Plutella xylostella etc.) (Mustaţă Gh. et col., 2005). Also, secondary parasitoids could be sporadically noticed. From one decade to another, the efficiency of the primary parasitoids increased considerably. Why? The Plutella xylostella populations were found as reducing by 70-80, up to 90% or even more, in certain cultures, so that the idea the phytophagous species is on the brink of extinction appeared as possible (Mustaţă Gh., 1974, 1992, 1992-1993). A similar situation was also recorded in the Pieris brassicae and P. rapae populations. Quite surprising, indeed, was the observation that, from one period of time to another, the number of secondary parasitoid species increased, as well as – in the last decade, mainly – their efficiency. This was quite an alarming aspect, once the biological combat against pests had been always viewed as beneficial. Consequently, the authors focused their scientific concerns on such aspects, the results being published along the years (Mustaţă Gh., et col., 1974, 2000, 2001). Still, no satisfactory explanation for such a phenomenon was found until the research came to include the complex of parasitoids known as restricting the populations of such aphid species. Let us consider, for example, the complexes controlling the Brevicoryne brassicae and Uroleucon cichorii populations.

As previously mentioned, the huge, immensely huge number of parasitoids, as well as the complexity of the trophic networks are astonishing, indeed. The phenomenon can be understood in all its intricacy only if accepting a new view on the way in which nature works.

Man looks at nature exclusively from the perspective of one’s immediate interest, and not from that of nature’s economy. Starting from this, we simply divide animals into useful and pest species. For example, Cihorium intybus L. ssp. sativum (D.C.) Janchen var. foliosum Hey is a quite appreciated culture plant in some regions, while Uroleucon cichorii Koch is a pest species, once it attacks the former. Primary parasitoids from the Aphididae family are useful, as they restrict the negative action of U. cichorii. In a similar manner, the whole complex of secondary parasitoids is also harmful, once it affects the beneficial action of the primary parasitoids. Tertiary parasitoids might be also beneficial, as they reduce, to some extent, the disastrous effect of the secondary parasitoids. The fact still remains that the tertiary parasitoids are extremely unreliable, frequently acting as secondary and even as quaternary parasitoids. Therefore, the mystery remains non-elucidated.
Let us now analyze all these relationships from the perspective of nature’s interest. As biologists, the authors known that, in nature, nothing is missing, nothing is in excess. Any possible absence is exclusively the result of human intervention. Each species occupies its precise position in nature, fulfilling its pre-established function. As already stated, nothing is accidental or chaotic.

Let us now imagine a deserted island, on which endive cultures grow. Let us assume that, by migration, the *Uroleucon cichorii* species is present in these cultures. With such a rich biomass available, the aphid has multiplied overwhelmingly, up to jeopardizing the very existence of the plants, which is unacceptable. Equilibrium should be re-established in the plant – aphid relations, as the biosystem has to survive and not to collapse. Quite accidentally, the *U. cichorii* colonies are traced by some species of primary parasitoids belonging to the Aphidiidae family. The rich biomass provided by this aphid led to an exponential development of these species. The host plant is thus saved from extinction and the biosystem gets recovered. However, the observation is made that *U. cichorii* starts to decline, an almost dangerous decline, while some species of secondary parasitoids become prosperous after the discovery of the endive cultures, along with the presence of aphids and primary parasitoids. They build up impressively large populations, thus providing a “new breathing” to the *U. cichorii* colonies. Tertiary parasitoids begin to manifest their presence, as well. Their action will last long at this trophic level, however some equilibrium is gradually established among the species. In such a case, tertiary parasitoids begin to act as secondary parasitoids, as well, thus assuring to themselves the necessary hosts. If larvae of tertiary parasitoids appear, they do not refuse them, either. Gradually, the parasitoids come to exhibit their buffer system function. However, their action will depend on the type of biomass at hand, which means that the species with the largest number of individuals will become the target of the main attack. A self-regulation system, which prevents the exponential development of some species, becomes therefore active. In such a stage, the assertion may be made that the biocoenosis reached its full maturity. The biocoenotic complex attained its climax.

Now, natural equilibrium may be maintained within natural limits, as long as no perturbing factors, capable of inducing disequilibrium, are manifested.

The old, not-answered questions still remain: What does really happen inside the parasitoid complexes attacking the *Plutella xylostella*, *Pieris brassicae*, *Pieris rapae*, *Brevicoryne brassicae*, *Delia radicum* populations? Nothing special, indeed, apart from the normal development of the natural relations among species.

In the environmental conditions characteristic for the province of Moldova or, better, for the whole Romania, *Plutella xylostella* is controlled by a large complex of parasitoid insects. This control occurs quite naturally, no artificial intervention – i.e., growing of parasitoids and their launching in nature – being ever necessary.

In the Romania of the last two decades, agriculture suffered a terrible decline. Among others, the chemical combat against pest insects was renounced at for quite a long time, after which the situation got reserved: numerous farmers simply burn their cabbage cultures with too large amounts of pesticides, which is a pity, indeed! In the period along which no chemical treatments had been applied to the fields, nature wisely intervened. As known, the virulence of the primary parasitoids is extremely high; for example, in some cabbage cultures, the *Plutella xylostella* larvae and pupae were parasitized in ratios of 70-80%, sometimes exceeding even 90%, which is quite alarming for the economy of nature: *Plutella xylostella* was facing extinction. Nature should re-activate its self-regulation
mechanisms, among which of special importance is increasing the number of secondary parasitoids and of their efficiency. The occurrence of a buffer system in this biocoenotic system would support the correctness of such reasoning.

The hypotheses put forward by the authors were confirmed. The occurrence of the *Oomyzus sokolovskii* species in the fauna of Romania could not be precisely dated, however it is present, and its presence in quite active. Especially important is that the new species acts both as a primary and as a secondary parasitoid, in the *Plutella xylostella* populations, coming to take over the buffer system function within the biocoenotic complex. The assumption may be therefore made that the biocoenotic complex under discussion approaches its climax.

The swarm of species acts in an efficient and highly organized manner. The question still remaining is related to its size: why is it so huge? Why is *Plutella xylostella* controlled by such a high number of parasitoids? The only possible explanation in that this part of Europe might be - according to the ideas of N. Vavilov – the genetic center of the world. In Asia and America, the number of parasitoid species is extremely low. For example, in Taiwan, *P. xylostella* is comparable to *Leptinotarsa decemlineata* Say, which arrived in Europe without its natural enemies.

The condition of the *P. xylostella* species has been also followed in other parts of the world. For example, N.S. Talekar analyzed – and elucidated – numerous aspects on the biological control of this species in Asia, while D.F. Waterhouse and M.M. Alam brought important contributions in the Pacific, and also in Jamaica and the Carabbees.

Ayalen G., B. Löhr, Baumgärtner C.K. et al. (2004), who investigated the *P. xylostella* populations of Kenya, have grown parasitoid insects, known as playing an important part in the biological combat of such a pest.

Sall-Sky et al. provided important information on the complex of parasitoid hymenoptera controlling the *P. xylostella* populations of Senegal, while A.A. Kirk and R. Kfir (2004) published promising results on the biological control of this species.

*P. xylostella* has conquered the whole planet, being spread all over the world. However, in many cases, it was not accompanied by its whole suite of natural enemies, which creates serious problems in numerous parts of the globe, related to the control of these populations.

Under such circumstances, a question still to be asked is whether all parasitoid species present in these pest populations are equally important. Consequently, a synecological analysis of the parasitoid species from each complex should be necessarily performed.

Such a synecological analysis, devoted to the parasitoid species present in the *Uroleucon cichorii* colonies will evidence a relative abundance of *Aphidius funebris* (2,164 individuals), while the *Charips cameruni*, *Ch. Carpenterii* and *Ch. Victrix infuscatus* are represented by only 5 individuals. Out of the 34 parasitoid species, 10 are euconstant, 11 are constant, 4 are accessory, and the rest are accidental. As to dominance, only 2 species are eudominant, two are dominant and two are subdominant, 4 species are recedent and the remaining ones are subrecedent. A similar situation should be also mentioned for the index of ecological significance. Consequently, not all species bear the same significance within a biocoenotic complex. The presence of species as part of the biocoenotic complex is conditioned by the biomass available to them. The accidental species occurring in such colonies have appeared accidentally, indeed. Most certainly, the females of these species would have preferred other species, however, being in a situation
of crisis and finding none of the desired species, they accepted to put their eggs even in the *U. cichorii* colonies, thus assuring the continuity of the species. As polyphagous species, they control several host species, moving easily and freely from one host to another, looking for those capable of offering a richer biomass. At a global level of the biocoenosis, one may therefore state that the polyphagous species take over the buffer system function, as well, thus impeding the exponential development of some species inside the biocoenotic complex (Mustață Gh. et col., 1991, 2001).

For the first time, the authors have had the intuition of this mechanisms in the 70’ies, during the investigations devoted to the efficiency of the *Trichogramma evanescens* Westw. species in controlling the *Mamestra brassicae* populations, through egg parasition (Mustață Gh., 1974).

For years and years, the values recorded on *Mamestra brassicae* egg parasitation did not exceed 20-30%. However, in 1978, values between 60-70% were suddenly registered, so that a gradual increase of the *Mamestra* egg parasitation ratio was expected – which was not the case. What might have explained such an unexpectedly high ratio? Possibly, this polyphagous species might have also parasitized other species, capable of providing a higher egg biomass and, after some reduction of such populations, they got re-grouped and moved to *Mamestra brassicae*.

Why have the authors resorted to a biosemiotic language in the attempt of elucidating the essence of some complex structures and biological processes?

In their paper entitled *Reading Hoffmeyer rethinking biology*, issued in 2002, Emmecke Claus, Kull Kalevi and Sjønfeldt Frederik give their interpretation on the biosemiotic principles stated by Jasper Hoffmeyer. As known by the specialists of the field, the 7th principle states that “The living organism is a swarm”.

According to Jasper Hoffmeyer, the swarm of cells forming the organism of a pluricellular animal may be viewed as a swarm of swarms, as a huge swarm formed of various, hierarchically–superposed swarms (Hoffmeyer J., 1995, 1996). In other words, the cells forming the organism do not constitute a self-contained entity, nor are they isolated. Instead, they communicated among them, interact and conjugate their efforts for assuring the vital functions of the organism (such as immunity, recovery of some injured organs, etc.), quite similarly with the bees inside a colony. At first sight, the swarm appears as irregular developing hazardous, random activities. Instead, things are entirely different. The multitude of cells intervening in the active defense of the organism, their incredible communication and mobilization capacity for assuring their scope: the immunity of the organism is an impressive show, indeed.

In the opinion of Jacob Uexküll (1980), differentiation of the cells and tissues from pluricellular organisms granted the special capacity of receiving and transmitting information, so that large environmental areas should be manipulated, in both space and time, which finally favors the increase of the so-called *Umwelt*.

One can easily imagine the swarms of cells, either in the moment of their mobilization or simply mobilized for facing the attack of a pathogenic agent, or for repairing a blood vessel, the breaking of which might produce an internal hemorrhage, possibly fatal for the respective living organism.

Therefore, a living organism appears as a swarm of cellular swarms, which communicate among them and develop coordinated actions for assuring a normal running of the entity represented by the organism (Mustață Gh., Mustață M., 2006).
Biosemiotics permits a more profound understanding of certain biological processes and phenomena. The same biosemiotics made us rediscovery the cell as an edifying unit of the organism structure (Mustăţă Gh., Mustăţă M., 2006).

Application of the biosemiotic principles may help one to view not only the organism, but also the species (population), the biocoenosis and the biosphere, as a whole. Similarly with cells, the individuals belonging to some species form a structural and functional unit, actually represented, at organizational level, by the species.

The heterogeneity characterizing the individuals belonging to a species confers to it a higher integrality and a special openness towards the other species.

The syntagm “the species is a swarm of swarms” may appear as a simple metaphor, having no real meaning. However, a more careful analysis might bring to light important aspects that should be necessarily taken into consideration.

According to the systemic theory of Ludwig von Bertalanffy, any material system, the biological ones included, possesses certain characteristics, such as: integrality, dynamic equilibrium, self-regulation, programs, historical evolution and heterogeneity.

The species represents a biological system, a level of organization, which grants its heterogeneity; consequently, the individuals forming the species are different and may play different roles.

Let us exemplify the above statements with the *Brevicoryne brassicae* L. species. In Romania, it hibernates as resistance eggs, deposited on the strain and on the leaves remaining after cabbage harvesting. In the springtime, the founding (womb) females come out from the eggs, giving birth - through parthenogenesis – to unwinged virginogene (virginopare) females. When the density of such wingless virginogenous females is sufficiently high, there appear the winged virginogenous females, which assure spreading of the colonies on other plants and even on other cultures. They get installed on other plants and, until autumn, they give birth to other generations. When autumn is near, the sexupare females – the last generation of parthenogenetic females – appear and give birth to sexuate (female and male) forms which immediately begin their nuptial dance, thus forming innumerable swarms. The fertilizing mating is followed by egg deposition and by the harsh winter, followed by spring revival.

Tracing out the most suitable places for egg deposition, from the part of female swarms, represents the last vital activity prior to the beginning of winter.

Generations and generations of *Brevicoryne brassicae* L. swarms, following one after another, may be cyclically observed from early spring until late autumn, either as real swarms of winged organisms or only as imaginary, yet perpetual dynamics of swarms of winged and wingless virginogeneous females.

The uninterrupted succession of these swarms represent a major condition for the accomplishment of the yearly biological cycles, no matter how many generations are involved. Nothing is accidental, the aphid generations contribute together to the fulfillment of the ontogenetic cycle and to successfully facing any moment of crisis.

In *Brevicoryne brassicae* L., no castes occur; however, the fundatrigeneus element is wholly different from the winged ones, and the sexupare differ from the sexuate ones.

The generations overlap on one another, the whole works as an immense swarm, formed of numerous other swarms.

The same metaphor will be employed for describing the succession of other generations of species – be them phytophagous or parasitoid. The large swarm forming
the species modifies its structure and functionality as a function of the concrete environmental conditions, on one side, and of its specific requirements, on the other.

If analyzing the swarm of swarms of the *Brevicoryne brassicae* L. species as such, *i.e.* isolated, without considering its complex relationships with the swarms of parasitoids and predatory insects, no reliable results will be attained.

However, once accepting the idea that the producers continue their existence in the swarms of swarms represented by parasitoid and predatory species, one will easily understand that, in nature, *everything depends on everything*, and it is exactly this manner of approaching nature that facilitates one to view the biological concept of species as a swarm of swarms, belonging to the huge swarm represented by the biocoenosis. No species can ever live isolated, separated from the other species and from the whole which is the biosphere. Therefore, the assertion that: *everything depends on everything* is an ecological principle perfectly applicable, too, for a deeper understanding of the structure and functionality of some species.

As demonstrated above, the existence of a vegetal species depends on a complex of phytophagous species, on a swarm of phytophagous insects which attacks its various organs. Such attacks are highly different, as a result of the different specialization, as to the manner in which the attack is conducted and also as to the nutrition mode of the assailant. That is why, no study on any species from the vegetal world should leave aside the corroborated analysis of the swarm of phytophagous insects which controls and determines its existence.

More than that, any investigation should consider that each phytophagous species is accompanied by a swarm of entomophagous insects. As to the parasitoid insects, they are acting as primary, secondary, tertiary and/or quaternary parasitoids, which form extremely complex trophic networks. All these species live and exist as part of the huge swarm of the integral biocoenosis, within which *everything depends on everything*.

It is only in this way that one can really and thoroughly understand the organization levels of the species (populations), biocoenosis and biosphere type. No living being can ever live alone, isolated from its fellow creature from the same species and/or from its neighbors belonging to other species from the same biocoenosis. Therefore, it is only at the level of such complex structures of swarms of swarms, which are part of the huge swarm of the biocoenosis, that one may really grasp the complex interrelations established among species, and “translate” into human terms the semiotic dialogue permanently developed among them.

**Conclusions**

Investigation of the complex of phytophagous species that attack some cultivated plants put into evidence innumerable swarms of species which control one another in an amazingly reciprocal manner, and which depend wholly, along their entire life, on the inter-relationships consolidated along millions and millions of generations.

The attempt of applying certain biosemantic principles for better understanding the vital structures and processes led to the discovery that any species is formed of swarms of swarms, busily active in the huge swarm represented by the biocoenosis.

Along its whole life, *Brassica oleracea* var. *capitata* L. is controlled by a huge complex of phytophagous insects, which represents a first huge swarm; in their turn, the phytophagous species are accompanied by a bigger or smaller swarm of entomophagous insects, as actually illustrated by the investigations performed by the authors on the

Therefore, in the present study, the authors attempted – successfully, they hope! – at applying the seventh biosemiotic principle established by Jasper Hoffmeyer, according to which any organism is a swarm of swarms, for understanding the species as a *swarm of swarms*, acting unitarily within the huge swarm represented by the biocoenosis.

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Table 1. Sinecological analysis of the species from the biocenotic complex of the Uroleucon cichorii species

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Abundance</th>
<th>Constance</th>
<th>Dominance</th>
<th>Index of ecological significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aphidius funebris</td>
<td>2164</td>
<td>C₄</td>
<td>D₃</td>
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<td>D₃</td>
<td>4.00 W₃</td>
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<td>Praon dorsale</td>
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<td>C₄</td>
<td>D₃</td>
<td>3.22 W₃</td>
</tr>
<tr>
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<td>Charips curvicornis</td>
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<td>C₄</td>
<td>D₂</td>
<td>1.67 W₃</td>
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<td>Charips victrix victrix</td>
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<td>C₃</td>
<td>D₂</td>
<td>1.10 W₂</td>
</tr>
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<td>Charips microcerus</td>
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<td>C₃</td>
<td>D₂</td>
<td>1.07 W₂</td>
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<td>Ephedrus campestris</td>
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<td>C₄</td>
<td>D₃</td>
<td>0.96 W₃</td>
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<td>Alloxysta campyla</td>
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<td>C₃</td>
<td>D₃</td>
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<td>15</td>
<td>Dendrocerus bicolor</td>
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<td>C₄</td>
<td>D₃</td>
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<td>Charips perpusillus</td>
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<td>Value</td>
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<td>D</td>
<td>W</td>
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<td>17</td>
<td><em>Alloxysta subaperta</em></td>
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<td><em>Dendrocerus carpeneteri</em></td>
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<td>D1</td>
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<td><em>Alloxysta ulrichii homotoma</em></td>
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<td><em>Aphidencyrtus aphidivorus</em></td>
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</table>

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The species. Biosemiotic dimensions

Figure 2. The parasitoid complex of the *Plutella xylostella* L. species
Figure 3. The parasitoid complex limiting the *Pieris* populations
Figure 4. The parasitoid complex of the *Mamestra brassicae* populations
Figure 5. The entomophagous complex controlling the *Brevicoryne brassicae* L. populations
Figure 6. The parasite complex controlling the Delia radicum L. populations.
Figure 7. The swarm of swarms of the *Brassica oleracea* var. *capitata* L. species
Figure 8. The parasitoid complex of the *Uroleucon cichorii* Koch. populations