

ON SOME FEATURES OF BEHAVIOR
OF THE ANTS *FORMICA RUFa* L. INFECTED
WITH FUNGOUS DISEASE

By P. I. MARIKOVSKY

The present paper deals with some interesting facts observed by the author in changes of behavior of ants infected with fungous disease. The author also makes a number of suppositions explaining to a certain degree this phenomenon.

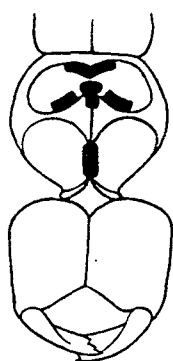
Ants are not usually subjects to the contagious diseases. This is especially true for the ants *Formica rufa* L. Close contact inside the ant nest, constant interchange with food belchings and wide cannibalism would help spreading any infection among a colony of ants and be the cause of their dying out. The capacity to resist the infectious diseases is a special feature acquired by a very rigid selection thanks to which the social system of life has been established. However the ant society is not quite free from the infectious diseases. The author, for instance, has had a chance to observe the fungous disease widely spread among *Tetramorium caespitum* (L) — one of the common species of ants in the southern regions of our country. The disease spread on a large territory, and was the cause of dying out of a large number of this species. In one case as a result of counteraction the ants started a very distant emigration of the colony. One part of the infested ants was left in their old nest, the other part had to be left on the way being too weak to follow their healthy mates (MARIKOVSKY, 1957). Later it was discovered that this disease was caused by the *Fungi Tarichium* sp. (RUDAKOV, 1959).

During four years the author has constantly observed and thoroughly studied the fungous disease of ants of this species in the vicinity of Tomsk city and in several regions of Western Siberia. This disease is very interesting because of its clearly marked specificity manifested by very peculiar changes in the behavior of ants.

As a rule, the disease spread during late summer and early fall. In spring and summer it was very seldom observed, and was of a sporadic nature. A few hours before death the infected ant would appear in a very good health, it could move about normally and even quite vigorously. It would also defend itself if attacked. It would emerge out from the nest and climb on the very tip of a low grass blade. As a rule, diseased ants chose the grass from 10 to 30 cm high, which would be necessarily in the vicinity of the ant-hill, or on the mound range.

Sometimes they chose grass growing near one of the busy trails leading from the nest. They never climbed on the grass growing far from their hill. It was especially easy to observe in shady forests with poor grass cover. Moreover so, as this species never climbs upon the grass. In this respect it is quite different from all other species. The ants of this species prefer the soil surface of forests and of other arboreous and shrub communities.

After inspecting the grass blade for some time the diseased ant clings fast to it with its mandibles. At the same time it moves its legs continuously in the air as if trying to gain a foothold. Some time later it presses its thorax to the plant in such a characteristic way by which one with some experience unmistakably recognises an infested ant. If the ant is forcibly taken off the plant and put on the top of the



ant-hill, it will again return to the vicinity of the nest and climb up the stem of the low grass. If the ant was taken away from the nest, its reaction was different depending on the ability to find its way back. Usually diseased ants climbed up the grass in the evening, which beside everything else, had a special significance.

FIG. 1. — The spots of appearance of viscous substance on the ventral surface are marked with thick lines.

On the top of the plant the ant very soon clutched the stem with its legs and gradually became quiet. At this moment in strictly defined spots of the seams between the segments of the central thoracic surface there appeared some viscous substance (fig. 1), with which the ant became glued to the stem. The substance hardened very quickly in the air. It looked like several transparent threads, which were pretty strong and would not soften in water. Simultaneously the ant closed its mandibles on the stem harder and harder. It resembled something like a spasm, for the ant was unable already to open the mandibles even if it was touched. Thus the ant became attached to the stem with the mandibles and transparent threads so fast that it took some time and effort to detach it. By this time the ant could hardly move with its legs and soon died. After being fixed the ants died very quickly. In the morning of the second day on the body of a dead ant in the intersegment folds there appeared narrow stripes of dazzling white fungus myselia, which grew through the ant's body. The appearance of the ant was quite unusual. White stripes girdled its abdomen in such a way that all its segments were clearly contoured. The thoracic segments, the bases of mandibles and even the antennae were clearly set off with such white stripes. On the third day mycelia gradually changed gray and on the long pedicles there appeared conidia. Conidia

were so numerous that they covered almost the whole body of the ant, which then looked like some woolly ball.

If the death of ants coincided with dry sunny weather fungi did not grow on all of them, and usually the symptoms of fungous disease did not appear on most of the dead ants. The damp warm weather was favorable for the growth of fungi. Possibly in damp weather fungi penetrated through the intersegment folds easier, while in the dry air they became hard and inflexible. In the laboratory conditions, as a rule, fungi grew only through the bodies of dead ants placed into a test tube with some damp cotton in it, and would not grow in a dry test tube.

Ants covered with conidia were the source of infection in other ants. However the healthy ants prevented the spreading of this disease themselves. A day or two after the epizooty broke out workers began to search for the diseased ants very carefully. The former crawled all over the place : around the hill and on the plants growing near the trails. They searched the vegetation most thoroughly, climbed up to the tip of grass stems where infected ants attached themselves before death. However, unlike the latter they did not stop there, but moved incessantly. Whenever they discovered an infested ant, they most painstakingly removed it from the grass. But a dead ant would be glued to the blade so fast that they had to take it by parts. First they detached its abdomen, then the thorax and at last the head. It was quite impossible to remove the body of a dead ant whole, because of its being attached to the blade so fast. Especially hard task for the healthy ants was to detach the head with its clutched mandibles. Thus, at a high death rate one could see numerous ant heads hanging from the blades at which the healthy ants were working hard.

The infected ants in the first stage of the disease did not look ill though they already tried to attach themselves to the blades. The healthy ants did not touch them but guarded them suspiciously for a long while. Sometimes they would try to pull the infected ones from the grass stem. However ants with strongly marked symptoms were destroyed by them at once.

Even long after the epizooty had been over the workers still were searching carefully for the dead ants.

The removed ants were usually carried into the nest and there eaten by the healthy ones. This could be easily detected by the empty cases thrown out from the nest. It is interesting to note that dead ants covered with gray conidia were never used for food, probably because of their contagiousness.

Long spells of cold weather during, which ants stayed within the nest, always were the cause of cessation of the epizooty. Most probably all the infested ants were killed within the nest at the very outset of the disease, which prevented further spreading of the epizooty. Thus cold weather served as a sort of quarantine against the disease.

In spite of the fact that the author has investigated the course of this epizooty most thoroughly, he as never succeeded in finding an infested queen, which usually stays within the nest, neither he has found its remains. It appears that infestation by fungi occurs outside the nest from dead ants hanging on the grass blades and serving the source of infection.

Fungous diseases, which make their victims climb up the very top of the plants, are known also in caterpillars of many species of butterflies. This feature of behavior is so strongly marked, that this disease has been called a « summit disease ». In the foothills of the Zailiskoe Ala-Tau Mountains the author has observed the same reaction in *Gonophyme semenovi* Zub., infested with fungi. The great number of these insects climbed up the tip of very high grasses and shrubs. Under the influence of solar irradiation some of the grasshoppers recovered (MARIKOVSKY, 1955), so it was surmised that the impulse to climb up was the instinctive urge towards the sunlight. In 1959 the author noted the same behavior in other species of grasshoppers in the Tuva A. S. S. R. Steinhaus (1952) in his well known paper also wrote about analogous phenomena in locusts. In 1959 the author registered mass death of caterpillars (unidentified) on the tips of wormwood growing in the ephemeral desert in the South-East of Kazakhstan (The Kopchegai Canyon). Some of the caterpillars climbed up the very top of plants periodically, stayed there for some time without any movement, then climbed down and continued their normal existence. The observations on ants proved the wrong conception formed earlier. And yet the sun irradiation may play some part in the control of the disease. Undoubtedly it was caused chiefly by the influence of fungus toxin on the behavior of insects, which has organic significance, as fungus spores from a dead insect are dispersed more effectively when it is on the vegetation growing near the ant-hill. Moreover, ants always climbed up the plants growing in the vicinity of the hill and trails — the principle site of aggregation of workers. The former chose only low plants, so that the wind could not carry the spores far away, which would be useless as the larger mass of healthy ants are always near the hill. Thus their climbing up can be explained only by the most suitable conditions for dispersion of spores.

Other features of behavior of the diseased ants were also very interesting. They never died in the nest, because they would be eaten by their healthy mates before their bodies were covered with spores. They clung to the very tip of a stem, otherwise certain part of the spores would be glued to the plant instead of being dispersed. The dying ant had spasms in the mandibles, which together with very peculiar sticky sweating from the thorax ensured its very fast clinging to the plant, so that workers were unable to remove the dead body at once. Infected ants crawled from the nest and climbed up the plants always in the evening, i. e. the time of the least activity of workers, especially during late summer and early fall. This greatly lessened their chance to be

removed from the plant too early. Moreover, there was no opportunity for them to have beneficial effect of the sun rays. The air at night was more humid, which facilitated the growth of fungi through the body. Thus the whole complex of an infested ant's actions was directed to the welfare of the fungus and served to its dispersion. Evidently the toxic substance exuded by the fungus influenced the ant's psyche and made it change its behavior in a certain direction. Such amazingly subtle adaptation of the pathogenic agent to its host could exist only with the help of creative role of natural selection — this powerful factor of evolution of the organic world. On the other hand, this factor proves the possibility to rule in some degree the psychic processes with the help of chemical substances or with subtle morphological influence, which cause the body of the fungus to take roots in the brain tissue. This supposition may seem almost fantastic, and yet, speaking in general, there are known certain substances which have influence on the behavior.

Evidently such cases of pathological influence of pathogenic agent on the psyche of a host are not singular. The influence of the virus of rabies on a mad dog in some respect is analogous to the above case. It is well known, that a mad dog tries to bite nearby people and animals, which helps the distribution of the virus.

Fungous disease is specific for the ants *Formica rufa* according to the marked features of adaptation.

By A. B. GUKASYAN, the agent of the fungus was *Alternaria tennis* Nes., which grows on lesions of certain plants. Possibly, ants were infested with this species from plants, while evolutionary cycle of the fungus is very complicated and passes through particular chain of hosts.

Summary.

The changes in behavior of the ants *Formica rufa* L. infested with fungi *Alternaria tennis* Nes. is described.

The disease has been observed during several years in Western Siberia. It appeared mostly during late summer and early fall. The infected ants leave their nest only in the evening, and climb up to the tip of low grass blades in the vicinity of the ant-hill and trails. Ants cling fast with their mandibles and legs to the blades, where they become glued to the substratum with sticky sweat exuded from thoracic articulations. The next day fungus mycella are grown through the ant's body, and on the third day conidii, or mature spores, begin to develop. In dry weather fungi do not grow through the bodies of dead ants.

With the commencement of the epizooty and appearance of dead ants near the nest, healthy ants begin to watch nearby vegetation very carefully. They remove the dead ants from the blades, carry them to

the nest and use them for food. The infectious ants, i. e. ants with mature spores of fungi grown through their bodies are left intact. If during the epizooty the weather becomes colder and ants stay within their nest the infection ceases. This is due, probably, to the fact that workers destroy the diseased ants in the nest before the growth of fungi takes place.

Behavior of the diseased ants serves well the pathogenic organisms and probably is influenced by the toxin of the fungus (escaping of the infected ants from the nest so as not to be destroyed; their escape occurring only late in the evening, when it is very damp which facilitates fungous growth through the ants; climbing on the grass in the vicinity of the ant-hill or near the trails so that depersion of fungus spores would be most effective; their sticking to the grass stems etc.).

Résumé.

Dans cet article, il s'agit de changements survenant dans le comportement des fourmis *Formica rufa* L. atteintes par le fungus *Alternaria tennis* Nes.

Cette maladie, qui se manifeste surtout à la fin de l'été et pendant l'automne, a été signalée durant quelques années dans la Sibérie occidentale.

Au cours de cette maladie, les fourmis malades quittent leur fourmilière chaque soir pour grimper sur le sommet des herbes basses autour de la fourmilière, ou tout près, non loin des sentiers. Là, les fourmis s'accrochent bien solidement aux brins d'herbes par leurs mâchoires et leurs pattes. L'exsudat visqueux se formant aux articulations du thorax fixe l'insecte fortement au substrat. Le lendemain les mycelium du mycète germent à travers le corps des fourmis et, le surlendemain, on voit apparaître les spores matures, les conidies. Si la mort des fourmis advient en temps sec, la germination du mycète n'a pas lieu.

Dès le commencement de l'épizootie, à l'apparition des premières fourmis mortes autour de la fourmilière, les fourmis bien-portantes inspectent minutieusement la végétation d'alentour et enlèvent les fourmis mortes pour les emporter dans la fourmilière, où elles servent de nourriture pour les autres. Elles ne touchent pas aux fourmis contagieuses, portant les spores matures, et celles-ci restent en place sur leurs brins d'herbe. En cas de refroidissement subit survenant au cours de l'épizootie, la maladie est coupée, car le froid empêche les fourmis de sortir et tous les insectes malades sont détruits, probablement, dans la fourmilière — même avant leur mort et la germination des conidies.

Tout le comportement des fourmis malades est favorable à l'agent de la maladie, et il paraît que c'est une conséquence de l'activité — même de la toxine de cette mycose (la sortie des fourmis malades hors de la fourmilière pour éviter la destruction anticipée; la sortie pour la

nuit justement pendant l'humidité la plus importante, qui favorise la germination du mycète; l'ascension des insectes sur les herbes autour de la fourmilière et non loin de là, près des sentiers, facilite la dispersion effective des spores; l'attachement à la végétation).

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