= GENERAL BIOLOGY =

Interaction of the Ant *Myrmica rubra* L. as a Predator with Springtails (Collembola) as a Mass Prey

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Active hunting of ants for springtails has been considered thus far only as an exotic phenomenon. Although springtails (small Apterygota) are abundant inhabitants of the litter-soil stratum in various natural zones and landscapes throughout the world, they should not be regarded as a readily available prey for predatory invertebrates. Indeed, most species of springtails have a jumping forked appendage (furcula) attached at the end of the abdomen. The furcula is a jumping apparatus enabling the animal to catapult itself (hence the common name springtail), thereby changing sharply the direction of the springtail's movement. Of various ant groups, only tropical species of the tribe Dacetine have been known so far as active hunters for springtails. Some of these species (e.g., Strumigenys ludia and Trichoscapa membranifera) are specialized hunters for this prey and develop the corresponding morphological structures intended to facilitate catching and holding of springtails (e.g., snap-on mandibles). In combination with specific behavioral stereotypes, these morphological structures allow these species of ants to be effective "springtailers" (for review, see [3]). However, nothing has been yet known about the possible trophic interactions between ants and springtails in nontropical regions. Ants of the genus Myrmica are as abundant inhabitants of soil and litter in the forest and steppe-forest zones as the springtails Collembola. Although many authors reported that collembolans make up a significant fraction of the Myrmica food, it has been widely believed until now that these ants are only capable of collecting either dead or immobile (e.g., postmoult) springtails [1].

The goal of this work was to describe the results of field experiments in which we, for the first time, studied relationships between *M. rubra* and springtails as a predator and a mass prey, respectively.

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Experiments were carried out at the forest-park zone near Novosibirsk Akademgorodok in 1998–2000 after experimental methods had been developed and tested in 1997. Preliminary experiments showed that M. rubra is a specialized species. Therefore, we used Lasius niger, a species of soil ants of the same size category and similar food spectrum, for comparison. The following method was developed to observe the process of hunting. Live springtails (Tomocerus sibiricus) were placed into glass containers (diameter, 6 cm; height, 12 cm) with gypsum bottom, 30 specimens per container. A transparent substrate (polystyrene scrap of chopped plastic bottles) was added to the containers to simulate forest litter. Methodological experiments revealed that, under these conditions, ants displayed hunting and searching behavior, whereas no such behavior was observed in containers with springtails but without litter-like substrate. It may be suggested that litter (or litter-like substrate) provides both shelter for prey and a system of hunting traps, thereby facilitating the prey-catching behavior of those predators who are capable of bringing potential prey to bay.

Open containers were dug in soil near ant nests. A total of 11 families of M. rubra and 3 families of L. niger were monitored during periods of high behavioral activity from 9:00 to 12:00 a.m. and from 17:00 to 22:00 p.m. (a total of 70 h). The food units brought by M. rubra to the nests were counted for seven days in the 11 nests to estimate the fraction of springtails in ant food under natural conditions. In special experiments, the hunting activity of ants was compared at sites with different sizes of springtail populations. The dynamic density of Collembola was estimated using a transparent plate (225 cm²) placed on the surface of litter [7]. Springtails were counted at four plots (10 counting sessions each) near each of the six Myrmica nests chosen as reference. Then, 20 ant specimens were taken from the feeding area of each plot and placed one-by-one into the experimental container, and their behavior was monitored until the ants left the container. The number of aggressive contacts of ants with springtails was counted in habitats with high and low abundances of springtails.

Ant family	Number of ants visited the container	Mean time spent by ants in the container, min	Mean number of aggressive contacts of ants with springtails	Total number of springtails killed by ants
M. rubra 1	30	5.20 ± 2.10	1.67 ± 0.28	18
M. rubra 2	17	7.50 ± 2.50	1.80 ± 0.32	10
M. rubra 3	24	8.00 ± 2.21	1.79 ± 0.31	19
L. niger 1	17	12.00 ± 1.80	0.22 ± 0.04	4
L. niger 2	21	9.50 ± 2.00	0.57 ± 0.09	3
L. niger 3	12	9.00 ± 1.95	0.49 ± 0.08	0

Table 1. The results of *Myrmica rubra* and *Lasius niger* hunting for springtails

Table 2. Comparative data on the hunting efficiency of the *Myrmica rubra* families living in places with different population densities of springtails

No. of the <i>Myrmica</i> rubra family	Springtail population density (number of specimens per 225 cm ²)	Number of aggressive contacts of ants with springtails (mean value averaged over 20 ants)	Number of prey units brought by ants for 2 h	Fraction of springtails in prey, %	Characteristic of habitat
4	0	0.35 ± 0.6	19	0	Dry pine forest
5	0	0.20 ± 0.3	19	0	The same
6	2.10 ± 0.4	0.54 ± 0.09	18	17	Birch forest
7	6.8 ± 1.56	3.10 ± 0.53	34	36	Pine forest
8	6.8 ± 1.56	3.31 ± 0.57	22	80	The same
9	8.1 ± 1.25	7.30 ± 1.33	28	100	The same

Field experiments demonstrated an unexpectedly high activity of *Myrmica* hunting for springtails. Moreover, it seems that these ants are able to adapt themselves to this particular prey by developing specific hunting stereotypes. Comparative assessment of L. niger and Myrmica revealed that, although the two groups of ants were capable of catching live springtails, the former ants are significantly less successful hunters than the latter. It follows from Table 1 that, even though the L. niger ants spent more time in containers than Myrmica, the latter caught two to three times as many springtails as the former. According to our observations, in all cases of successful hunting, L. niger caught springtails as a result of accidental encounters rather than goal-seeking behavior. All specimens of L. niger demonstrated similar behavior. They neither searched for prey nor pursued it. Upon encountering a springtail, the L. niger ant tried to catch it, but without using specific hunting tricks. In the case of successful catching, the prey was transported to the nest, but the hunter never returned back to the container for new prey. In contrast to L. niger, the M. rubra ants fell into two groups, which distinctly differed from one another in relationships with the potential prey. Some ants demonstrated indifferent behavior, whereas the other ("springtailers") demonstrated searching and sufficiently specific hunting behavior. These ants moved relatively fast and freely through the bulk artificial litter. Once the ant found itself in the immediate proximity to a springtail, it attacked the prey (bent the abdomen and head to the thorax and jumped to the springtail). In the case of a successful catching attempt, the prey was transported to the nest, and the hunter returned back to the container for new prey.

The results of hunting were assessed in a special series of experiments, in which experimental containers were placed near six nests of *Myrmica*. Of 292 visits of ants to the containers, 157 visits resulted in successful attempts of springtail catching. This catching rate is regarded as sufficiently high for both invertebrate and vertebrate predators [2].

Comparative analysis of the hunting activity of *Myrmica* families living in places with different densities of springtail population demonstrated that, in places with high population densities of the potential prey, both the fraction of springtails in the natural food spectrum and the number of aggressive contacts of ants with springtails in containers were higher than in the places with low density of population of the potential prey (Table 2). This suggests that the ants *Myrmica* are capable of switching to Collembola as a mass prey. The ability of ants to switch to such a specific object of hunting and use elements of stereotypic (probably, specialized) hunting behavior requires additional research. It should be noted that the switching ability of predators based on image formation was generally described for the first

time by Tinbergen in 1960 [6] and has mainly been studied on predatory birds since then [5]. We only know one study of the switching ability of invertebrate predators [4]. It was shown by Lawton *et al.* that, on the basis of accumulated hunting skill, the water bug *Notonecta glauca* was capable of switching from feeding on one species of small crustaceans to another abundant species replacing the former in the aquatic ecosystem [4].

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