

Ewa Joanna GODZIŃSKA\*, Maria KIERUZEL, Julita KORCZYŃSKA

**Predation of ants of the genus *Formica* L. (Hymenoptera, Formicidae) on Colorado beetles, *Leptinotarsa decemlineata* SAY (Coleoptera, Chrysomelidae)**

**Abstract.** Possibility and effectiveness of attacks of *Formica* L. (especially *F. rufa* L. and *F. polyctena* FOERST.) ants on Colorado beetle adults and larvae were studied, with special regard to occurrence and effectiveness of chemical and behavioural defence of victims. Field experiments were carried out at a few sites in central-eastern Poland in 1984-1988.

INTRODUCTION

Colorado beetles (*Leptinotarsa decemlineata* SAY) are well known as pests of potatoes and other plants of the family *Solanaceae*. They are particularly well protected against predators. Adult beetles may display four defensive reactions: 1) secretion of drops of repellent substances produced by defensive glands located on their pronotum and elytrae; 2) secretion of drops of haemolymph (so called "reflex bleeding"); 3) regurgitation of crop contents; 4) defecation (DEROE, PASTEELS 1977, DALOZE et al. 1986). Both adults and larvae protect themselves also by accumulating alcaloid solanine, produced by their principal host plant, the potato (WĘGOREK 1957).

In this report we present the data demonstrating that these multiple systems of chemical defense do not, however, protect Colorado beetles from ants of the genus *Formica* L. We summarize briefly the cases of spontaneous ant predation on Colorado beetle, recorded in central-eastern Poland in 1984-1986 by GODZIŃSKA (1986, 1989). Next we report the results of pilot field tests, in which we observed responses of *F. polyctena* FOERST. and *F. rufa* L. to adults and larvae of beetles, released near the ant-hills.

ANT PREDATION ON COLORADO BEETLE

(after GODZIŃSKA 1986, 1989)

In 1983-1984, the population of Colorado beetle in Poland reached one of its peaks [PIEKARCZYK, pers. comm. (according to data of the Institute of Plant Protection, Poznań)]. During the summer 1984, large numbers of dispersing adult beetles could be found practically in all habitats, including forests and towns. For

\* Previous address: Université Paris Nord, Laboratoire d'Éthologie et Sociobiologie, URA C.N.R.S. 667, Av. J. B. Clément, F 93430 Villetaneuse (France).

example, at one site in central-eastern Poland (the locality of Golice), estimate density of adult Colorado beetles along a road in a patch of a mixed forest, more than 1 km from the nearest potato field, reached 0.9 individuals per 1 m<sup>2</sup>.

During that time, more or less ample and direct evidence for predation on Colorado beetle was found for 10 colonies of four *Formica* species, namely *F. polyctena* (7 colonies denoted here as 1–7), *F. rufa*, *F. pratensis* RETZ., and *F. rufibarbis* FABR. (one colony of each, denoted, respectively, as 10, 12, and 13). These colonies were situated at 4 sites: Mrozy, Golice, Brzozów, and Rzeszotków (Fig. 1), in various habitats.

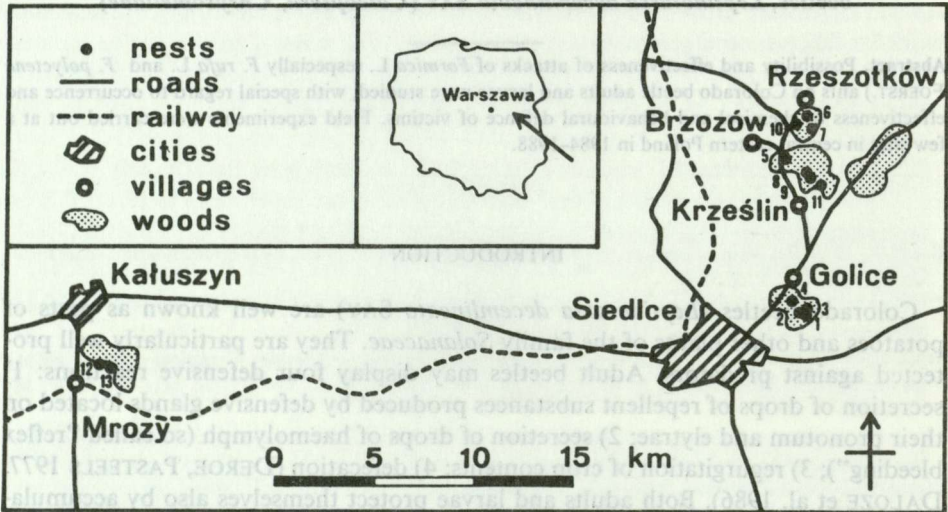


Fig. 1. Location of the observed ant colonies: 1–9 – *F. polyctena*; 10, 11 – *F. rufa*; 12 – *F. pratensis*; 13 – *F. rufibarbis*.

Ants were observed attacking and dragging adult beetles (Colonies 1, 3, 4, 7, 10), carrying their remnants (1–3, 5), and regularly attacking and dragging L<sub>3</sub> and L<sub>4</sub> larvae (12). Numerous remnants of adult Colorado beetles were also found on dumping grounds of the *F. polyctena* colonies (1, 3, 5–7) and the colony of *F. rufibarbis*. The dumping ground of *F. pratensis* contained few Colorado beetle elytrae (GODZIŃSKA 1986).

In 1985, only a single case of dragging of adult Colorado beetle was recorded for one of the *F. polyctena* colonies (1) at the site of Golice (GODZIŃSKA 1986). In 1986, some remnants of adults were found at dumping grounds of three *F. polyctena* colonies at the sites of Golice (1) and Rzeszotków (3, 6), and of another colony of this species (8) at a new site of Krześlin (GODZIŃSKA 1989).

These observations suggested the existence of interspecific differences of hunting behaviour in ants, directed towards Colorado beetle. *F. rufibarbis* ants evidently had difficulties in cleaning and cutting up adult beetles, and they almost completely avoided that prey in 1984. *F. pratensis* hunted regularly Colorado beetle larvae but it almost did not hunt adults, although they were equally easy available. Several

colonies of *F. polyctena* hunted adult beetles regularly and/or on a large scale. These ants attacked both individuals strayed into forests and ones stayed on nearby fields.

#### RESPONSES OF *F. POLYCTENA* AND *F. RUFa* TO ADULTS AND LARVAE OF COLORADO BEETLE

##### Experiment 1 (after GODZIŃSKA 1986)

The experiment was carried out in June 1984. 15 adult beetles were released on a small patch of bare soil close to the nest of Colony 1 of *F. polyctena*. The beetles were thoroughly soaked in a mixture of their defensive secretions. To provoke releasing of these secretions, the beetles were shaken in a glass jar.

Within 1 minute of their release near the nest, all the beetles were seized by ants. Attacking ants showed no signs of being repelled either by defensive secretions covering beetle bodies, or their drops fallen on the ground.

##### Experiment 2

The experiment was carried out in July-August 1988. We observed *F. polyctena* ants from Colony 9. It was situated at the site of Krześlin, in a patch of a mixed forest composed mainly of pines and oaks, about 400 m from the forest border. There were no potato fields closer than about 1 km from the nest. 33 larvae (L<sub>4</sub> instar) were released close to the nest on 3 consecutive days (7-9 July 1989), and then after one month. The larvae were always collected just before the test. To provoke the release of defensive secretions, they were shaken in a glass tube. They were always released at the same point, about 30 cm from the nest, within the ring of bare soil. During each test we recorded the latency from the release of the larvae to the first ant attack. Then, every 5 minutes we recorded the number of ants attacking each larvae not yet transported to the nest. The observations were continued until all the larvae were carried to the nest.

Table. Responses of *F. polyctena* ants to 33 larvae of Colorado beetle released near their nest on 3 consecutive days and after one month

	7 July	8 July	9 July	9 August
First attack after ... seconds	15	3	1	2
All the larvae attacked after ... minutes	40	20	25	15
First larvae dragged to the nest during ... minutes	15-20	5-10	0-5	0-5
Number of larvae transported to the nest after 10 minutes	-	2	6	8
All the larvae dragged to the nest after ... minutes	75	55	90	70

Results were as follows (Table):

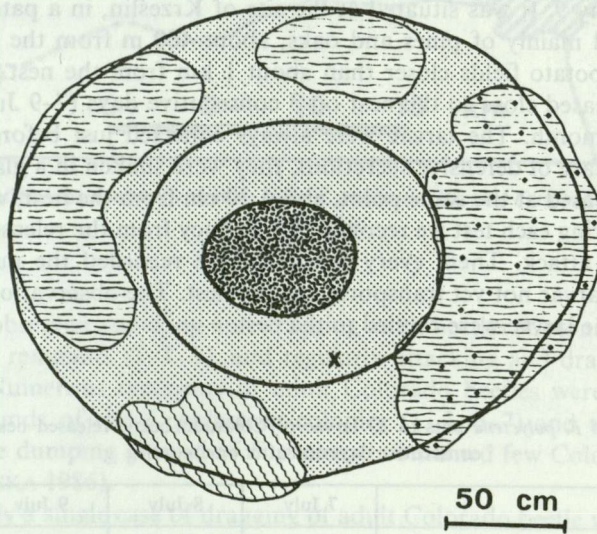
1) During all the tests, ants attacked the larvae almost unhesitatingly (after 1–15 seconds);

2) All of the released larvae were accepted as prey – attacked and then transported to the nest;

3) Contact with larvae and their defensive secretions was not followed by avoidance them by ants during subsequent tests. Interestingly, predatory behaviour of ants changed towards facilitation rather than acquired aversion: during subsequent tests, the larvae were attacked more readily, and transported to the nest quicker than on the initial test.

### Experiment 3

The experiment was carried out on 8 July 1988. 10 larvae ( $L_4$ ) and 10 adults were simultaneously released near the nest of Colony 10 of *F. rufa* at the site of Krześlin, about 400 m from the border of a wood. The ant-hill, about 50 cm in diameter, was surrounded by a wide ring of bare sand, and then by an outer, about 60 cm wide ring of slightly elevated soil, overgrown by patches of blackberries, high grasses (*Agrostis vulgaris* WITH.), and herbs of *Rumex acetosella* L. The beetles were released about 30 cm from the nest, within the ring of bare soil (Fig. 2). During the








-  ant hill
-  sand
-  *Agrostis vulgaris* With.
-  *Rumex acetosella* L.
-  *Vaccinium myrtillus* L.

Fig. 2. Surroundings of the nest of Colony 11 of *F. rufa* (X – place of the release of Colorado beetles).

test, we recorded the latency from the start of the test to the first attack on an adult and on a larva. Then, every 5 minutes we counted the number of ants attacking each of the beetles not yet dragged to the nest. We noted also the occurrence of behavioural defensive responses of the beetles, such as firm gripping of twigs [a defensive reaction reported in chrysomelids by EISNER (1972)], and gripping of twigs followed by climbing up the plants. The test continued during 90 minutes.

Adult Colorado beetles were attacked by *F. rufa* sooner than the larvae. Whereas the first attack directed at an adult took place 20 seconds after the start of the test, the larvae were left unattacked until 62 seconds. As seen in Fig. 3, during 90 minutes ants transported to the nest almost all (9) of the released larvae, but only half (5) of the adults. Half of the larvae were carried to the nest already 20 minutes after the start of the test. Thus, although ants attacked at first the adults (probably

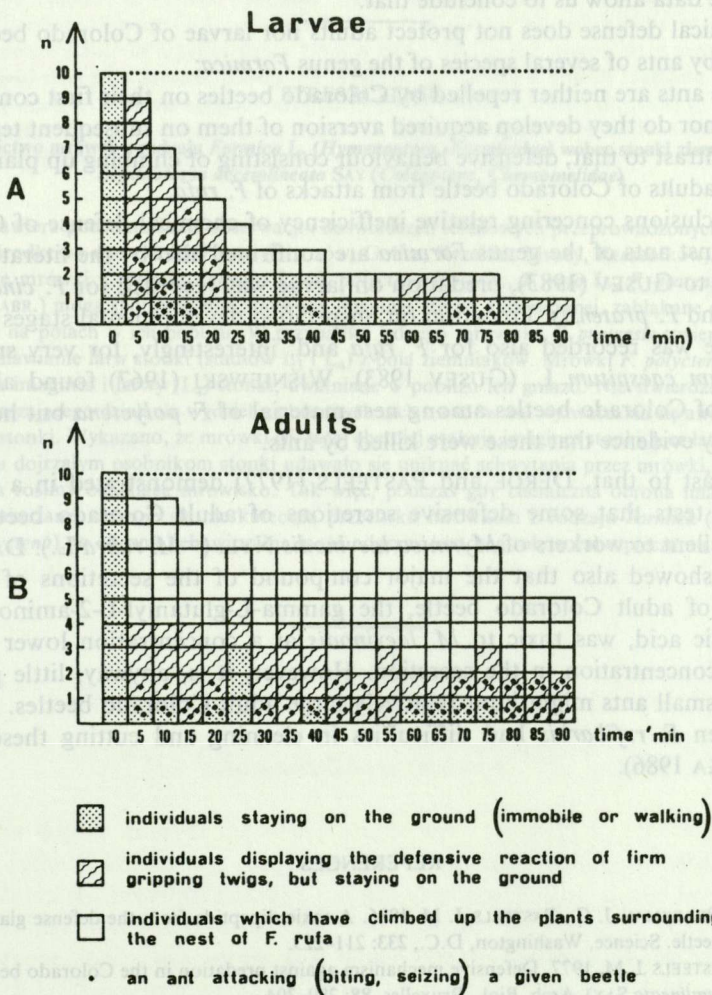


Fig. 3. Numbers (n) of Colorado beetle larvae (A) and adults (B) not yet dragged to the nest as function of time from the start of the test. (Each square represents one individual).

because they were mobile, and produced more stimuli eliciting behaviour), they captured first the larvae. To explain that, we may observe that, as seen in Fig. 3, workers of *F. rufa* continued to attack individuals which were gripping twigs but they never pursued those which had climbed up plants. As can also be seen, although the defensive response of climbing up plants was displayed both by the larvae and the adults, the last ones were much more skilled in climbing plants and resting there. It was thus due to that behaviour that adults were relatively well protected against attacks of *F. rufa*.

#### DISCUSSION

All these data allow us to conclude that:

- 1) Chemical defense does not protect adults nor larvae of Colorado beetle from predation by ants of several species of the genus *Formica*;
- 2) These ants are neither repelled by Colorado beetles on their first contact with that prey, nor do they develop acquired aversion of them on subsequent tests;
- 3) In contrast to that, defensive behaviour consisting of climbing up plants seems to protect adults of Colorado beetle from attacks of *F. rufa*.

The conclusions concerning relative inefficiency of chemical defense of Colorado beetle against ants of the genus *Formica* are confirmed also by the literature data. According to GUSEV (1983), predation on larvae was recorded for *F. cinereofusca* KARAW. and *F. pratensis*. Predation on unspecified developmental stages of Colorado beetle was recorded also for *F. rufa* and, interestingly, for very small ants *Tetramorium caespitum* L. (GUSEV 1983). WIŚNIEWSKI (1967) found also some remnants of Colorado beetles among nest material of *F. polycetena* but he did not provide any evidence that these were killed by ants.

In contrast to that, DEROE and PASTEELS (1977) demonstrated in a series of laboratory tests that some defensive secretions of adult Colorado beetles were highly repellent to workers of *Myrmica laevinodis* NYL. (= *M. rubra* L.). DALOZE et al. (1986) showed also that the major compound of the secretions of defensive glands of adult Colorado beetle, the gamma-L-glutamyl-L-2-amino-3(2), 5-hexadienoic acid, was toxic to *M. laevinodis* at a concentration lower than its estimated concentration in the secretion. However, it is, anyway, little probable that these small ants might hunt relatively large adult Colorado beetles. As mentioned, even *F. rufibarbis* had difficulties in cleaning and cutting these insects (GODZIŃSKA 1986).

#### REFERENCES

- DALOZE D., BRAEKMAN J. C., PASTEELS J. M. 1986. A toxic dipeptide from the defense glands of the Colorado Beetle. Science, Washington, D.C., **233**: 211-223.
- DEROE C., PASTEELS J. M. 1977. Defensive mechanism against predation in the Colorado beetle (*Leptinotarsa decemlineata* SAY). Arch. Biol., Bruxelles, **88**: 289-304.
- EISNER T. 1972. Chemical ecology: on arthropods and how they live as chemists. Verh. dtsh. Zool. Ges., Hamburg, **65**: 123-137.

- GODZIŃSKA E. J. 1986. Ant predation on Colorado beetle (*Leptinotarsa decemlineata* SAY). J. appl. Ent., Hamburg, **102**: 1-10.
- GODZIŃSKA E. J. 1989. New records of predation of the ant *Formica polyctena* FÖRST. on adults of Colorado Beetle (*Leptinotarsa decemlineata* SAY) in Poland. Pol. Pismo ent., Wrocław, **58**: 831-833.
- GUSEV G. V. 1983. Annotirovannyj spisok entomofagov koloradskogo zhuka. Byull. VPS MOBB, Moskva, **7**: 6-34.
- WĘGOREK W. 1957. Stonka ziemniaczana (*Leptinotarsa decemlineata* SAY) na tle biocenozy pól ziemniaczanych. Pol. Pismo ent. Ser. B, Wrocław, **5**: 31-43.
- WIŚNIEWSKI J. 1967. Analiza resztek pochodzenia zwierzęcego występujących w mrowiskach *Formica polyctena* FÖRST. (*Hym.*, *Formicidae*). Pol. Pismo ent., Wrocław, **37**: 385-390.

Instytut Biologii Doświadczalnej PAN  
im. M. Nenckiego  
Zakład Neurofizjologii  
ul. Pasteura 3, 02-093 Warszawa (Poland)

#### STRESZCZENIE

#### Drapieżnictwo mrówek z rodzaju *Formica* L. (Hymenoptera, Formicidae) wobec stonki ziemniaczanej, *Leptinotarsa decemlineata* SAY (Coleoptera, Chrysomelidae)

Artykuł zawiera podsumowanie obserwacji i doświadczeń terenowych przeprowadzonych na 5 stanowiskach w środkowo-wschodniej Polsce (Brzozów, Golice, Krześlin, Mrozy, Rzeszotków). Obserwacje wykazały, że mrówki z rodzaju *Formica* L. (*F. polyctena* FOERST., *F. rufa* L., *F. pratensis* RETZ., *F. rufibarbis* FABR.) mogą spontanicznie atakować imagines stonki ziemniaczanej, zabłąkane do lasów lub występujące na polach w ich pobliżu. W przypadku jednego mrowiska *F. pratensis* stwierdzono także regularne odławianie larw stonki (stadiów L<sub>3</sub> i L<sub>4</sub>) z pola ziemniaków. Mrówki *F. polyctena* atakowały bez wahania imagines i larwy (L<sub>4</sub>) stonki, uwalniane w pobliżu ich gniazd. Nie stwierdzono żadnych oznak odstrasżającego działania wydzielin obronnych tych owadów ani wytwarzania się awersji mrówek wobec larw stonki. Wykazano, że mrówki (*F. rufa*) chętniej atakują imagines stonki, lecz łatwiej zabijają larwy. Wielu dojrzałym osobnikom stonki udawało się uniknąć schwytania przez mrówki, dzięki wspinięciu się na rośliny okalające mrowisko. Tak więc, podczas gdy chemiczna obrona imagines i larw stonki ziemniaczanej okazuje się nieskuteczna przeciwko mrówkom z rodzaju *Formica* (zwłaszcza *F. rufa* i *F. polyctena*), to obrona behawioralna może odgrywać istotną rolę w zabezpieczeniu stonki przed ich atakami.