

ANTIPREDATORY SIGNALIZATION OF LADYBIRDS (COLEOPTERA: COCCINELLIDAE)

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Introduction

The ladybird beetles (Coleoptera: Coccinellidae) have been believed to be a textbook example of aposematic insects. There are two groups of organic chemicals used by ladybirds for defense: alkaloids and pyrazines. Both of them are generally widespread among ladybirds and present in their hemolymph actively excreted in tibiofemoral junctions when attacked by vertebrate or arthropod predators. Alkaloids cause the poisonousness of ladybirds and pyrazines are used as a repellent working on longer distances. The unprofitability (and often dangerousness) of ladybirds as a prey is usually proclaimed by bright coloration (combinations of red, yellow and black). Nevertheless, actual effectivity of antipredatory signalization of ladybirds has rarely been studied before.

In our study we tried to test this effectivity using adult (in wild caught) and naïve (hand-reared) birds (great tit *Parus major*) as predator, and several ladybird species common in central Europe as a prey.

Actually, we tested

- the reaction of adult birds to several species of ladybirds different in pattern, body size and color (*Coccinella septempunctata*, *Exochomus quadripustulatus*, *Subcoccinella vigintiquatuorpuntata*, *Cynegetis impunctata* - Fig. 1, 2, 3, 4),
- the reaction of adult birds to *Coccinella septempunctata* without warning coloration (brown painted),
- the reaction of adult birds to *Coccinella septempunctata* with changed body appearance (removed elytra),
- reaction of naïve predators to two unmodified ladybird species (*Coccinella septempunctata* and *Scymnus frontalis* - Fig. 5).



Fig. 1 - *Coccinella septempunctata*



Fig. 2 - *Exochomus quadripustulatus*



Fig. 3 - *Subcoccinella vigintiquatuorpuntata*



Fig. 4 - *Cynegetis impunctata*



Fig. 5 - *Scymnus frontalis*

Material and methods

Ladybirds for experiments were collected in the field in South Bohemia (Czech Republic), and stored at low temperature in laboratory. Experimental predators were a) caught as adults in the field in South Bohemia as well, b) taken from nest boxes at the age of 10 days and hand reared till they were able to forage independently. Experiments were conducted in cages where individual ladybirds were presented to particular birds. 15 individual birds were used for testing each type of prey. Each bird was successively confronted with five ladybirds to check possible effect of neophobia. The duration of each session was five minutes. Number of birds that attacked at least one of the five offered ladybirds was used as a measurement of admissibility of a particular ladybird species (type) as a prey. Each of the naïve birds was tested four times - first, second, eighth and ninth day, to reveal the ability of birds to learn, memorize and recall the ladybird signalization.

Results

Differences between particular ladybird species: The only difference between ladybird species in the attack rate was found between *Cynegetis impunctata* and the other tested species (ANOVA: $F_{4,95}=5.20$, $p=0.003$; and subsequent Fischer LSD post hoc tests). The other species (*Coccinella septempunctata*, *Exochomus quadripustulatus*, *Subcoccinella vigintiquatuorpuntata*) were attacked equally (Fig. 6).

Differences between Coccinella modifications: The number of birds that attacked at least one of the five offered *C. septempunctata* with removed elytra was significantly higher than the number of birds that attacked unmodified or brown painted form (ANOVA: $F_{2,142}=9.17$, $p<0.001$; and subsequent Fischer LSD post hoc tests). There was no significant difference in risk of attack between unmodified and brown painted form of *Coccinella septempunctata* (Fig. 6).

Differences in reactions of naïve birds: There was no difference between reactions of birds toward both tested ladybird species. The naïve birds attacked ladybirds (only *Coccinella septempunctata* was used in experiments) significantly more often than experienced adults (Fischer exact test, $p=0.021$). There were significant differences in reactions of birds toward both ladybird species during the four experimental repetitions (ANOVA, $F=4.1$, $p=0.008$). The attack rate was significantly lowered on the second day, but it was the same on the eighth and ninth days as on the first day (Fig. 7).

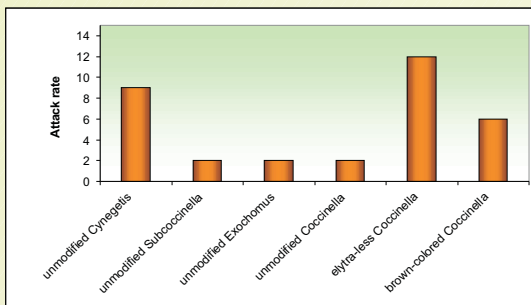


Fig. 6 - Number of adult birds that attacked at least one of five offered ladybirds

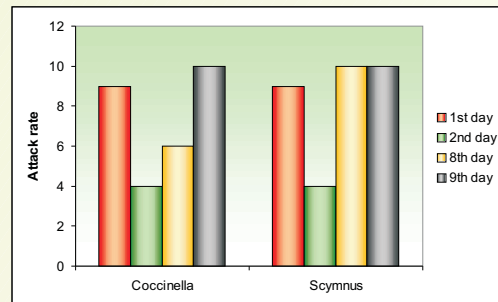


Fig. 7 - Number of naïve birds that attacked at least one of five offered ladybirds

Conclusions I

Results based on four ladybird species proved a low importance of body size as well as number, shape and colour of spots of the ladybird but a high importance of presence of spotted pattern. The only plain colored species *Cynegetis impunctata* was attacked more often than the spotted species.

Contrary to this, experiments with optical modifications of *Coccinella septempunctata* suggested low importance of both the coloration and the spotted pattern of the beetle. Brown painted ladybirds were attacked similarly often as those unmodified.

Nevertheless, there is a high importance of general ladybird body appearance (oval or rounded convex shape); since ladybirds with removed elytra were no longer recognized as ladybirds (might be confused to some dipterans).

Acknowledgement

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Conclusions II

Experiments with naïve birds suggested that the unprofitability of the ladybirds has to be learned (at least by two thirds of great tits) as the naïve birds attack ladybirds more often than the adults. The chemical abilities of ladybirds to threaten predators' lives are generally high, so we expected that the ability to recognize a ladybird is very essential and is innate, because trying to feed a ladybird might be fatal for the predator. Nonetheless, we can suggest that the predator has an opportunity to learn the inedibility of ladybirds during simply handling them, as no ladybird in our experiments has been eaten.

Moreover, the process of learning is not fast and easy, since individual birds in our experiment forgot the unprofitability during one week and were not able to learn it again during one day.