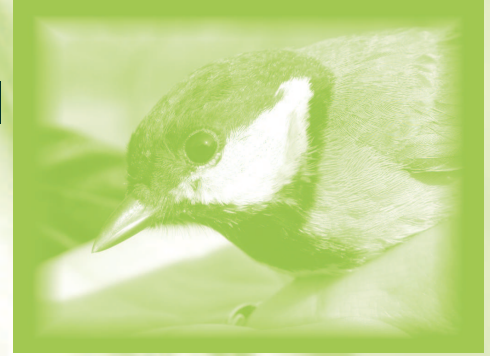


# The role of black pattern elements in the anti-predator warning signal in pyrrhocoroid bugs

Milena Prokopová, Roman Fuchs and Jan Zrzavý

Department of Zoology, Faculty of Biological Sciences, University of South Bohemia  
 Branišovská 31, České Budějovice 370 05, Czech Republic



## Introduction

Pyrrhocorid bugs represent a group of mostly unpalatable species whose coloration is generally regarded as warning (aposematic). Some elements of their colour patterns are homologous across a wide phylogenetic group (Pyrrhocoroidea), viz., the black pattern on the forewing, pronotum and scutellum (Zrzavý 1999). Earlier, we have found out that wild-caught bird predator (Great tits, *Parus major*) strictly avoided adults of the red-black firebug (*Pyrrhocoris apterus*) but often attacked its 5th instar larvae, although both are conspicuously coloured, unpalatable, and of similar size (in prep). However, they clearly differ in their black pattern organization. Therefore we tested whether discrimination of the aposematic of the pyrrhocorid bugs by their predators may be affected by details of the black pattern.

Fig. 1. Variants of the firebug pattern



## Results

- The experimental birds touched no firebugs carrying the *normal* pattern label (see Fig. 2). Birds also avoided to touch the *black more*, *black less*, *inverse*, and *spotted* patterns.
- The birds tend to avoid attacking most other pattern variants, viz., *fully red*, *longitudinally halved*, *stripe*, *camouflage*, *corium*, and *corium less* patterns, with a few exceptions (1-2 of 9 birds tested). In cases of the *pronotum* and *scutellum* patterns, 3-4 birds attacked the prey but the differences between these pattern variants on the one hand and the *normal* pattern on the other were not significant.
- A larger number of birds (5-6 of 9) attacked only firebugs carrying the *black* and *transversally halved* patterns, with significant differences between the numbers of birds touching prey items carrying one of these and those touching the *normal* pattern (see Tab. 1).

Tab. 1 Numbers of Great tits that touched and/or killed at least one prey item in the two trials of an experiment. The last column shows significance levels of Fisher's exact test, compared with the experiments with birds to which normal pattern was presented. The red colour indicates the significant differences.

Pattern	Birds touched at least one prey	Birds killed at least one prey	Fisher exact test (p)
normal	0	0	-
fully red	2	1	0.4706
fully black	5	3	0.0294
black more	0	0	>0.5
black less	0	0	>0.5
inverse	0	0	>0.5
corium less	1	1	>0.5
corium	1	1	>0.5
pronotum	3	1	0.2059
scutellum	4	2	0.0824
transversally halved	6	4	0.0090
longitudinally halved	2	1	0.4706
camouflage	2	0	0.4706
spotted	0	0	>0.5
stripe	2	0	0.4706
sum	28	14	-

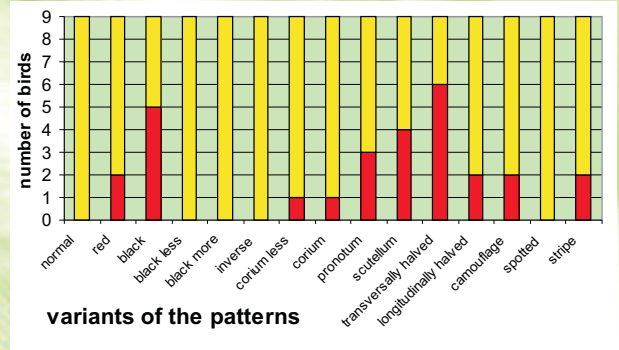


Fig. 2 Numbers of birds that touched a firebug (red).



*Pyrrhocoris apterus* carrying the *corium less* pattern label

## Conclusions

- The artificial *normal* aposematic pattern was able to protect the firebugs from bird attacks. The method of artificial pattern labels is then suitable for investigating the role of different pattern elements.
- Birds avoided to attack firebugs with the patterns different insignificantly from the *normal* pattern, with retained number as well as arrangement of pattern's elements (*black more*, *black less*, *inverse*). With respect to natural variability of the black:red ratio in firebug coloration, birds should be able to adjust their reactions to such minor differences.
- The *spotted* pattern was also strongly avoided, possibly because this pattern could evoke an aversive reaction originally caused by other aposematic species, e. g., by ladybirds.
- We have considered *a priori* that the "eye-like" spots on the corium might be an important element of the warning signal. Indeed, only one bird attacked firebugs carrying the *corium* pattern label; however, birds also refused the *inverse*, i. e., *corium less*, pattern from which the spots were eliminated.
- Unfamiliar patterns (*stripe*, *longitudinally halved*, and *camouflage*) evoked an aversion in majority of the experimental birds, which may be explained as a neophobic behavior. However, the aversion decreased gradually from the *pronotum* through the *scutellum* to the *transversally halved* patterns. The firebugs carrying the last pattern labels strongly suffered from the bird predation although this completely unnatural coloration was expected to evoke the neophobic reaction as well.
- Effects of the one-colour patterns, *fully red* and *fully black*, were different. While the first pattern helped to protect firebugs from a bird attack, the second often failed in this role (2 resp. 5 of 9 tested birds). These results indicate that the red colour itself provides protection for the firebugs to a certain extent. Earlier analyses of the bird behavior to variously coloured (white, yellow, orange) but identically patterned mutants of *P. apterus* (in prep.) yielded the same results.
- In general, all pattern variants that retain more or less symmetrical distribution of the black pattern elements along the anterior-posterior axis (like in the wild form, *normal* pattern) were able to evoke a strong aversion. When the birds encountered patterns with the black elements concentrated onto either anterior or posterior halves of the body (*pronotum*, *scutellum*, *transversally halved*), their aversion decreased, and the birds were ready to attack this prey more frequently.

## References

Zrzavý (1999) Comparative and developmental morphology of the forewing colour pattern in Pyrrhocoridae (Hemiptera). *Acta Soc. Zool. Bohem.* **63**, 279-289