Color polymorphism in *Chauliognathus flavipes* Fabricius (Coleoptera, Cantharidae). II. Patterns of emergence of morphs and mating system

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ABSTRACT. This study presents data on the color polymorphism in *Chauliognathus flavipes* Fabricius 1781 (Coleoptera, Cantharidae), analysing the variations in the emergence pattern of phenotypic classes for elytra color and mating system. The frequency of the phenotypic classes varies significantly throughout the season (males: X^2 = 59,705; females: X^2 = 61,017; 10 gl; $p<0.001$) being similar in males and females. The frequency of classes does not differ significantly among the insects that were copulating and those that were not copulating at the time of collection, *i.e.*, the matings are random for elytra color patterns. The variations observed in frequency of phenotypic classes are not influenced by factors associated with sex. Furthermore, the elytra color patterns probably do not influence the individuals' ability to copulate.

KEY WORDS. Polymorphism, phenotypic class, emergence, assortative mating, Coleoptera

The occurrence of color polymorphism in a natural population immediately raises questions concerning its origins and maintenance. As regards the origins, it may be related to protection against visually oriented predators; however, for unpalatable species, the presence of polymorphism is unexpected, except under special conditions.

Chauliognathus flavipes Fabricius, 1781 is a common species in Rio Grande do Sul, Brazil, and it is outstanding for its marked polymorphism for elytra and pronotus color patterns. Adults are unpalatable (Vasconcello-Neto, personal communication); the background color is bright yellow, and on this can be found a variety of strips or dark dots. The adult insects are found mainly from the end of November to the beginning of February, on flowers of various plant species.

In previous studies (MACHADO & ARAÚJO 1995) geographic variation in the polymorphism of this species in populations of Rio Grande do Sul, was analysed, as well as its stability in two successive generations. The current study was performed to detail color polymorphism in *Chauliognathus flavipes*, and to analyse the variation in color frequency patterns throughout the adult season.

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MATERIAL AND METHODS

The data analysed were obtained from several samples of an aggregate located on the Campus of the Universidade do Vale do Rio dos Sinos at São Leopoldo, Rio Grande do Sul, Brazil.

The study site was located close to an eucalyptus woods, with a sub-growth of indigenous plants. The plant cover consisted of scrub growth with several types of grasses and varied herbaceous vegetation. The area was approximately one hectare in size; the insects were concentrated on the border of the eucalyptus woods, over an area of approximately 400 square meters, where the food sources were more plentiful.

The samples were obtained at different times in the adult season. The term "season" or "adult season" used in this study refers to the period in which adult insects are found at feeding and copulation activities. The collections were performed manually and the insects were classified in the field and later released. The sex and color pattern of the elytra were recorded for each specimen. The collections were performed in the morning between 10 a.m. and noon; the duration of each collection ranged from 60 to 90 minutes. The insects were collected on or close to the food sources (*Eryngium* sp. and *Eucalyptus* sp.).

The data were obtained in collections performed from december/90 to january/91 (samples:1; 07 dec, 2; 14 dec, 3; 21 dec, 4; 02 jan, 5; 09 jan, 6; 31 jan).

The color patterns were defined as a function of the presence or absence of black spots, as well as by the size of the spots (Fig. 1). The spots may appear as strips (patterns 3, 4, 5), and there can also be individuals without any spots (pattern 1) or very dark (patterns from 6 to 9). There are also variations in thickness and shape of the strips. This figure is different from the one presented by MACHADO & ARAÚJO (1995), since some patterns shown in it belong to other species of the genus *Chauliognathus*). For further information about color patterns in species of *Chauliognathus* see MACHADO & ARAÚJO (1998).

To analyse the variation of frequency of the nine color patterns of the elytra, they were grouped in phenotypic classes: light-colored (patterns 1 and 2); intermediate (3, 4 and 5) and dark (patterns 6 to 9); full data can be seen in the table I.

RESULTS

The numbers of insects in each phenotypic class, by sex and samples are shown in table II and their frequency distributions in figure 2. The analysis of the differences in frequency of phenotypic classes throughout the weeks indicates that these are highly significant ($P < 0.001$) for males and females. On the other hand, the analysis of this variation between the sexes indicates that it is not significant (X^2 heterogeneity = 12.028; 10 GL; $0.10 < P < 0.50$); i.e., the variations observed in the frequency of phenotypic classes over weeks occur equally for males and females. However when we consider the pooled data for samples, keeping sexes and phenotypic class separately there is significant association ($X^2 = 8.714$; d.f.= 2; $p < 0.05$). This is probably due to the occurrence of pattern 8 only in males or to a sample error (class Dark has the double of male than female insects, 51:25); if only Light and Intermediate classes are considered this difference disappears.

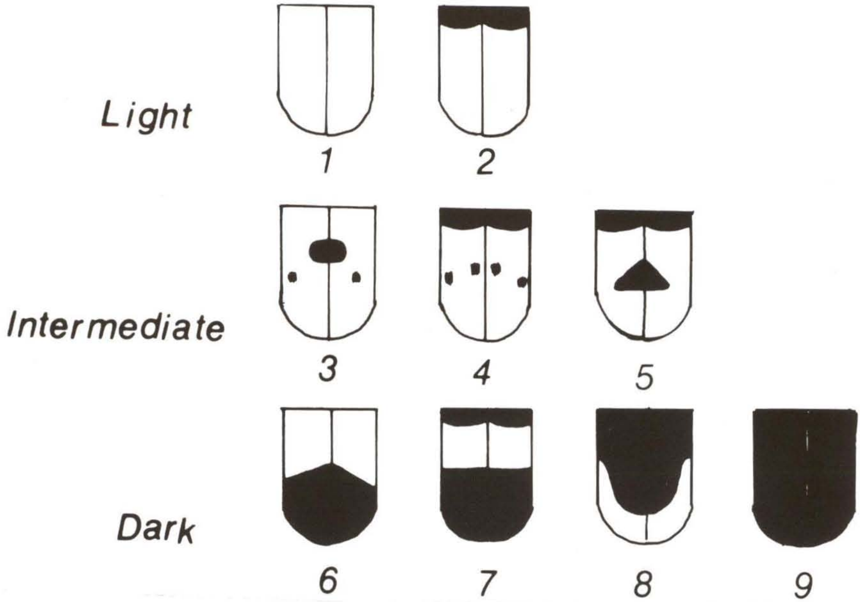

Fig. 1. Color pattern of the elytra for different morphs in *Chauliognathus flavipes*.

Table I. Time distribution of the phenotypic patterns for elytra in males (b) and females (b).

		Morphs						
Samples		1	2	3	4	5	6-9	Total
a	1	5	31	3	15	6	2	62
	2	7	24	18	21	10	5	85
	3	10	7	13	27	31	5	93
	4	20	35	70	116	40	11	292
	5	36	48	88	173	44	23	412
	6	10	12	25	46	12	5	110
	Total	88	157	217	398	143	51	1054
b	1	7	53	35	32	3	4	134
	2	18	37	37	46	6	1	145
	3	10	17	28	41	45	1	142
	4	16	25	44	83	18	5	191
	5	23	35	64	112	16	12	262
	6	0	14	20	62	9	2	107
	Total	74	181	228	376	97	25	981

Figure 2 supply information regarding how adult insects enter the population, indicating when the phenotypic classes are present in larger amounts. For both sexes, for instance, the maximum period of recruitment occurred in sample 5. The pattern of change in the frequency of phenotypic classes occurred similarly in both sexes,

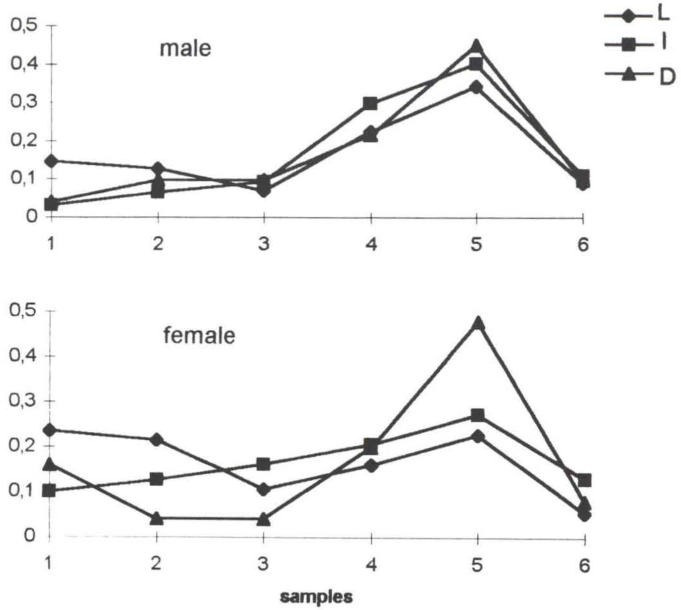

Fig. 2. Frequency distribution of the phenotypic classes, by sex, during the period of study.

Table II. Number of insects for each phenotypic class (L) light, (I) intermediate, (D) dark, by sex and sample.

Samples	Males							Females						
	L	I	D	T	X^2	d.f.	P	L	I	D	T	X^2	d.f.	P
1	36	24	2	62				60	70	4	134			
2	31	49	5	85				55	89	1	145			
3	17	71	5	93				27	114	1	142			
4	55	226	11	292	59.705	10	<0.001	41	145	5	191	61.017	10	<0.001
5	84	305	23	412				58	192	12	262			
6	22	83	5	110				14	91	2	107			
Total	245	758	51	1054				255	701	25	981			
%	23.2	71.9	4.9					25.9	71.5	2.6				
X^2 Sum					120.722	20	NS							
X^2 Total					108.694	10								
X^2 Heterogeneity					12.028	10	NS							

although with a smaller variation among the males. For all classes, a gradual increase in number of insects is observed, especially between the third and fifth samples. The reduction in frequency occurs in all classes from the fifth to sixth samples.

Taking each sex into account separately, the possibility of an association between phenotypic classes and copulating insects was tested (Tabs III, IV). As can be seen, there is no evidence of such an association. It should be pointed out that some column totals of these tables do not correspond to those of table II, since in a few cases there was inter-specific copulation (*C. flavipes* X *C. octomaculatus*), and they were excluded from this analysis.

Table III. Number of males copulating and non-copulating for each phenotypic class (L) light, (I) intermediate, (D) dark.

Class	L	I	D	X^2	d.f.	P
Copulating	35	88	3	3.199	2	NS
Non-copulating	209	670	48			
Total	244	758	51			

Table IV. Number of females copulating and non-copulating for each phenotypic class. (L) Light, (I) intermediate, (D) dark.

Class	L	I	D	X^2	d.f.	P
Copulating	31	92	3	0.141	2	NS
Non-copulating	221	607	22			
Total	252	699	25			

To analyse the occurrence or not of assortative matings for phenotypic classes, all pairs (n=126) found during the sampling period were used. Taking into account the frequency of each phenotypic class, independent of sex, we calculated the sample space of probabilities for the composite events L x L, L x I, D x D, etc, in order to test for the randomnes of mating. The results are shown in table V, and they indicate no departure from random mating.

DISCUSSION

Although males and females showed the same tendency in recruitment rates along the samples, females presented a greater variation in these rates. This fact could be associated with an excess of females in the first three weeks if the sexual maturity of females depends on the quality and quantity of nutrients. This type of association has been recorded for other insects, such as for instance females of *Ceratitis capitata* (HENDRICHS *et al.* 1991). A more detailed analysis of variation in sex proportion is presented in MACHADO & ARAÚJO 1998).

Why are the recruitment rates different among the phenotypic class both in males and females? To answer this question we probably need to design a special experiment; some guesses are, however, worth to mention. If developmental time is associated with elytra color then under theoretical grounds there is the possibility to maintain a polymorphism (MANI 1981).

A topic which has been discussed in studies with this genus is the occurrence of assortative matings (MASON 1980; MCAULEY & WADE 1978; WOODHEAD 1981; MCLAIN 1982, 1985). For *C. flavipes*, for instance, DIEHL-FLEIG & ARAÚJO (1991) indicate the possibility of positive assortative mating involving light-colored and dark classes (the species referred to by the authors is *C. fallax*, but it is actually *C. flavipes*). Our data do not support that finding (Tabs III-V); the analysis shown here is more reliable, since it compares copulating and lone individuals. Thus, it seems that the occurrence of assortative matings cannot be invoked as one of the mechanisms involved to maintain color polymorphism in this species. Studies are in progress to test this as well as other hypotheses.

Table V. Observed and expected number of copulating insects according to the phenotypic classes (L) light, (I) intermediate, (D) dark.

	L-L	L-I	L-D	I-I	I-D	D-D	X2	d.f.	P
Observed	15.0	33	2	72	4	0.0	10.808	5	NS
Expected	7.8	44	2	66	6	0.2			

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