Commonwealth Institute of Biological Control, European Station, Delémont, Switzerland

Sex-linked Colour Polymorphism in *Aphidecta obliterata* L. (Coleoptera: Coccinellidae)[1]

By O. EICHHORN and P. GRAF

With 2 Figures

Abstract

Aphidecta obliterata L. shows a pronounced sex dimorphism both in colour and size.

Colour polymorphism of the elytra is sex-linked and restricted to females. It ranges from complete yellow (colour group I = 0.9 %) to complete black (colour group V = 7.0 %). The greater majority of females, namely on average 78.3 %, belong to colour group II. 3.8 % are of colour group III and 10.0 % of colour group IV. Differences with regard to collecting areas exist.

The sex-ratio is remarkably constant in the different areas, there being a variation in females between 60.7 % and 65.4 %.

A. obliterata is a typical coccinellid, so far as the number (= 18) of autosomes is concerned, but unusual in that the sex-determining system is XX : XO.

Mated females of colour group IV/V (dark forms) produced about 6 times as many daughters of the colour group IV/V than females of colour group II. This means that the determination of the colour pattern is partly hereditary.

I. Introduction, Material and Methods

Colour polymorphism in Coccinellidae is well-known. Formerly the different colour variants were given so-called "aberration names"; for *Adalia bipunctata* L., there are about 150 of these (FÜRSCH 1967).

It was generally accepted that colour polymorphism affects both sexes. This is, however, not so in *Aphidecta obliterata* L., which is a univoltine predator of conifer aphids of the families Adelgidae and Aphididae (*Liosomaphis abietinum* Mordw.). Since 1951 it has been collected in large numbers in Europe and released in Canada and the U.S.A. for the biological control of *Adelges* (= *Dreyfusia*) *piceae* Ratz. (DELUCCHI 1953, GRAF & KRIEGL 1968).

A. obliterata hibernates in the adult stage underneath bark-scales of conifers, mainly spruce, but sometimes also on deciduous trees. The material used in this investigation was collected from such hibernating sites. 17 samples comprising 4.517 specimens were collected in five areas (Schleswig-Hol-

[1] Dedicated to Prof. Dr. F. SCHWERDTFEGER (Göttingen) for his 65th birthday.

stein, Soonwald in the Hunsrück mountains, southern Black Forest and northern Switzerland, Bavaria and Upper Austria, East Styria) between December 1968 and March 1970 (Table 1).

In order to study the development and maturation of the gonads of both sexes of *A. obliterata,* dissections were made regularly, and as a result the junior author found that colour polymorphism only occurs in the females.

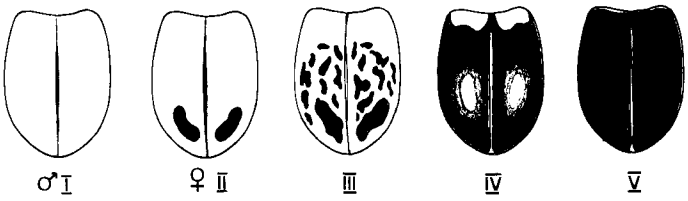

Fig. 1. Elytral colour pattern in males and females of *A. obliterata* L.

From the colouration of the elytra nine forms of *A. obliterata* have been described in the literature (MADER 1926–1934, KUHNT 1911). Our material has been grouped into five classes (Fig. 1):

I = uniform yellow-brown (similar to typical *A. obliterata* L., according to MADER),
II = yellow-brown with a kidney shaped black dot at the end of each elytra (similar to *livida* Deg., according to MADER),
III = yellow-brown and black speckled (similar to *6-notata* Thunb., according to MADER),
IV = black dominating (similar to *fenestra* Ws., according to MADER),
V = uniform black (similar to *fumata* W., according to MADER).

II. Results

1. Sex dimorphism

a. With regard to colouration

A. obliterata shows a pronounced colour dimorphism in the sexes (Fig. 1, Table 2). Between 99.1 and 100 per cent of the males are of colour group I (average 99.7 %), and only up to 0.9 per cent (average 0.3 %) are of group II.

In the females 96.7 to 99.8 per cent (average 99.1 %) of all individuals are of colour groups II–V and only 0.2 to 3.3 per cent (average 0.9 %) of colour group I.

The basic colour of the elytra is yellow-orange in males and light yellow in females. Only about 10 per cent of the males have the same (lighter) colour as the females. The kidney-shaped black dots in colour group II are generally less pronounced and discrete in males than in females.

b. With regard to size

Females are significantly ($p = 0.1$) larger than males both in length and width (Fig. 2). WITTER and AMMAN (1969) identified the sexes of *A. oblit-*

Table 1

Colour groups in males and females of *Aphidecta obliterata* in Central Europe

Locality	Date collected	No. of individ.	♂♂ I n/in %	♂♂ II n/in %	♀♀ I n/in %	♀♀ II n/in %	♀♀ III n/in %	♀♀ IV n/in %	♀♀ V n/in %	♀♀ %	♂♂ %
Schleswig-Holstein	13. 12. 68	100	25	2	5	63	5	—	—		
Schleswig-Holstein	3.– 4. 3. 70	650	255	—	—	388	6	1	—		
Total		750	280/37.3	2/0.3	5/0.7	451/60.1	11/1.5	1/0.1	—	62.4	37.6
Soonwald (Hunsrück, Germany)	15. 3. 68	100	32	—	3	45	6	8	6		
Soonwald (Hunsrück, Germany)	2.– 5. 12. 69	900	300	—	—	370	10	110	110		
Soonwald (Hunsrück, Germany)	27. 1. 70	541	200	—	—	265	5	41	30		
	24.–25. 3. 70	650	227	—	—	291	5	87	40		
Total		2191	759/34.6	—	3/0.1	971/44.3	26/1.2	246/11.2	186/8.5	65.4	34.6
Neustadt (Black Forest)	21. 1. 68	53	17	—	—	27	3	3	3		
Biberach (Black Forest)	22. 1. 68	50	14	—	—	26	4	6	—		
Villingen (Black Forest)	22. 1. 68	100	42	—	3	39	8	5	3		
Bonndorf (Black Forest)	18.–19. 2. 70	105	45	—	—	50	3	5	2		
Northern Switzerland	4.– 7. 12. 67	68	19	—	5	34	1	7	2		
Total		376	137/36.4	—	8/2.1	176/46.8	19/5.1	26/6.9	10/2.7	63.6	36.4
Wasserburg (Bavaria)	13. 12. 67	34	14	—	1	16	3	—	—		
Hausrück (Upper Austria)	14. 12. 67	46	24	1	3	12	6	—	—		
Hausrück (Upper Austria)	15. 3. 68	100	32	—	3	45	6	8	6		
Hausrück (Upper Austria)	7.–10. 1. 70	175	56	—	—	108	6	5	—		
Total		355	126/35.5	1/0.3	7/2.0	181/51.0	21/5.9	13/3.6	6/1.7	64.2	35.8
East Styria	15. 3. 68	100	39	3	2	55	1	—	—		
East Styria	2.– 6. 1. 70	745	290	—	—	420	32	2	1		
		845	329/38.9	3/0.4	2/0.2	475/56.2	33/4.0	2/0.2	1/0.1	60.7	39.3
Grand Total		4517	1631/36.1	6/0.1	25/0.6	2254/49.9	110/2.4	288/6.4	203/4.5	63.8	36.2

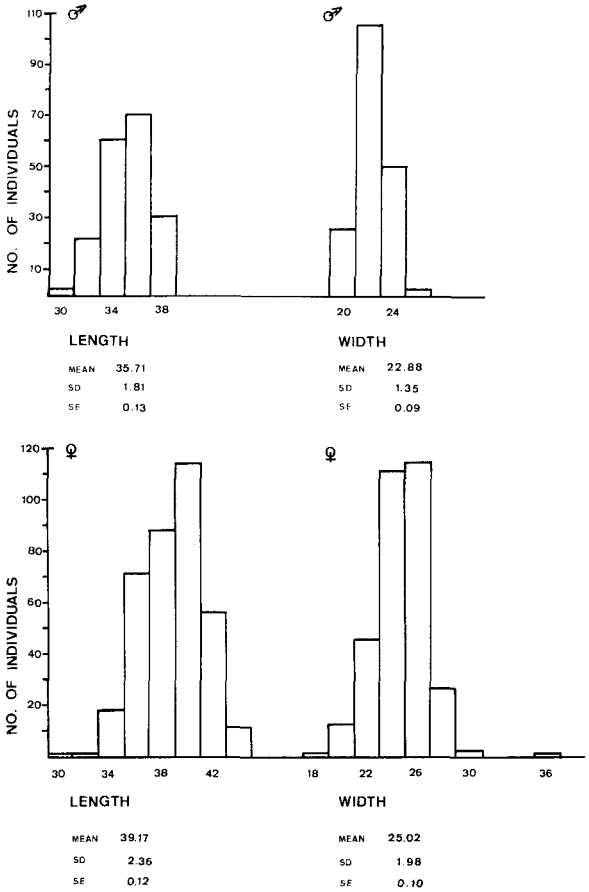

Fig. 2. Sex dimorphism in size in *A. obliterata* L. (1 unit = 0.1 mm)

erata adults correctly in 93 % and 100 % of individuals examined by observing differences in head markings, and in head markings and length, respectively.

Size differences in the female colour groups II, IV and V are not significant.

2. Colour polymorphism in females

Colour polymorphism is restricted to females. It ranges from complete yellow (colour group I = 0.9 %) to complete black (colour group V = 7.0 %). The greater majority of females, namely on average 78.3 per cent, belong to colour group II, 3.8 per cent are of colour group III and 10.0 per cent of colour group IV.

Differences with regard to collecting areas

Table 2

Colour dimorphism in sexes and polymorphism in the females of *Aphidecta obliterata* L.

Collecting area		colour groups (figures representing percentages) I	II	III	IV	V
Schleswig-Holstein	♂	99.3	0.7	—	—	—
	♀♂	1.0	96.4	2.4	0.2	—
Soonwald	♂	100.0	—	—	—	—
(West Germany)	♀♂	0.2	67.8	1.8	17.2	13.0
South. Black Forest/	♂	100.0	—	—	—	—
northern Switzerland	♀♂	3.3	73.6	8.0	10.9	4.2
Bavaria/Upper	♂	99.2	0.8	—	—	—
Austria	♀♂	3.1	79.4	9.2	5.7	2.6
East Styria	♂	99.1	0.9	—	—	—
	♀♂	0.4	92.6	6.4	0.4	0.2
Average	♂	99.7	0.3	—	—	—
	♀♂	0.9	78.3	3.8	10.0	7.0

exist (Table 2), the most remarkable being the almost complete lack of females of colour groups IV and I in Schleswig-Holstein, and the common occurrence of these dark forms in the Soonwald area, where they account for about 30 per cent of the total female population. Dark-coloured forms have also been quite frequent in the Black Forest, northern Switzerland, Bavaria and Upper Austria, but relatively scarce in eastern Styria.

3. Sex-ratio

The sex-ratio was remarkably constant in the different areas, there being a variation in females between 60.7 (East Styria) and 65.4 per cent (Soonwald) (Table 1). In hibernating beetles the average was 63.8 % females. In laboratory rearings the respective figure was 65.5 % females (Table 3).

Table 3

Analysis of the offspring (F_1-generation) of mated females of the colour group II and IV/V respectively

No. of mated females and resp. colour groups	Total laid eggs by 3 ♀♀ of each group (and average)	Total reared specimens of the F_1-generation	Total No. in the resp. colour groups ♂ I	♀ I	♀ II	♀ IV/V	♀ in %	sex ratio in % ♂	sex ratio in % ♀
8 II	138 103 71 av. 104	65	24	12	27	2	4.9	35.4	64.6
8 IV/V	125 59 54 av. 79	45	14	8	14	9	29.0	31.1	68.9

4. Genetic aspects

a. With regard to chromosomes

Dr. S. G. SMITH of the Forest Research Laboratory, Sault-Ste-Marie, Canada, investigated the cytological aspect of this sex dimorphism and colour polymorphism in *A. obliterata*. He found that the species "has particularly small chromosomes, without useable diagnostic characters. It proved to be a typical coccinellid, so far as the number (= 18) of autosomes is concerned, but unusual in that the sex-determining system is XX:XO, a situation previously encountered only twice among the some 120 species that are known" to him (SMITH 1953, 1960). Dr. SMITH could detect no differences in chromosomes among the different colour groups.

b. Breeding results

The offspring of 16 mated females, eight each of colour groups II and IV/V, respectively, were reared in spring 1970[2].

[2] The parent beetles were collected in the Soonwald on March 24/25, kept in cold storage until April 20 and afterwards transferred to fir branches heavily infested by *A. nüsslini* CB. The branches were stood into glass vials filled with water and kept in ventilated plastic cages.

The average number of eggs laid by each of three females was 104 in group II and 79 in colour group IV/V. Rearing mortality due to food shortage, cannibalism, etc. was high, as only 65 and 45 adults of the F_1-generation were obtained (Table 3). These experiment showed that, under laboratory conditions, it took the beetles about six weeks to develop their final colour patterns.

Two results are remarkable:

1. Mated females of colour group IV/V produced about 6 times as many daughters of coulour group IV/V (29.0 %) than females of colour group II (4.9 %). This means that the colour pattern is partly hereditarily determined.
2. The sex-ratio in this rearing experiment, amounting to about $^2/_3$ females and $^1/_3$ males, is the same in nature, and appears therefore to be constant and probably related to the unusual sex-determining mechanism in this species.

III. Discussion

A. obliterata is the only Coccinellid species so far known with a sex-linked colour polymorphism in the females. This unique feature is combined with a sex-determining mechanism (XX:XO) unusual for this family. The sex-ratio is remarkably constant (about $^2/_3$ females and $^1/_3$ males).

In maritime, humid climates and in industrial areas the proportion of dark forms in a given Coccinellid species is greater than in continental climates (FÜRSCH 1967). This general observation is not confirmed in *A. obliterata*.

TIMOFEEFF-RESSOVSKY (1940) observed that red forms of *Adalia bipunctata* suffer less from winter mortality than black ones. Cold-hardiness tests and regular field observations conducted in the present investigations did not reveal significant differences between light and dark forms of *A. obliterata* with regard to coldhardiness and winter mortality.

LUSIS (cited after FÜRSCH 1967) found that in *A. bipunctata* the black forms were more active during the propagation period than the red ones, which consequently led to a temporary preponderance of black individuals. There are no such indications in *A. obliterata*.

The sex-ratio, being the same both in nature and in laboratory rearings, is obviously a fixed one and not induced or altered by differential mortality.

The exceptionally high proportion of females of colour group I bred in laboratory rearings (Table 3) can be explained and does not contradict the field results, since individuals of that colour group died comparatively soon after hatching and thus lacked time to develop their final colour pattern.

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Zusammenfassung

Geschlechtsgebundener Farbpolymorphismus bei Aphidecta obliterata L. (Col.: Coccinell.)

Der Marienkäfer *A. obliterata* zeigt hinsichtlich Farbe und Größe einen ausgeprägten Geschlechtsdimorphismus. Der Farbpolymorphismus der Elytren ist auf das ♀ Geschlecht beschränkt. Die Farbskala reichte hier von rein Gelb (0,9 %) bis rein Schwarz (7,0 %). Die Mehrheit der ♀♀ zeigt dazwischenliegende schwarz-gelbe Farbmuster. Das Geschlechterverhältnis erwies sich in verschiedenen Gebieten als auffällig konstant (60,7–65,4 % ♀♀). *A. obliterata* ist ein typischer Coccinellide soweit es sich um die Anzahl (= 18) der Autosomen handelt. Er fällt aber durch seine Geschlechtsbestimmung nach dem XX : XO-System aus dem Rahmen. Befruchtete ♀♀ der Farbgruppe IV/V (dunkle Formen) erzeugten 6mal so viele Töchter der Farbgruppe IV/V als die ♀♀ der helleren Farbgruppe II. Das bedeutet, daß die Bestimmung des Farbmusters teilweise erblich ist.

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