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Inheritance of Body Coloration in the Small Brown Planthopper, *Laodelphax striatellus* (Hemiptera: Delphacidae)[1]

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Brachypterous *L. striatellus* females, with the exception of the macropterous ones, exhibit a continuous variation in abdominal color ranging from milky white (W) to black (B). Brachypterous and macropterous males have two color variants, one with a white stripe on the mesoscutellum (S) and one without the stripe (NS, black scutellum). The adult body coloration in populations of *L. striatellus* was darker at higher nymphal rearing densities. The inheritance of body color was studied by mass-crossing single phenotype of females or males with randomly colored individuals of the opposite sex. In addition, female and male body colors were selected simultaneously for 11 generations in the following combinations: B×S, B×NS, W×S and W×NS. The development of both female and male adult body coloration had a genetic basis, and the genetic determination of male body coloration was independent of female.

Key words: body coloration, *Laodelphax striatellus*, inheritance, wing form, density effect

INTRODUCTION

The small brown planthopper, *Laodelphax striatellus*, has macropterous and brachypterous wing forms. The wing form varies with environmental factors, including population density, temperature, photoperiod and nutrition (KISIMOTO, 1959). The wing form of the planthoppers is also controlled by genetic factors (IWANAGA et al., 1985; MAHMUD, 1980; MORI and NAKASUJI, 1990), and recently, MOROOKA et al. (1988) found that the wing form of *N. lugens* correlates with the adult body coloration. It is possible that the wing form and body coloration of planthoppers are controlled by similar genetic factors and are determined by a common physiological mechanism.

In the present study, we investigated the genetic basis of body coloration and the relationship between body coloration and nymphal density in *L. striatellus*.

MATERIALS AND METHODS

We used *L. striatellus* that were reared for two generations in a stock culture, which

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originated from rice fields near Okayama in June, 1987. Brachypterous females showed abdominal color variation from milky white to black. We graded the color variation into three categories, white (W), intermediate (I), and black (B), and scored them −1, 0, and +1, respectively. Macropterous females exhibited no color variation except black. Males had two types of coloration pattern on the mesoscutellum, either with a central longitudinal white stripe (S) or without it (NS, black scutellum). The white stripe resembles that found on *Sogatella furcifera*.

First instar nymphs within 24 hr after hatching were reared at densities of 1, 2, 4, 8, and 16 individuals in glass tubes (2 cm in diamter and 17 cm in height) containing 7 rice seedlings (var. Akebono). The number of replications at each density was 128, 64, 32, 16, and 8, respectively. Seedlings were renewed every 6 days and experiments were conducted under 16L–8D photoperiod at 25°C. The body coloration of emerged adults was evaluated.

To examine inheritance of body coloration, crossing experiments were conducted. Three lines of *L. striatellus* were established from either 40 mated B females, 40 mated W females, or 40 mated randomly selected females from the stock culture, and reared on rice seedlings in cases (12 cm in diameter, 20 cm in height). Another two lines were established from either 40 S or 40 NS macropterous males and 40 randomly selected virgin females from the stock culture. Males and females were allowed to mate *ad libitum* in the cage. The coloration of all progeny from each line was examined.

To obtain further evidence for inheritance of body coloration, we conducted a selection experiment. Four lines were established from 40 virgin brachypterous females and 40 males with different coloration patterns by the following matings: B×S, B×NS, W×S, and W×NS. In each generation, 160 first instar nymphs were collected from each cage and reared at a density of 8 per glass tube under 16L–8D and 25°C. The body coloration of all emerged adults was evaluated. All emerged adults with the same body color as their parents were selected and were allowed to mate in the cage to start the next generation. Selection continued for 11 generations.

RESULTS

The relationship between the adult coloration and nymphal density in the non-selected *L. striatellus* is shown in Fig. 1. The body coloration of brachypterous females was predominantly white at nymphal densities of 8 or less, and intermediate at the highest nymphal density. Similarly, the white-striped males were more common (>60%) at nymphal densities of 4 or less. The non-striped males (black scutellum) increased in frequency at higher densities.

The relationship of body coloration between the parents of different body color and progeny is shown in Table 1. White mothers had more white progeny and fewer black progeny than the black mothers. The body color of the mother had no effect on the body coloration of male progeny. Striped fathers had more striped progeny and fewer non-striped progeny than non-striped father, but the body color of the father had no effect on the body coloration of female progeny.

Body coloration in populations of *L. striatellus* responded quickly to selection (Fig. 2). In less than 11 generations of selection, a higher proportion of brachypterous females were black when black individuals were selected, and white when white individuals were selected. Selection for male body color had no influence on the response

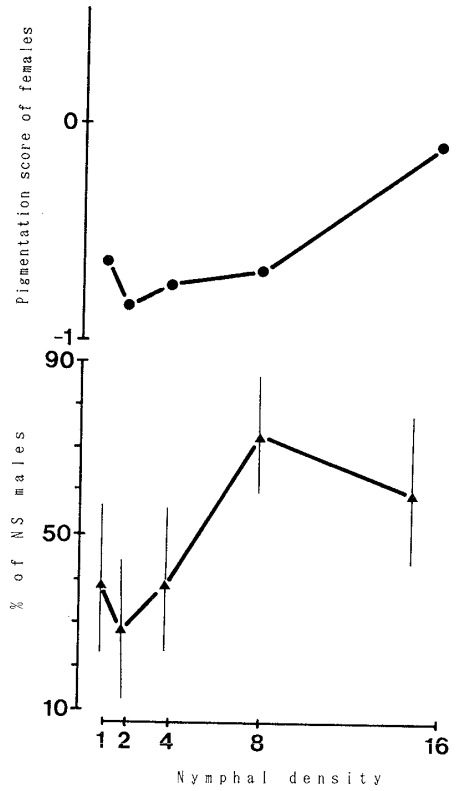

Fig. 1. The relationship between the pigmentation score of brachypterous females (Top) or the percentage of non-striped males (NS) (Bottom) and nymphal density. The insects were obtained from the non-selected stock culture. The vertical line for males shows 95% confidence intervals.

Table 1. Body color type of the F_2 progeny from the parents of different coloration

Color of parent	Color type of parents					
	Female[a]			Male[b]		
	White	Black		Non-Stripe	Stripe	
F_1 progeny	%	%	χ^2-test	%	%	χ^2-test
Female (Brachypters)						
White (W)	70.00	25.00	$p<0.01$	42.55	40.39	N.S.
Intermediate (I)	30.00	35.71	N.S.	55.32	57.69	N.S.
Black (B)	0.00	39.29	$p<0.01$	2.13	1.92	N.S.
Male (Macropters)						
Non stripe (NS)	81.48	82.05	N.S.	73.02	57.38	$p<0.05$
Stripe (S)	18.52	17.95	N.S.	26.98	42.62	$p<0.05$

[a] The males were not selected for color.
[b] The females were not selected for color.
N.S. shows non-significance.

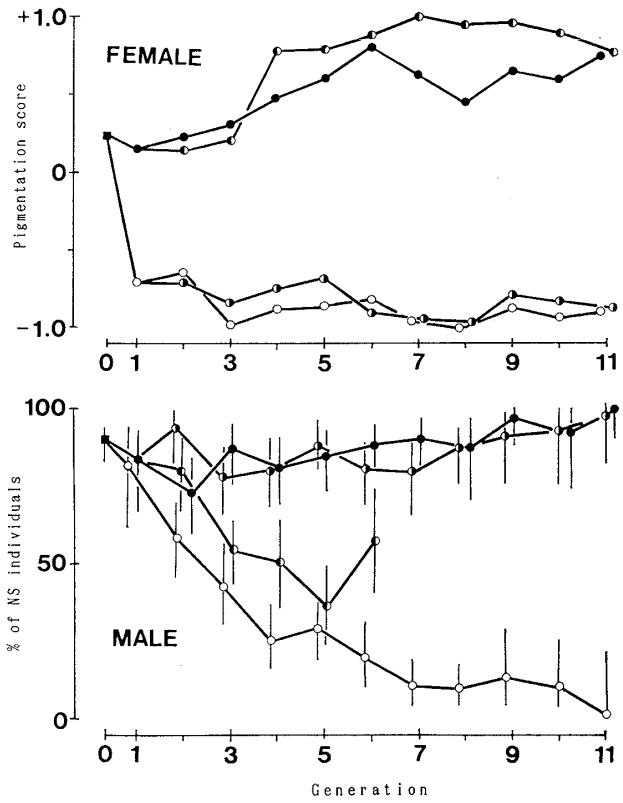

Fig. 2. Changes in the pigmentation score of females and percentage of non-striped males (NS) in successive selection for body color, white (W) and black (B) in females, and striped (S) and non-striped (NS) in males, reared at a density of 8 per glass tube. The vertical lines in the lower figure show 95% confidence intervals. The curves in the figure represent the selected strains for respective color variation of females and males, with B×S (◐), B×NS (●), W×S (○), W×NS (◑) showing the value of the parents.

of female body coloration during selection for female body color. Similarly, populations of males developed a higher frequency of striped individuals when striped males were selected, and a slightly higher frequency of non-striped individuals when non-striped males were selected. Selection for female body color had no influence on the response of male body coloration during selection for male body color.

DISCUSSION

It is well known that several insect species exhibit variation in adult body color in relation to nymphal density (Uvarov, 1966; Iwao, 1962; Nijhout and Wheeler, 1982). The proportion of adults with dark body coloration in *L. striatellus* was higher at higher nymphal rearing densities (Fig. 1).

The occurrence of black pigmentation in the ultimate instar of *Spodoptera litura* is associated with higher larval densities (Yamanaka et al., 1975), but larvae from strains selected for production of black ultimate instars were black even when they were reared individually (Tojo and Morita, 1984). This suggests that the development of black pigmentation has a genetic basis in *S. litura*. Results from our inheritance and selection

experiments involving female and male body color of *L. striatellus* suggest that the development of both female and male adult body coloration has a genetic basis (Table 1 and Fig. 2). Moreover, the determination of body coloration in males and females appears to be genetically independent of each other (Table 1 and Fig. 2).

Variation in body coloration can be related to variation in wing form. MOROOKA et al. (1988) showed that populations of *N. lugens* with a higher frequency of black individuals tended to have a lower percentage of brachypters. We have obtained brachypterous lines by selection on adult body color (MORI, unpublished). The percentage of brachypterous females increased rapidly in all four of our selected lines shown in Fig. 2 but not in the unselected line (MORI and NAKASUJI, 1990). The percentage of brachypterous males increased noticeably in the line selected for black females and striped males. We could obtain few brachypterous males in the line selected for brachyptery (MORI and NAKASUJI, 1990). The variation in body coloration in *L. striatellus* may be correlated genetically with variation in wing form, and the variations in coloration are influenced by the nymphal density.

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