Appl. Ent. Zool. 26 (4): 557–561 (1991)

Effects of Day Length and Density on Development and Wing Form of the Small Brown Planthopper, *Laodelphax striatellus* (Hemiptera: Delphacidae)[1]

Kiyoko MORI[2] and Fusao NAKASUJI[3]

Laboratory of Applied Entomology, Faculty of Agriculture, Okayama University, Okayama 700, Japan

(Received May 2, 1991; Accepted July 12, 1991)

Nymphal development of the small brown planthopper, *Laodelphax striatellus*, is delayed by short day photoperiod. The incidence of 'delayed development (DD)' individuals under 12L–12D at 25°C was compared among unselected parents, offspring of DD-type parents, and of 'non-delayed development (ND)'-type parents. The incidence of DD in the offspring of DD-type parents was 33.7%, and that of ND-type parents was 5%. The former was slightly higher and the latter was significantly lower than the incidence, 24.7%, of DD in the unselected parents. Both the incidence of DD and the incidence of macroptery in females increased with an increase in nymphal density. Moreover, the line which has been selected for macroptery for 15 generations showed a higher incidence of DD than the line selected for brachyptery.

Key wors: *Laodelphax striatellus*, day length, density, delayed development, wing form

INTRODUCTION

The small brown planthopper, *Laodelphax striatellus* has two wing forms, macropters and brachypters. Various environmental factors such as population density, temperature and nutritional conditions of host plants during nymphal period (KISIMOTO, 1959), and genetic factors (MAHMUD, 1980; MORI and NAKASUJI, 1990) are implicated in the determination of wing forms. *L. striatellus* is indigenous to Japan and overwinters as a diapausing nymph during short days. The incidence of brachypters is high in male adults of the overwintering generation (KISIMOTO, 1956). This fact suggests that the day length is also implicated in the determination of wing forms. Furthermore, the genetic basis of day length sensitivity for this species is unknown.

To investigate the effect of the photoperiod on the wing form and nymphal development in *L. striatellus*, we reared them under two photoperiods at different nymphal densities. A crossing experiment between a delayed development and a non-delayed development line was also conducted.

[1] This work was supported in part by a Grant-in-Aid (Bio Cosmos Program) from Ministry of Agriculture, Forestry and Fisheries, Japan (BCP-91-I-B-8) and Grant in-Aid for Scientific Research No. 02454054 from the Ministry of Education, Science and Culture (Mombusho), Japan.

[2] Present address: *Earth Environmental Sanitary Service Co. Ltd., 1–2–1, Awajicho, Chuo-ku, Osaka 541, Japan*

[3] To whom all correspondence should be addressed.

MATERIALS AND METHODS

L. striatellus, collected from rice fields near Okayama during June 1987, were reared for three generations before use. To evaluate the effect of rearing density on the developmental period, 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 diameter and 17 cm in height) each containing seven rice seedlings (var. Akebono). The number of replications at each density was 64, 32, 16, 8 and 8, respectively. Experiments were conducted at 25°C under 12L–12D (short day). In addition, the nymphs were reared at a density of eight individuals at 25°C under 16L–8D (long day) for eight replications. When the nymphs died, they were replaced with spare replicates in order to maintain constant density. Seedlings were renewed every six days. The developmental period of the nymphs and the wing form of the emerged adults were recorded. Since nymphal period at 25°C under 16L–8D was 15.6 days on the average ($\pm$1.2, SD), and all of the periods were less than 19 days, we regarded individuals with a nymphal period of greater than 20 days under 12L–12D as 'delayed development' individuals. To evaluate the inheritance of delayed development under short day conditions, we conducted a crossing experiment. The first instar nymphs were reared at a density of eight individuals per glass tube under 12L–12D (20 replicate tubes), and their developmental period was measured. Ten pairs of females and males that had nymphal periods of less than 20 days were mated, as were another ten pairs that had nymphal periods of more than 20 days. Nymphs from each pair were reared at a density of eight individuals per glass tube under 12L–12D, and their developmental period was measured.

We examined the relationship between the wing form variation and the developmetal period. Nymphs from populations selected for either brachyptery or macroptery for 15 generations under 16L–8D (Mori and Nakasuji, 1990) were reared at densities of 1, 2, 4, 8 and 16 per glass tube under 12L–12D, and their developmental period was measured. The number of replicate tubes for each density was 64, 32, 16, 8 and 8, respectively.

RESULTS

The developmental period was influenced by the photoperiod. Under the long day photoperiod (16L–8D), all individuals developed to adults in less than 20 days. Under the short day photoperiod (12L–12D), 75 percent of individuals emerged to adults in less than 20 days, but 25 percent took longer than 25 days to complete the development. The former individuals were called 'non-delayed development (ND)' type and the latter 'delayed development (DD)' type. The incidence of DD or ND did not differ between sexes. The incidence of DD was higher at higher rearing densities (Fig. 1), although this was only significant between the highest and the lowest rearing densities ($p<0.05$, F-test).

The crossing experiments provided evidence that some of the variation in developmental period had a genetic basis. Under short day conditions, the incidence of DD in the population of unselected parents was 24.7%; in the offspring of DD-type parents it was 33.7%; and in the offspring of ND-type parents it was only 5.3%. The incidence of DD in the offspring of ND-type parents was significantly lower than in the unselected parents ($p<0.05$, F-test). The difference between the incidence of DD in the offspring

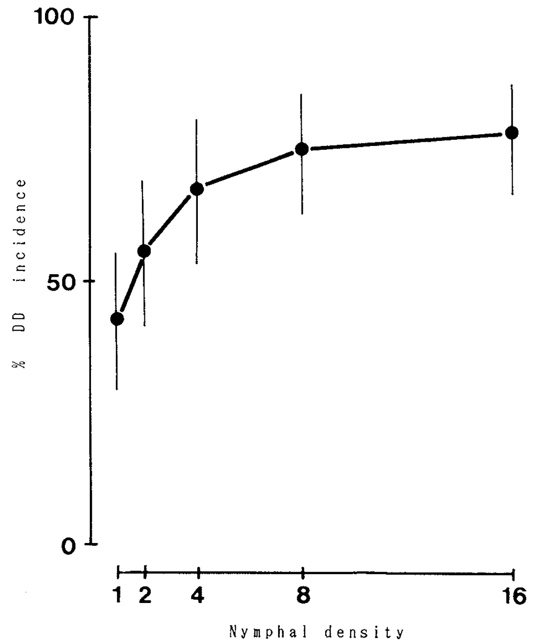

Fig. 1. Relationship between the percentage of 'delayed development' individuals and nymphal density under 12L–12D photoperiod. The vertical lines show 95% confidence intervals (*F*-test).

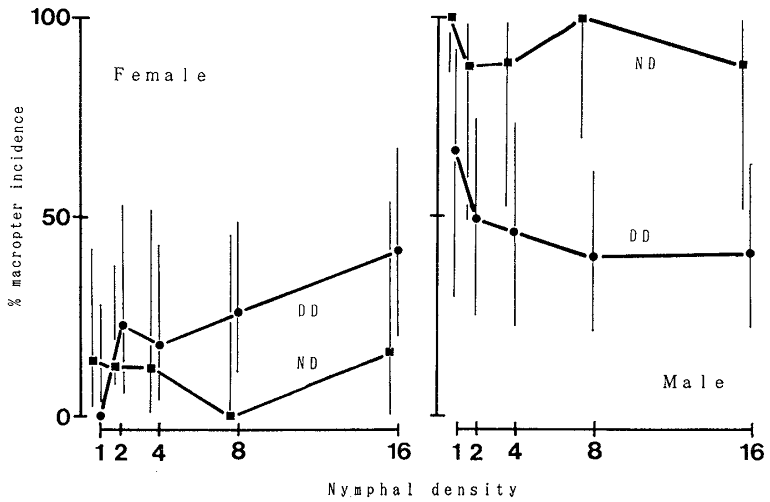

Fig. 2. The relationship between the percentage of macropters and nymphal density under 12L–12D. DD and ND refer to 'delayed development' and 'non-delayed development', respectively. The vertical lines show 95% confidence intervals (*F*-test).

of DD-type parents and in that of the unselected parents was not significant.

The relationship between the percentage of macropters and nymphal density under 12L–12D is shown in Fig. 2. In females, the percentage of macropters was slightly higher for DD-type individuals than it was for ND types, but the difference was not statistically significant. In males, the percentage of macropters was lower for DD-type individuals than it was for ND-type individuals. The difference at the density of eight was significant ($p<0.05$, *F*-test).

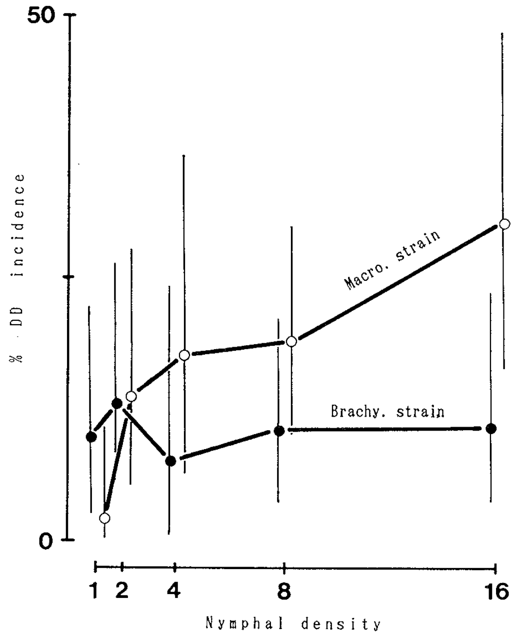

Fig. 3. The relationship between the percentage of 'delayed development' individuals under 12L–12D and nymphal density for the lines selected for macroptery or brachyptery for 15 generations. The vertical lines show 95% confidence intervals (*F*-test).

The relationship between the incidence of DD and the nymphal density under 12L–12D conditions in the lines selected for macroptery and brachyptery for 15 generations is shown in Fig. 3. The incidence of DD tended to be higher for the macropterous line than for the brachypterous line. It also tended to increase with increasing density in the macropterous line but did not change in the brachypterous line. None of these tendencies were statistically significant. The reason why the percentages of DD in the lines selected for wing forms (Fig. 3) were lower than those in the non-selected stock culture (Fig. 1) is unknown.

DISCUSSION

L. striatellus enters diapause under short day conditions (KISIMOTO, 1956; NODA, 1988), but the genetic basis of the diapause for this species is unknown. The 'delayed development' of individuals does not correspond directly to the diapause, but it may reflect a difference in sensitivity to short day length which induces diapause. Our crossing experiments provided evidence that there is a genetic basis to the day length sensitivity in *L. striatellus*.

Our observations might imply that variation in the incidence of DD is related to variation in wing form. The incidence of DD was higher at higher rearing densities (Fig. 1) and, correspondingly, the incidence of macroptery in females was higher at higher rearing densities (KISIMOTO, 1956; MORI and NAKASUJI, 1990). In addition, under short day conditions and high rearing densities, DD females had a slightly higher incidence of macroptery than ND females (Fig. 2), and the line selected for macroptery tended to have a higher incidence of DD than the line selected for brachyptery (Fig. 3).

These parallels may suggest that incidence of DD and incidence of macroptery are positively correlated traits. Observations on other insects support this hypothesis. The migratory bug, *Oncopeltus fasciatus*, shows such a correlation (DINGLE, 1982): females with greater flight activity were more easily induced to diapause. Furthermore, long-winged adults of a tropical seed bug, *Jadera aeola*, usually enter diapause after emergence, but short-winged ones do not enter diapause under any photoperiod (TANAKA and WOLDA, 1987). However, this hypothesis is not sustained by our observation that DD males of *L. striatellus* had a significantly lower incidence of macroptery than ND males (Fig. 2). In addition, KISIMOTO (1956) observed that post-diapause males, which had a greatly delayed nymphal development period, had a high incidence of brachyptery. Further research will be necessary to clarify this issue for males of *L. striatellus*.

ACKNOWLEDGMENTS

We thank Prof. T. YOSHIDA, Ms. R. TSUKUDA and the members of the Laboratory of Applied Entomology of Okayama University for their helpful suggestions throughout this work, and Associate Professors D. A. ANDOW, University of Minnesota and K. FUJISAKI, Okayama University for their critical reading and verbal correction of the manuscript.

REFERENCES

DINGLE, H. (1982) Function of migration in the seasonal synchronization of insects. *Entomol. Exp. Appl.* **31**: 36–48.

KISIMOTO, R. (1956) Effect of diapause in the fourth larval instar on the determination of wing-form of adults of the small brown planthopper, *Delphacodes striatella* FALLEN. Studies on the polymorphism in the planthoppers (Homoptera, Araeopidae). *Oyo-Kontyu* **12**: 202–210 (in Japanese).

KISIMOTO, R. (1959) Brachypter and macropter of planthoppers. *Shokubutsu-bōeki* **13**: 298–302 (in Japanese).

MAHMUD, F. S. (1980) Alary polymorphism in the small brown planthopper *Laodelphax striatellus* (Homoptera: Delphacidae). *Entomol. Exp. Appl.* **28**: 47–53.

MORI, K. and F. NAKASUJI (1990) Genetic analysis of the wing-form determination of the small brown planthopper, *Laodelphax striatellus* (Hemiptera: Delphacidae). *Res. Popul. Ecol.* **32**: 279–287.

NODA, H. (1988) Beginning of speciation: Cytoplasmic incompatibility of *Laodelphax striatellus*. In *Entomology Seminar* 1. *Evolution and life history strategy* (F. NAKASUJI, ed.). Tojusha, Tokyo, pp. 19–68 (in Japanese).

TANAKA, S. and H. WOLDA (1987) Seasonal wing length dimorphism in a tropical seed bug: ecological significance of the shortwinged form. *Oecologia* (*Berlin*) **73**: 559–565.