Response to selection for different wing forms in the pyrrhocorid bug, *Pyrrhocoris sibiricus* (Heteroptera: Pyrrhocoridae)

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Abstract

The pyrrhocorid bug, *Pyrrhocoris sibiricus*, which is a ground-dwelling seedfeeder, shows a wing polymorphism producing brachyptery and macroptery. A selection experiment for different wing forms was carried out at 30°C under 12L–12D to investigate whether or not the wing form of this species is a heritable trait. In the macropterous selected line, the incidence of macroptery reached a plateau at around 70% in females and at 80% in males after the 4th generation. On the contrary, in the brachypterous selected line, almost no macropters were produced after the 6th generation in either sex. These responses to selection for the two wing forms clearly showed that wing form is a heritable trait in *P. sibiricus*. Realized heritabilities for the two wing forms were estimated by the degree of response to wing form selection in both sexes. The realized heritability for macroptery was estimated to be 0.48 for females and 0.78 for males. On the other hand, the realized heritability for brachyptery was estimated to be 1.57 for females and 1.54 for males.

Key words: *Pyrrhocoris sibiricus*, wing polymorphism, wing form selection, realized heritability

INTRODUCTION

The ground-dwelling pyrrhocorid bug, *Pyrrhocoris sibiricus* Kuschakewitsch, feeds on seeds of leguminous and gramineous plants. This species shows wing polymorphism, producing brachyptery and macroptery in both sexes (Sakashita et al., 1995, 1996). The production of *P. sibiricus* macropters was accelerated under rearing conditions such as high temperature (30°C), short day-length (12L–12D) and moderate nymphal crowding (Sakashita et al., 1995). In many wing polymorphic insects, however, wing morphology is affected not only by environmental factors but also by genetic factors (Roff and Fairbairn, 1991).

The redfire bug, *P. apterus*, which is closely related to *P. sibiricus*, also shows wing polymorphism, producing brachyptery and macroptery (Honěk, 1986), and rarely microptery (Socha et al., 1993). It is known that the wing polymorphism of *P. apterus* is affected not only by environmental factors but also by genetic factors (Honěk, 1986). In *P. sibiricus*, however, the genetic background for the determination of wing form is unknown. Therefore, a selection experiment for different wing forms

was carried out to determine whether or not the wing form of *P. sibiricus* is a heritable trait. Realized heritabilities for the two wing forms were also estimated by the degree of response to wing form selection in both sexes.

MATERIALS AND METHODS

The stock culture which was used in the present selection experiment was established from different wing forms of adults (19 brachypterous females, 20 brachypterous males, 23 macropterous females and 20 macropterous males) collected from a field in Okayama, western Japan, in 1994. The stock culture was maintained at 30°C under 12L–12D for 3 generations before the onset of the selection experiment.

Selection for different wing forms was conducted at 30°C under 12L–12D. Rearing density during the nymphal stage was 8 individuals per petri dish (9 cm in diameter, 2 cm in depth). Forty eight replications were prepared for each selected line. Newly emerged adults were checked for wing form after the definition by Sakashita et al. (1996). Approximately 80 brachypters (females : males = 1 : 1) were selected as parents for the brachypterous selected line in each generation. Similarly, ap-

proximately 80 macropters (females : males = 1 : 1) were selected as parents for the macropterous selected line in each generation. The adults of each selected line were maintained under mass rearing conditions using a container (15 cm in diameter, 6.5 cm in depth) in order to minimize the effect of inbreeding. Nymphs and adults of each selected line were provided with soybean seeds and water. Petri dishes, containers, seeds and water were replenished twice a week.

RESULTS AND DISCUSSION

In the macropterous selected line, the incidence of macroptery tended to decrease at the 1st generation, but was followed by a rapid increase (Fig. 1). Why the incidence of macroptery decreased at the 1st generation despite the selection for macroptery remains unclear. There is the possibility, however, that some environmental variation in the culture may have affected the temporal decrease in the incidence of macroptery. The incidence of macroptery reached a plateau of around 70% and 80% after the 4th generation in females and males, respectively (Fig. 1). In *P. apterus*, the incidence of macroptery finally reached ca. 90% in the macropterous selected line (Honěk, 1979, 1986). Similarly, in the wing dimorphic cricket,

Fig. 1. Response to selection for macroptery (dashed line) and brachyptery (solid line) in *P. sibiricus*.

Gryllus firmus, the limit of the incidence of macroptery was 90% rather than 100% in the macropterous selected line (Roff, 1990). Therefore, the tendency for the incidence of macroptery in the macropterous selected line not to reach 100% appears to be common in wing polymorphic or dimorphic insects. On the contrary, in the brachypterous selected line, almost no macropters were produced after the

Fig. 2. Relationship between the cumulative value of selection response and the cumulative value of selection differential in the lines selected for macroptery and brachyptery. * $p < 0.05$ and ** $p < 0.01$.

6th generation in either sex. Thus, the response to wing form selection was asymmetric in the macropterous and brachypterous selected lines. In the present study, however, no replication was made for each selected line. Therefore, the existence of the asymmetric response may be in doubt, because it can easily appear as a result of genetic drift (Falconer, 1989). At least two selected lines in each direction are required to confirm whether or not the asymmetric response is real. Nevertheless, the present selection experiment clearly showed that wing form is a heritable trait in *P. sibiricus*.

Genetic systems of wing polymorphism are divided into two groups; a single locus system and a polygenic system (Roff, 1986). Roff (1986) proposed a threshold model for the determination of wing form. According to the model, wing form is under the control of juvenile hormone (JH), and wing production will be suppressed if the titre of JH exceeds some threshold level. The above results for wing form selection in *P. sibiricus* suggest that the determination of wing form is controlled by a polygenic system. Therefore, the polygenic threshold model of Roff (1986) was applied to estimate the realized heritabilities for the two wing forms of *P. sibiricus* in each sex.

Realized heritabilities for the two wing forms of each sex were estimated using data for 6 generations in the selection experiment (Fig. 2). In brachypterous females, however, the realized heritability was estimated using the data for 5 generations, because no macropters were produced in the 6th generation. The values of the cumulative selection response ($\Sigma(x_1 - x_2)$) were plotted against the values of the cumulative selection differential (Σi), where x is the deviation of the threshold from the mean in terms of standard deviation units, and i is the mean deviation of individuals with values exceeding threshold in standard deviation units from the population mean (see appendix Table A in Falconer, 1989). The realized heritabilities were estimated from the slopes of the regression

lines. The correlation coefficients for the two selected lines were significant in both sexes.

The realized heritability for macroptery was estimated to be 0.48 and 0.78 for females and males, respectively. These estimates are similar to those for other wing dimorphic insects such as *G. firmus* (Roff, 1990). On the other hand, the realized heritability for brachyptery was estimated to be 1.57 and 1.54 for females and males, respectively. These values, per se, are doubtful because they exceeded 1 as a maximum value of heritability. There is a high possibility that the rapid increase in the incidence of brachyptery in the 1st generation has led to an overestimate of the realized heritability for brachyptery. Other methods such as offspring-parent regression and the full-sib family method are required for a more exact estimation of narrow sense heritabilities in the two wing forms of *P. sibiricus*.

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