

GENETIC CORRELATION OF WING POLYMORPHISM BETWEEN
FEMALES AND MALES IN THE ORIENTAL CHINCH BUG,
CAVELERIUS SACCHARIVORUS OKAJIMA
(HETEROPTERA: LYGAEIDAE)

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SUMMARY

Genetic correlations of the wing form and the relative wing length between females and males were estimated in the oriental chinch bug, *Cavelerius saccharivorus*, by calculating the correlation between the sexes of the proportion macropterous or the mean relative wing length in full-sib families obtained from different wing forms of parents emerged in a high density population. There was a significantly positive genetic correlation between the sexes in both the proportion macropterous and the mean relative wing length. However, the appearance rate of macropters tended to be much lower in males than in females under the rearing conditions which promote the appearance of macropters. This was evident especially in the offspring of brachypterous parents. These indicated that in *C. saccharivorus* the wing polymorphism of males is not a simple result of the genetic correlation of wing morphology between the two sexes. It was considered that both of the female and male fitness advantages to wing reduction, as well as the genetic correlation between the sexes, would influence the evolution of wing polymorphism in this species.

KEYWORDS: *Cavelerius saccharivorus*, wing polymorphism, genetic correlation between sexes, relative wing length, male fitness advantage.

INTRODUCTION

There are many insect species which exhibit wing polymorphisms that affect flight activity (Harrison, 1980). Correlations between wing morphology and life history traits have been well studied in females, and substantial fitness differences between brachypterous and macropterous forms have been demonstrated in many species (Roff and Fairbairn, 1991). In contrast to this, little or no attention has been paid to the fitness trade-offs in males (Wagner and Liebherr, 1992), although a few of recent studies have demonstrated that there exists a male fitness advantage to wing reduction in a thrips, *Hoplothrips pedicularius* (Crespi, 1986) and the oriental chinch bug, *Cavelerius*

saccharivorus (Fujisaki, 1992). Whether or not a trade-off exists, however, the evolution of wing dimorphism in males will be influenced by the genetic correlation of the trait between females and males (Roff and Fairbairn, 1994).

In this paper, I estimate the genetic correlation of wing form and relative wing length between the sexes in *C. saccharivorus*, an important pest of sugar cane in the subtropical region from Taiwan to the southwestern islands of Japan.

MATERIALS AND METHODS

Many 5th instar nymphs of *C. saccharivorus* were collected from a sugar cane field in Okinawa Prefectural Agricultural Experiment Station in Naha, Japan, on June 8, 1984. The population density of this species was extremely high in this field; the mean density of nymphs and adults per stalk was 79.2 ± 34.6 (S.D.) on June 8. Such a population density is high enough to produce abundant macropters. These nymphs were kept in glass vials (900 ml) with sugar cane cuttings as a food source under approximately natural conditions in an open insectary. On the day when they emerged as adults, they were checked for wing form and male-female pairs of various combinations of wing form were set up. Thirty and 23 brachypterous females were paired with brachypterous and macropterous males, respectively. Fifty eight and 27 macropterous females were paired with brachypterous and macropterous males, respectively. They were reared in small glass vials (50 ml) each containing a piece of sugar cane cutting (1.0–1.5 cm in diameter and ca. 5 cm in length) as a food source and oviposition site under the conditions of 28°C and 15L9D photoperiod. The food as well as the vial was renewed every three days.

The first clutch containing at least ten eggs deposited by each female was placed on a wet filter paper within a petri dish at 28°C. The nymphs hatched from each clutch were reared in a small glass vial (50 ml) containing a sugar cane cutting (ca. 1 cm in diameter and ca. 5 cm in length) as a food source under the same conditions as in adults until they eclosed to adults. The food as well as the vial was renewed every three days. The number of nymphs which moulted to the 4th instar was checked for all families.

The wing form of emerged adults was determined by their relative wing length (RWL) in terms of the number of abdominal segments overlapped by the forewings. Here, adults with RWL of equal to or less than 4.0 are defined as brachypters and those with RWL of equal to or more than 4.5 as macropters (Fujisaki, 1989a). Other morphometric variables measured were body length (from tip of head to tip of abdomen) and forewing length (from base to tip). A profile projector (Nikon, V-10) was used for the measurements.

RESULTS

Macropters of *C. saccharivorus* are likely to be produced in crowded populations (Fujisaki, 1985). The nymphal density at the 4th instar is most critical for the wing form determination (Fujisaki, 1989b) and ten individuals per container (50 ml) is enough to produce a considerable proportion of macropters (Fujisaki, 1986). Therefore, the full-sib families which contained at least 10 nymphs at the 4th instar period were selected for the analysis of genetic correlation of the wing form or the relative wing length between the sexes. The total number of families used for the analysis was 69 and the family size at the 4th instar ranged from 10 to 32.

The relative wing length in terms of the ratio of forewing length to body length was averaged together in each sex of each family, and the genetic correlation of the

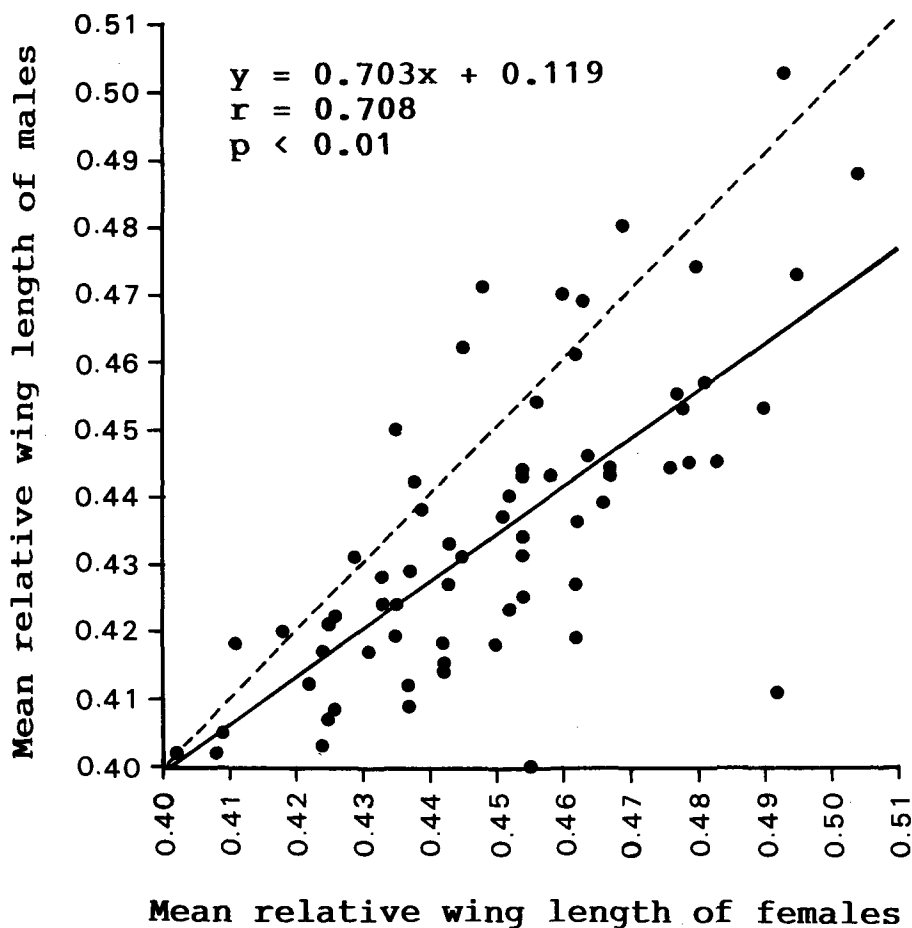


Fig. 1. Correlation of the relative wing length (forewing length/body length) between females and males in all families. Each solid circle represents a different full-sib family. The dotted line is an iso-proportional one.

relative wing length between females and males was calculated (Fig. 1). The estimated genetic correlation was 0.708 and highly significant ($p < 0.01$), although the average relative wing length often showed much lower values in males than in females. The proportion macropterous in each sex of each family was arcsine squareroot transformed, and the genetic correlation of the proportion macropterous between the sexes was calculated (Fig. 2). In this case, any families in which there was zero of one morph were not used for the calculation. The estimated genetic correlation was 0.517 and also significant ($p < 0.01$). Here again, the proportion macropterous often showed much lower values in males than in females.

It should be noted here that much variation in the relative wing length or the proportion macropterous occurred among families. This variation may be attributed to the difference in the parental wing form. Therefore, the genetic correlation of the relative wing length between the sexes was analyzed for the offspring of different male-female pairs of various combinations of wing form. The correlation of the relative wing length between the sexes was significantly positive in the offspring of all kinds of

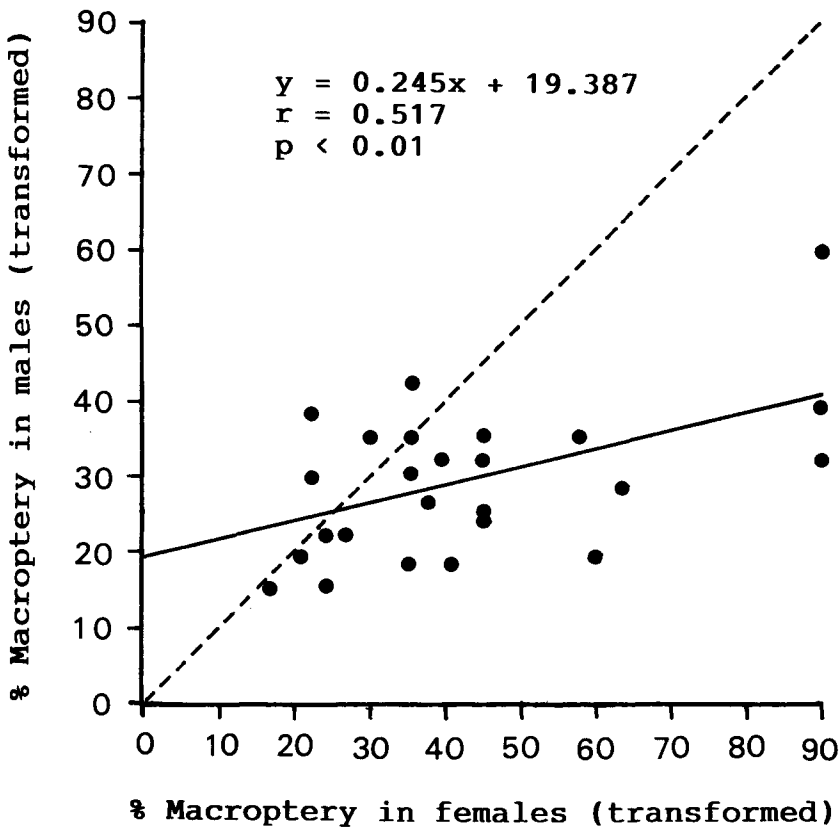


Fig. 2. Correlation of the proportion macropterous (arcsine squareroot transformed %) between females and males in all families. Each solid circle represents a different full-sib family. The dotted line is an iso-proportional one.

parental pairs, although the correlation coefficient showed a much lower value in the offspring of brachypterous parents (Fig. 3).

Table 1 shows the results of two-way ANOVA for testing the effects of parental wing form and sex on the relative wing length of offspring. The differences between the parental wing forms and between the sexes were highly significant ($p < 0.01$). However, there was no significant interaction between these two factors.

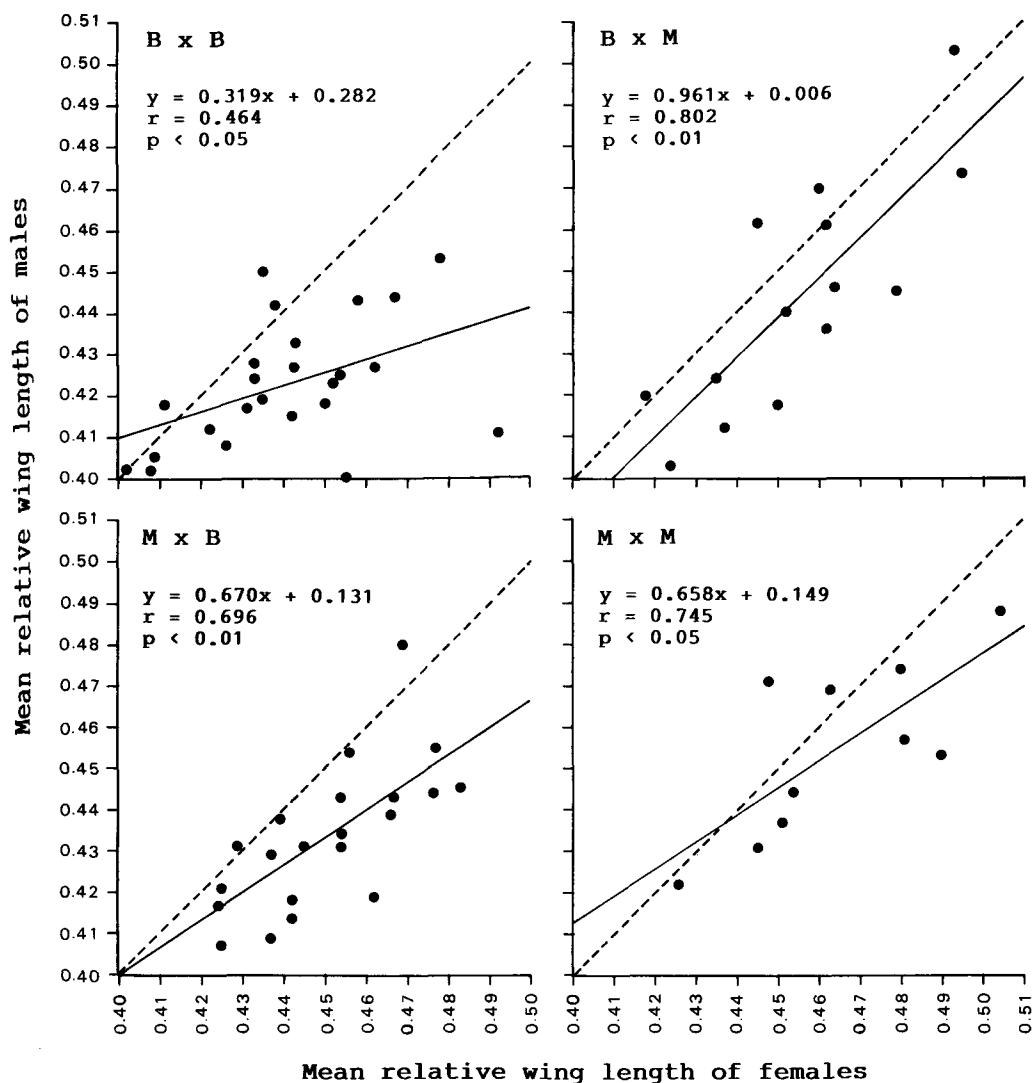


Fig. 3. Correlation of the relative wing length (forewing length/body length) between females and males in each of four family groups produced by different wing form of parents (B × B: brachypterous female × brachypterous male; B × M: brachypterous female × macropterous male; M × B: macropterous female × brachypterous male; M × M: macropterous female × macropterous male). Each solid circle represents a different full-sib family. The dotted line is an iso-proportional one.

Table 1. A two-way analysis of variance, for testing the effects of sex and parental wing form on the mean relative wing length of the offspring.

Source of variation	df	SS	MS	F_{cal}
Sex	1	0.003	0.003	6.85**
Wing form	3	0.018	0.006	13.68**
Interaction	3	0.001	0.000	0.43 ^{ns}
Error	130	0.056	0.000	
Total	137	0.077		

** $p < 0.01$, ns: $p > 0.05$

DISCUSSION

Roff and Fairbairn (1994) reported that there is a high genetic correlation of wing dimorphism between females and males in the sand cricket, *Gryllus firmus*. The present study also showed a positive genetic correlation of relative wing length and wing form between females and males of *C. saccharivorus* (Figs. 1 and 2). However, the mean relative wing length and the proportion macropterous often showed much lower values in males than in females.

In this study, the nymphs were reared under the conditions of high temperature, long day length and high density. These environmental conditions promote the production of macropters in *C. saccharivorus* (Oshiro, 1981; Fujisaki, 1989b). Therefore, the difference in the relative wing length or the proportion macropterous of adults between females and males would reveal a differential nymphal response between the sexes to the above conditions.

The wing reduction was evident especially in the offspring of brachypterous parents (Fig. 3). A marked wing reduction under extremely high density conditions during nymphal period has been already confirmed in *C. saccharivorus* offspring of brachypterous parents which appeared in a high density population (Fujisaki, 1986). The present study, as well as the study mentioned above, indicates that the density response in the determination of wing form is different between genotypes of *C. saccharivorus*.

These results also indicate that in *C. saccharivorus* the wing polymorphism of males is not a simple result of the genetic correlation of wing morphology between the two sexes. Fujisaki (1992) examined trade-offs between morphology and sexual maturation in *C. saccharivorus* adults and found that brachypterous males as well as brachypterous females matured earlier than macropterous ones. This shows that there is a cost associated with being winged not only in females but also in males. Therefore, it is no doubt that there is a male fitness advantage to wing reduction in this species, indicating that natural selection for brachyptery can act on not only females but also males. Furthermore, the frequency of brachyptery is higher in males than in females in *C. saccharivorus* (Fujisaki, 1986, 1989a), suggesting that brachyptery may be more advantageous for males than for females.

However, the occurrence of genetic correlation of wing morphology between the two sexes shows that the frequency of brachyptery in one sex may be strongly influenced by selection acting on opposite sex. Female and male fitness advantages to wing reduction, as well as the genetic correlation between the sexes, would influence the evolution of wing polymorphism in this species.

ACKNOWLEDGEMENTS: I express my sincere thanks to Drs. F. Nakasuji of Okayama University and D. A. Roff of McGill University for their critical reading of the manuscript. This work was supported in part by a Grant-in-Aid No. 05660050 from the Japan Ministry of Education, Science and Culture. This work was also supported in part by a Grant-in Aid (Bio Cosmos Program) from the Ministry of Agriculture, Forestry and Fisheries, Japan (BCP-94-I-B-1).

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カンショコバネナガカメムシにおける雌雄間での翅多型性の遺伝相関

藤 崎 憲 治

カンショコバネナガカメムシの雌雄間での翅型と相対翅長に関する遺伝相関が、高密度個体群で羽化した異なる翅型の両親に由来する全兄弟ファミリーにおける、長翅率あるいは平均相対翅長の相関を算定することにより推定された。

長翅率と平均相対翅長の両方において雌雄間には有意な正の遺伝相関が存在した。しかし、長翅型の出現を促進する飼育条件下で、長翅の出現率は雌より雄ではるかに少ない傾向が認められた。このような傾向は、短翅型両親の子供で特に顕著であった。これらのことは、本種における雄の翅多型性が雌との単なる遺伝相関の結果ではないことを示唆した。雄と雌それぞれにおける短翅化の適応度上の利益および雌雄間の遺伝相関が、本種の翅多型性の進化に影響しているものと考えられた。