Morphometric Characters of Overwintering Adults of the Bombay Locust, *Patanga succincta* (L.) (Orthoptera: Cyrtacanthacridinae) in Outbreak Areas of Okinawa

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Overwintering adults of the Bombay locust, *Patanga succincta* (L.), were collected in the outbreak year (1980) from two adjacent areas in the southern part of Okinawa Is. and their morphometric characters were examined. The number of eye stripes was either 7 (6-instar type) or 8 (7-instar type). The proportion of the 7-instar type in the females (70.7%) was significantly higher than in the males (18.6%). The head width (C), lengths of hind femur (F) and elytron (E) in each sex were all significantly greater in the 7-instar type than in the 6-instar type. However, these differences were much smaller than the sexual differences. The means of F/C (4.31–4.40) and E/F (1.61–1.65) were not significantly different between the two instar types in each sex.

These results are discussed in relation to moultng polymorphism in locusts and grasshoppers.

INTRODUCTION

Polymorphism in the number of eye stripes in adults of locusts and grasshoppers belonging to Cyrtacanthacridinae is due to variation in the number of moults (Albrecht and Blackith, 1957; Uvarov, 1966). Two or more eye-stripe morphs occur in the desert locust, *Schistocerca gregaria*, the red locust, *Nomadacris septemfasciata*, the Bombay locust, *Patanga succincta*, and the Mediterranean grasshopper, *Anacridium aegyptium*.

*P. succincta* is widely distributed in the tropical and subtropical regions. Six to nine hopper instars have been reported (cf. Roffey, 1979) although the occurrence of 9 instars requires confirmation (Uvarov, 1979). The hoppers do not form bands and adult migrating swarms have been reported only from India (Maxwell-Lefroy, 1906; Rao, 1943, quoted from Roffey, 1979).

In the tropical regions, *P. succincta* is univoltine and the adults spend 7 to 8 months of the dry season in a reproductive diapause (Uvarov, 1966; Roffey, 1979). In the subtropical climate of Okinawa, the univoltine cycle seems to be stabilized both by adult aestivation and hibernation in the adult stage (Hokyo and Fujisaki, in preparation).

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In 1980, an unusual drought prevailed in Okinawa during the hopper period (May–June). Apparently, this favoured the hopper survival and caused unusual infestations of sugarcane fields in the southern part of Okinawa Is. and in Miyako Is. As a result, about 70–80% of the total acreage was lightly or severely infested. This paper deals with some morphometric characters of overwintering adults of the outbreak population.

**MATERIALS AND METHODS**

Adult locusts were collected in the daytime with a sweep net once or twice a month from December, 1980 to April, 1981. Collections were made in several sugarcane fields in two adjacent areas (Hyakuna and Niibaru) of Tamagusuku village in the southern part of Okinawa Is. where hopper infestations were severe (Fig. 1). Hand collection at night, attempted only once at Niibaru, was much easier than daytime netting.

The two areas where adult locusts were collected are characterized by the clay soil derived from the Ryukyu limestone. The soil is generally reddish brown in colour with a well developed crumb structure suitable for oviposition (Fujisaki and Hokyo, 1982). Egg pods survive well because the soil is not waterlogged.

The adults collected were brought to the laboratory and anaesthetized with chloroform before being measured. Maximum width of head (C), length of hind femur (F)
Table 1. Numbers of adult eye-stripe morphs of *P. succineta* collected in the two areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Female 7 stripes</th>
<th>Female 8 stripes</th>
<th>Male 7 stripes</th>
<th>Male 8 stripes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyakuna</td>
<td>43</td>
<td>99</td>
<td>113</td>
<td>20</td>
</tr>
<tr>
<td>Niibaru</td>
<td>24</td>
<td>63</td>
<td>80</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 2. Morphometric comparison of two adult forms of *P. succineta*.

Data are pooled for the two collecting sites

<table>
<thead>
<tr>
<th>Items</th>
<th>Female 7 stripes</th>
<th>Female 8 stripes</th>
<th>Male 7 stripes</th>
<th>Male 8 stripes</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>8.17±0.07 (62)</td>
<td>8.48±0.05 (155)</td>
<td>6.85±0.03 (186)</td>
<td>6.97±0.07 (43)</td>
</tr>
<tr>
<td>F</td>
<td>35.55±0.38 (62)</td>
<td>37.31±0.29 (155)</td>
<td>29.54±0.15 (186)</td>
<td>30.45±0.36 (43)</td>
</tr>
<tr>
<td>E</td>
<td>58.14±1.43 (23)</td>
<td>60.35±0.71 (62)</td>
<td>48.87±0.04 (83)</td>
<td>49.89±0.77 (22)</td>
</tr>
<tr>
<td>F/C</td>
<td>4.36±0.03 (62)</td>
<td>4.40±0.01 (155)</td>
<td>4.31±0.02 (186)</td>
<td>4.37±0.04 (43)</td>
</tr>
<tr>
<td>E/F</td>
<td>1.64±0.02 (23)</td>
<td>1.61±0.01 (62)</td>
<td>1.65±0.01 (83)</td>
<td>1.63±0.03 (22)</td>
</tr>
</tbody>
</table>

* Maximum width of head (scale in mm).
* Length of hind femur (scale in mm).
* Length of elytron (scale in mm).

Note: in brackets are the numbers of specimens examined.

and elytron (E) were measured with a caliper as described by Drnšt (1953). The number of eye stripes was counted with the aid of a low power lens. Measurement of C and F was made for most of the specimens, but E was measured only for about one third of the females and one half of the males.

RESULTS

Table 1 shows the numbers of males and females of each eye-stripe morph. Both sexes had either 7 or 8 eye stripes, indicating that they had spent 6 or 7 hopper instars. The significance of the difference in frequency of the two morphs between the two areas of collection was examined by $\chi^2$-test. No significant difference was found in the female ($\chi^2_2=0.189$, $0.5<p<0.7$, d.f. = 1) and in the male ($\chi^2_2=2.495$, $0.1<p<0.2$, d.f. = 1). The data of the two areas were then pooled and 70.7% of the females and 18.6% of the males were found to be the 7-instar type. This difference between the sexes was highly significant ($\chi^2_2=122.6$, $p<0.001$, d.f. = 1).

When the same eye-stripe morphs of each sex were compared between the two collecting sites, there was no significant difference in the means of C, F and E ($t$-test). The data were then pooled for the two collecting sites as shown in Table 2. The means of C, F and E for each sex were significantly larger in the 8 than in the 7 eye-striped morphs. However, the ranges of these measurements of the two moulting types overlapped considerably. On the other hand, the sexual dimorphism in these size characters was much clearer than the moulting dimorphism. The males were much smaller
than the females.

In each sex, the mean of F/C was slightly larger in the 7 eye-striped morphs than in the 8 eye-striped ones, and the reverse was true for E/F. However, these differences were not significant (p > 0.05, see Table 2).

**DISCUSSION**

Developmental polymorphism (moulting polymorphism) is an aspect of phase polymorphism in *S. gregaria*, *L. migratoria migratorioides* and *N. septemfasciata* (Uvarov, 1966, 1977). In these locusts, solitarious hatchlings are much smaller than gregarious ones and only smaller hatchlings undergo extra moults. Albrecht (1955) and Albrecht and Blackith (1957) suggested that the intercalation of an extra instar largely compensated for the initial size difference. However, Albrecht’s concept of growth adjustment does not explain the difference in the expression of sexual dimorphism between the solitarious and gregarious phases. The sexual difference in size is more conspicuous in the solitarious than in the gregarious phase (Uvarov, 1966).

The ratio F/C is a useful index of phase in locusts (Dirsh, 1953; Uvarov, 1966, 1977) because F and C vary in similar ways between males and females but in opposite ways in response to population density. C is significantly greater, while F, and therefore F/C, smaller in the gregarious than in the solitarious phase. In *P. succincta*, however, the means of F/C and E/F were fairly constant among different instar types and sexes, suggesting that this species is much less ‘phase sensitive’ than its closest relative, *N. septemfasciata*.

Moulting polymorphism in locusts and grasshoppers is partly related to body size. Uvarov (1966) noted three ways in which moulting and phase variation are related to size. (i) The smallness of advanced groups such as the Gomphocinæae is related to the small number of moults. The majority of species pass through only four instars. The Moroccan locust, *Docioptaurus marocanus*, belonging to Gomphocinæae is highly ‘phase sensitive’ and gregarious phase adults are very much larger than solitarious. (ii) Most Cyrtacanthacridinae, which include *S. gregaria*, *L. migratoria migratorioides*, *N. septemfasciata* and *P. succincta*, are large and the number of instars recorded never falls below five and may be as high as nine (this record for *P. succincta* requires confirmation). In the first three highly ‘phase sensitive’ species, discriminant function analysis using C, F and E values showed that whereas gregarious males are larger, gregarious females are smaller than solitarious ones (Uvarov, 1966). In *P. succincta*, however, a large disparity in C, F and E values was found between the sexes irrespective of moulting types (Table 2), and hence it seems that the morphometric characters and differential incidence of the extra instars between the sexes might be closely linked with sex as in the third case. (iii) Where there is notable sexual dimorphism, the larger females normally undergo an extra moult. Further studies will elucidate the relative importance of sex, density and environmental factors (e.g., food) in determining the number of instars, morphometric characters and adult mobility in *P. succincta*.

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REFERENCES


