to coagulate very rapidly.

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REFERENCES

BLUM, M. S. and A. SANNASH (1974) J. Insect

Mating Status Depending on the Growing Stage of the Rice Plant in the Population of *Cnaphalocrocis medinalis* Guenée (Lepidoptera : Pyralidae)¹

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It is considered that the rice leaf roller, *Cnaphalocrocis medinalis* Guenée, is a long-distance migrant and immigrates into Japan from overseas countries every year in June and July, the rainy season called 'Baiu', instead of wintering on the Japanese main islands (MIYAHARA et al., 1981). Recent study has shown that the proportion of mated females in the population of the paddy field fluctuates greatly by season and that it decreases extremely beginning in early autumn (WADA et al., 1980). In order to clarify the cause of the disappearance of sexually mature moths, we have undertaken the present investigation.

In northern Kyushu, south-western Japan, moths were collected at the same time from paddy fields in several areas where rice was cultivated in different seasons in order to discover the relationship between the reproductive status of moths and the growing stages of the rice plant. Captured moths were first examined for torn or tattered their wings. Then, female moths were dissected under a binocular microscope to check for the presence of the spermatophore in the bursa copulatrix. Observations were also made of the development of their ovaries and the amount of body fat.

The places surveyed are shown in Fig. 1. Rice cultivation in these areas is briefly described below.

Chikugo-shi and Yame-shi: These places are included in the area of the so-called, normal season culture in northern Kyushu. The rice plant is transplanted in late June, flowers in early September and is harvested in late October or early November. The rice plant in a few paddy fields used in our experiment was not reaped even after full ripening in order to capture moths there in early and mid November. Nakatsuemura, Aso-cho and Yabe-mura: The places are in the mountains. Early maturing rice varieties are cultivated as an early planting culture. The

![Fig. 1. Map showing the places where moths were collected.](image)

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The rice plant is transplanted in late May or early June, flowers in mid- or late August, and is harvested in October. Tachibana-cho: This place is located on the boundary between areas with a normal season culture and an early planting area. So rice plants transplanted at different times can be found in this neighborhood.

Hondo-shi: The climate in this area facing the sea is mild and warm. An extremely early planting culture has been adopted in this area. The rice plant is transplanted in mid- or late April, flowers in July and is harvested from mid-August to early September. Paddy fields with a normal season culture are also scattered through this extremely early planting area. Among these paddy fields with different transplanting times, we also collected moths from a few fields in which the rice plant was especially young.

Seasonal changes in the mating status of the female population collected in the normal season culture paddy field from 1977 to 1980 are shown in Fig. 2, in addition to the growing stages of the rice plant. It seems that the mating status of moths in the paddy field with a normal season culture shows seasonal fluctuations as indicated by the solid line in Fig. 2, since the same tendency was obtained every year for four years. Namely, the proportion of mated moths in the field population decreases gradually from mid-August and rapidly from early September when the rice plant starts heading and flowering. The percentage of mated moths is extremely low from mid-September to October. In November, it increases somewhat again. The moths captured before mid-July in paddy fields with a normal season culture which was transplanted in late June were not ones which emerged there, but immigrants, because they require about a month to complete their maturation. The number of immigrants observed in the paddy field with a normal season culture is usually so small that it is difficult to determine the mating status of the population accurately. But the proportion of mated females seems to be high because the few moths collected were all mated. Roughly estimated values for the mating status in this season are shown by the dotted line in Fig. 2.

In 1979 surveys were made on August 25 and September 5 (Table 1). It will be seen that the mating status of the field population differs remarkably even in the same season, depending on the growing stage of the rice plants from which moths were collected. The adult population collected at Nakatsu, Aso (col., Aug. 25) and Yabe (col., Sept. 5), where the rice plant was in the ripening stage, showed an extremely low rate of mating, whereas the population in the area with a normal season culture showed a relatively high rate. A tendency was also recognized for the percentage of mated females to decrease as the growing stage of the rice plant.

Fig. 2. Changes in mating status in the population of *C. medinalis* in paddy fields with a normal season culture in relation to the growing stages of the rice plant. MTN: The maximum tiller number stage, Pl: The panicle initiation, ○, ●, □, ■: the results shown in 1977, 1978, 1979 and 1980, respectively.
Table 1. Copulation of female moths of the population in the paddy fields in relation to the growing stages of the rice plant

<table>
<thead>
<tr>
<th>Data</th>
<th>Place</th>
<th>Culture</th>
<th>Growing stage</th>
<th>No. of females</th>
<th>% of mated females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dissected</td>
<td>Mated</td>
</tr>
<tr>
<td>1979</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug. 25</td>
<td>Chikugo</td>
<td>Normal season</td>
<td>Booting</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>Aug. 25</td>
<td>Tachibana</td>
<td>Early and normal</td>
<td>Early ripening (early milk-ripe)</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>Aug. 25</td>
<td>Nakatsue</td>
<td>Early</td>
<td>Early ripening (milk-ripe)</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>Aug. 25</td>
<td>Aso</td>
<td>Early</td>
<td>Early ripening (milk-ripe)</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Sept. 5</td>
<td>Yame</td>
<td>Normal season</td>
<td>Late booting</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>Sept. 5</td>
<td>Chikugo</td>
<td>Normal season</td>
<td>Flowering</td>
<td>30</td>
<td>14</td>
</tr>
<tr>
<td>Sept. 5</td>
<td>Tachibana</td>
<td>Early and normal</td>
<td>Ripening (soft-dough)</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Sept. 5</td>
<td>Yabe</td>
<td>Early</td>
<td>Ripening (soft-dough)</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug. 17</td>
<td>Hondo</td>
<td>Extremely early (Late)</td>
<td>Fully ripening Maximum tiller number</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>Aug. 17</td>
<td>Hondo</td>
<td>Normal season</td>
<td>Early booting</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Aug. 18</td>
<td>Chikugo</td>
<td>Normal season</td>
<td>Early booting</td>
<td>30</td>
<td>21</td>
</tr>
</tbody>
</table>

The milk-ripe stage comes after the flowering stage and is followed by the soft-dough stage.

The maximum tiller number stage is before panicle initiation.

advances. But, at Tachibana, the boundary area, the percentages were comparatively high, even in the ripening stage. This may be due to the influence of nearby paddy fields with a normal season culture. In 1980 the surveys were made in the extremely early planting area and the area with a normal season culture. The proportions of mated females were quite different among the populations. It was very high in the paddy field at the maximum tiller number stage, high in the booting stage and low in the fully ripening stage.

From the results of the present surveys, it can be concluded that the mating status of the field population fluctuates mainly depending on the growing stage of the host plant without regard to season. The proportion of mated females in the population maintains a comparatively high level until the flowering stage (more than 50%). After that, it rapidly decreases to a very low level at the middle of milk-ripe stage. Most of mated moths inhabiting the paddy field at the early milk-ripe stage had worn-out wings and contained little fat body and a small number of matured eggs in their abdomens as compared with mated ones from paddies in the previous stage of rice growing. This suggests that these individuals had emerged and mated several days before they were captured. On the other hand, most of the unmated females at this rice growing stage possessed clean wings and contained immature ovaries and rich fat body in their abdomens, suggesting they were newly emerged. Further, when considering rapid decrease in the proportion of mated females after the flowering stage, it is likely that few moths copulate in the paddy field after the flowering stage.

Wada et al. (1980) suggested some possible causes of the sudden disappearance of the mated females in autumn. From the results mentioned above, there is little possibility of reproductive diapause induced by environmental factors, such as temperature, light and food conditions, because mating status often differ significantly among populations under almost the same condition of light and temperature. Even in autumn, moths copulated when they were confined to a paddy field in the ripening stage by screened cages (Wada, unpublished). This suggests that the disappearance of mated females in autumn is a phenomenon incidental to the dispersal or emigration of moths from paddy fields which have
gradually become unfavorable for their habitats. That is to say, in this season we can capture only sexually immature moths in the teneral stage before dispersal. It also agrees with this hypothesis that most of the moths are newly emerged and that the mating status is strongly influenced by the growing stages of the host plant.

In disregard of emigration, the density of moths in the paddy field generally increases remarkably in autumn. This may be due to the great increase in the number of moths which emerge there as the generation advances. In fact, the number of moths observed was much lower than we had been led to expect by the density of healthy pupae. Moreover, we observed numerous immigrants in grassy fields in autumn (WADA et al., 1980). These facts suggest mass dispersal of moths from the paddy field, too.

There is a slight increase in the proportion of mated females from the end of October through the rest of the season. Most of the mated moths in this season have poor body fat and look lean and exhausted. This increase is possibly because a few more mated moths out of the numerous moths emerging in autumn tend to stay in the paddy field as compared with virgin females. In November, moths newly emerged in the paddy field decrease greatly in number, which results in an increase in the proportion of mated females in the population.

The phenomenon of seasonal fluctuation in the mating status and sexual maturity of the adult population owing to dispersal or migration has been reported for some Lepidopterous insects (LOPEZ et al., 1978; OKU and KOBAYASHI, 1978). In the case of the rice leaf roller, it is here clearly shown that the changes in these population characteristics depend on the growing stage of the host plant. So, inversely, these population characteristics seem to be a good index of adult dispersal in a field.

REFERENCES


Changes in Size and Weight during Development of Tribolium freemani HINTON (Coleoptera : Tenebrionidae)

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HINTON (1948) described Tribolium freemani from a female adult which was collected in the 1890s in Kashmir in India. Since then no specimen of this species had been found until three years ago when a few adults were collected in Japan. NAKAKITA et al. (1981) studied some biological characters of this species and concluded that it was a sibling species of Tribolium castaneum and a potential pest of stored-products. In the present paper the development in body size and weight of this species was studied.

Stock culture has been reared on wheat-feed supplemented with brewer's yeast in a darkroom maintained at 32.5 ± 0.5°C and 70 ± 8% R.H. All experiments were carried out under these environmental conditions. Medium was a mixture of 19 parts of wheat flour to one part of brewer's yeast by weight and the mixture was conditioned for a fortnight under the experimental conditions. Eggs were obtained over 24 hours from groups of adults collected from stock culture

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