The Effect of *Drosophila* Release on the Spider Population in a Paddy Field

Shiro Kobayashi

Laboratory of Applied Zoology, Faculty of Agriculture, Yamagata University, Tsuruoka, Yamagata 997, Japan

(Received August 29, 1975)

*Drosophila* flies were released into dikes surrounding a paddy field during the period from late April to mid-July as an alternative prey of spiders. Flies were found to be devoured frequently by spiders and constituted 39% of the spider diet. The population density of spiders in the dikes increased soon after release and was followed by an increase in paddy fields situated adjacent to the dikes. The population density of leaf- and planthoppers inhabiting these plots was suppressed during late July in the dikes and during early September in the paddy fields, but the suppression was not evident thereafter. These results suggest that the abundance of spiders in any given paddy field depends upon the extent of food availability prior to migration from dikes, and that their predatory pressure upon hoppers is not significant.

INTRODUCTION

Spiders are natural enemies of insects such as the green rice leafhopper, *Nephrotettix cincticeps* Uhler, and the smaller brown planthopper, *Laelodelphax striatellus* Fallen, which cause damage to rice crops.

In a previous paper (Kobayashi and Shibata, 1973), it was suggested that dikes serve as a source from which spiders migrate to neighboring paddy fields, and that the increase in spider population depends upon the abundance of natural available food.

In Miyagi Prefecture, the natural food of spiders in the spring and early summer mainly consists of Chironomids and Ceratopogonids whose biomass is usually small in comparison to their numbers. In mid-summer and autumn, leaf- and planthoppers increase in both numbers and biomass in paddy fields. Spider proliferation demonstrates a time lag pattern which follows the increase in hopper numbers.

The purpose of this study was to examine the effect of spring and early summer release of a certain prey into dikes on the population density of spiders in paddy fields during the subsequent summer and autumn seasons.

MATERIALS AND METHODS

*Drosophila melanogaster* Meigen of the wild type were released into dikes located at Kashimadai-machi in Miyagi Prefecture during April 23 to July 12, 1973. The design of experimental plots is shown in Fig. 1. Each plot consisted of a dike (30 m

---

1 Contribution from the Laboratory of Applied Zoology, Yamagata University, No. 81
**Drosophila Release in Paddy Field**

![Map showing the experimental plots. Distance between plot C1 and C2 is about 500 m.](image)

Drosophila were reared in 300 ml polyethylene containers on a yeast-sugar medium. Twenty pairs of flies were put into each container and maintained at a temperature of between 24–26 °C for 10 days in the laboratory. Following the 10 day incubation period, the 20 rearing containers were placed on each of the “R” dikes at an interval of 1 m and were newly replaced every week. Each container was covered with a polyethylene cap in order to prevent the entry of rainwater; sides of the caps were perforated with small holes (6 mm in diameter) through which newly emerged adults could escape. The daily mean number of flies which emerged from containers during the first week following incubation was estimated to be 149. Based upon this figure, the number and biomass of flies released into each “R” plot during the experiment were roughly estimated to be about 240,000 flies (149 flies×20 containers×81 days) and 270 g (240,000 flies×1.12 mg), respectively. Since some of the emerged flies were known to disperse away from the site of the “R” dike, actual fly density of the dike...
was estimated from numbers recaptured with a sweep net. Spider numbers were compiled by direct counting of either 10 rice hills selected at random in the paddy field, or a $50 \times 50 \text{ cm}^2$ quadrat placed on the surface of dike. Numerical composition of other arthropods was ascertained by capture with a sweep net (20 strokes of a net, 40 cm in diameter, with a 1-m rod). The effective sweeping area was about 20 m$^2$ for the paddy field and 5 m$^2$ for the dike. The aforementioned censuses by direct counting and net sweeping were conducted once every two weeks, with replicate operations performed for each plot.

The diet of spiders was surveyed 6 times during the period of Drosophila release by means of direct observation by aid of artificial light of an electric torch. Observations were made between 6 and 9:30 p.m. Whenever predation was observed, both the spider and prey were captured with a glass tube and killed by anesthetization prior to laboratory examination.

The results are presented as averages of the censuses taken for $R_1$, $R_2$ and $C_1$, $C_2$.

RESULTS

Biomass of arthropods in dikes and paddy fields

Fig. 2 shows the seasonal changes in the biomass of arthropods collected by net sweeping. Since spiders usually prey on arthropods of smaller body size, the biomass given in Fig. 2 was arbitrarily limited to individuals whose body lengths were less than 1 cm.

Although the seasonal trend for biomass was virtually unchanged, Drosophila release resulted in an increase in biomass during June and early July. Most of the flies were found to remain nearby the rearing containers from which they had emerged,
Drosophila Release in Paddy Field

Table 1. PERCENT COMPOSITION OF SPIDER DIETS FOR PLOTS OF Drosophila
       RELEASE (R) AND THOSE OF UNTREATED CONTROL (C)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Prey</th>
<th>R</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoppers</td>
<td>2.2 (0.2)</td>
<td>0.0 (0.3)</td>
</tr>
<tr>
<td>Dipterons\textsuperscript{b}</td>
<td>32.6 (45.8)</td>
<td>58.7 (66.1)</td>
</tr>
<tr>
<td>Spiders</td>
<td>8.7 (14.9)</td>
<td>10.3 (9.9)</td>
</tr>
<tr>
<td>Released Drosophila</td>
<td>39.1 (27.1)</td>
<td>0.0 (0.1)\textsuperscript{c}</td>
</tr>
<tr>
<td>Others</td>
<td>17.4 (12.0)</td>
<td>31.0 (23.6)</td>
</tr>
<tr>
<td>Total no. of observation</td>
<td>46</td>
<td>29</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Figures in parentheses denote the percent composition of collections by net sweeping and direct counting.
\textsuperscript{b} Excluding released Drosophila.
\textsuperscript{c} An individual probably dispersed from “R”.

and a few were recaptured in paddy fields along the dikes where the rearing containers had been placed.

Preference of spiders for released Drosophila
The diet of spiders is shown in Table 1. Since food composition depends upon the relative abundance of prey species (Sasaba et al., 1973), the composition of collections by net sweeping and direct counting during Drosophila release is also shown in the table.

The similarity between the spider diet and the composition of collected arthropods suggests that the spiders attacked their prey at random. Predation was more frequently observed in “R” than in “C” as is shown by the total number of predations, which may indicate an increase in the amount of food eaten by the spiders in plot “R”.

Change in spider density
Seasonal changes in the population density of spiders in the dikes and paddy fields “R” and “C” are compared in Figs. 3 and 4, and the species of spiders found in paddy fields and dikes have been listed in a previous paper (Kobayashi and Shibata, 1973). Spider density in the dikes, with the exception of Pirata, increased significantly at “R” during the period of release, while that of Pirata did so about one month after the final release. This resulted in a higher density of the total population of spiders at “R” during and after release.

In the paddy fields, the spider population of “R” increased and attained a density about twice that of “C”.

Change in the density of prey insects other than Drosophila
As previously described (Kobayashi, 1961; Kobayashi and Shibata, 1973), dipterous insects were dominant in paddy fields during spring and early summer, while hoppers became more prevalent during mid-summer and autumn. Seasonal changes in density are shown in Fig. 5.

In both the dikes and the paddy fields, no significant difference in the density of dipterous insects (except the released Drosophila) in “R” and “C” was observed, while the density of hoppers in “R” decreased significantly during late July in the dikes and
during early September in the paddy fields. It appears, however, that the hoppers recovered from the decrease shortly thereafter.

**DISCUSSION**

Although caution should be given to any conclusion derived from the results obtained for a single year, observations presented in this paper suggest that *Drosophila* release was effective in promoting an increase in spider density of the paddy fields. This is in accord with the view of van den Bosch and Telford (1964) that alternative prey contribute to the maintenance of general predator populations during low density periods of target insect pests.

The increase of spider population due to *Drosophila* release could be attributed to (1) the concentration of spiders, (2) an increase in fecundity, and (3) a reduction in mortality. The first possibility is supported by the increase of spiders soon after
initial release (Fig. 3). It was frequently observed that spiders (Micryphantidae, Clubionidae, etc.) and beetles (adults and larvae of Harpalidae and Staphylinidae) entered the rearing containers and preyed upon newly emerged flies. The second factor has been shown by the laboratory observation on Lycosa (Suzuki and Kiritani, 1974). The third factor may be inferred by the result that the proportion of spiders in the prey composition did not rise in “R” regardless of the increase in their relative abundance (Table 1). This suggests that cannibalism between spiders decreases if other prey are abundant.

As a result of the increase in the spider populations, the hoppers were suppressed early in September in paddy fields. This delay in revealing the predatory effect may show that the spiders could hardly be a reliable controlling agent because the hoppers caused considerable damage to rice plants even before September. The upward trend in hopper population subsequent to the temporary suppression also indicates that they can escape the predatory pressure of spiders as suggested by Ito et al. (1962). However, if the effect of continuous food supply on the spider population accumulates from year to year, they could conceivably be a more effective controlling factor. Improvement of field conditions resulting in a continuous supply of prey for spiders may be of practical value.

ACKNOWLEDGEMENTS

The author is indebted to the members of the Experimental Farm of the Institute of Agriculture, Tohoku University, for the kind help received during the field work. This study was partly supported by a research grant from the Ministry of Education.
REFERENCES


