Fecundity and larval voracity of four ladybeetle species (Col., Coccinellidae)

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The fecundity and voracity of the ladybeetles, *Coccinella septempunctata, C. quinquepunctata, Adalia bipunctata* and *Propylaea quatuordecimpunctata* were investigated at 20°C and 30°C, the green peach aphid, *Myzus persicae,* being used as food. *C. septempunctata* and *A. bipunctata* were the most fecund species at both temperatures and the temperature had no significant effect on the number of eggs laid in either species. *C. quinquepunctata* and *P. quatuordecimpunctata* were significantly more fecund at 30° than at 20°, the egg-laying of *C. quinquepunctata* being very irregular and scanty at 20°. *C. septempunctata* was the most and *P. quatuordecimpunctata* the least voracious species at both temperatures. The total aphid consumption of the larvae was almost the same at the two temperatures in all species, except in *C. quinquepunctata,* which consumed significantly more aphids at 20°. The bulk of the aphids were consumed in the last larval instar of each species. It is concluded that *C. septempunctata* and *A. bipunctata* are more suitable for use in the control of *M. persicae* than *C. quinquepunctata* and *P. quatuordecimpunctata.*

Ladybeetles are effective predators of aphids and scales. In recent years an increasing amount of research has been devoted to their biology and suitability for use in practical crop protection (see e.g. Hodek 1973).

In Finland, the most common ladybeetles in agricultural areas include *Coccinella septempunctata,* L., *C. quinquepunctata* L., *Adalia bipunctata* (L.) and *Propylaea quatuordecimpunctata* (L.) (Clayhills & Markkula 1974), and these four species have been considered in the search for promising predators for the control of aphids in protected cultivation (Markkula 1973).

In the present study their potential effectiveness against the green peach aphid, *Myzus persicae* (Sulz.), was compared by checking their fecundity and food consumption at two temperatures.

Material and methods

F e c u n d i t y. Overwintered adult coccinellids were collected at Vantaa, Tikkurila, after their dispersal from hibernation quarters in May.

The beetles were first kept together in cages for copulation. Afterwards they were separated, and the females were placed individually in small glass jars (for details, see Hämäläinen & Markkula 1972). They were fed with *M. persicae* aphids, which had been reared on chrysanthemums or sugar beets and were put into the jars on the leaves of plants. There was always a surplus of prey in the jars.

Once a day the eggs laid were counted and removed from the jars, and fresh food was added. The test was continued until all the females had died.

V o r a c i t y o f l a r v a e. Larvae hatched from the eggs laid by the overwintered females were reared individually in small glass vials (diameter 2 cm, height 7 cm). A small leaf of sugar beet was placed in each vial and 100—400 *M. persicae* nymphs of medium size were transferred to the leaf with an artist's brush.

Table 1. Fecundity of coccinellids at temperatures of 20° C and 30° C. Mean values followed by the same letter are not significantly different ($P < 0.05$).

	Number of females	Average number of eggs per female	Range	Average number of eggs per day
20°				
C. septempunctata	10	654.4 ± 165.2 a	27—1387	24.9 ± 10.1
A. bipunctata	12	589.9 ± 100.4 a	145—1114	16.5 ± 2.1
P. 14-punctata	13	174.7 ± 31.7 c	56— 442	8.5 ± 0.9
30°				
C. septempunctata	10	695.6 ± 166.3 a	19—1443	23.3 ± 6.0
C. quinquepunctata	11	497.5 ± 116.9 ab	39—1400	15.4 ± 2.0
A. bipunctata	13	687.5 ± 73.1 a	88—1229	22.5 ± 3.3
P. 14-punctata	12	410.4 ± 48.4 b	139— 638	10.3 ± 1.5

After 24 hours the number of aphids left in the vials was counted. The decrease in their number was considered to represent the consumption by the larvae. The larvae were transferred to a clean vial with fresh aphids each day, and the amount of aphids given was increased as the larvae grew. The first-instar larvae received 100 aphids a day, and the fourth-instar larvae up to 400 aphids. There were always aphids left in the vials when they were checked.

Both the fecundity and voracity were tested at two temperatures, 20°C ± 0.5°C and 30°C ± 1.0°C. The relative humidity in the rearing cabinets was 80—90 % at 20° and 70—90 % at 30°, and they were illuminated with mercury lamps for 18 hours a day. There were 10—13 females and 10 larvae of each species at both temperatures.

Results

F e c u n d i t y. There were no statistically significant differences in fecundity between *C. septempunctata* and *A. bipunctata*, the two most fecund species (Table 1). The differences in fecundity at the two temperatures were also insignificant in both species. *P. quatuordecimpunctata* laid significantly more eggs at 30°, although the average daily egg production was almost the same. Although the fecundity of *C. quinquepunctata* did not differ significantly from that of *C. septempunctata* and *A. bipunctata* at 30°, only one *C. quinquepunctata* female laid a few eggs, very irregularly, at 20°. The poor fecundity of this species at 20° was subsequently confirmed by rearing a great number of additional females at this temperature.

V o r a c i t y. *C. quinquepunctata* larvae consumed significantly more aphids at the lower temperature. In the other species the consumption was nearly the same at both temperatures, although the active feeding period was almost doubled at 20° (Table 2). *C. septempunctata* consumed the greatest number of aphids at both temperatures. *A. bipunctata* and *C. quinquepunctata* were equal in aphid consumption at 30°, but *C. quinquepunctata* was more voracious at 20°. The consumption of *P. quatuordecimpunctata* was less than 1/3 of that of *C. septempunctata* and its larvae developed most rapidly at both temperatures.

Each species had four larval instars, the last of which was the most voracious. About 55—75 % of the total number of aphids was consumed during the last instar.

Discussion

The larvae of the four ladybeetles developed, and the adults produced progeny when they were fed with *M. persicae*. This aphid is therefore a suitable prey for these species (see HODEK 1973, 109—125).

Table 2. Voracity of coccinellid larvae at temperatures of 20° C and 30° C. Mean values followed by the same letter are not significantly different ($P < 0.05$). Ten larvae in each trial.

	Total number of aphids eaten per larva	Range	Duration of active larval stage, days.
20°			
C. septempunctata	1309.9 ± 88.5 a	1044—1966	17.3 (15—26)
C. quinquepunctata	1138.0 ± 57.5 a	944—1481	18.6 (18—20)
A. bipunctata	863.2 ± 54.3 b	591—1096	16.6 (14—18)
P. 14-punctata	343.6 ± 10.1 c	291— 378	10.0 (10—10)
30°			
C. septempunctata	1226.1 ± 57.3 a	833—1446	7.9 (7— 9)
C. quinquepunctata	943.6 ± 46.5 b	749—1236	8.1 (7—10)
A. bipunctata	941.7 ± 40.1 b	743—1216	9.5 (8—11)
P. 14-punctata	381.4 ± 29.4 c	238— 516	6.5 (6— 8)

C. septempunctata and *A. bipunctata* were the most fecund species. There seems to be considerable individual variation in the number of eggs laid by the beetles, especially in *C. septempunctata,* even when they are kept in identical conditions.

The optimum temperature for egg-laying differed between the species; 20° and 30° were equally suitable for *A. bipunctata* and *C. septempunctata,* but egg-laying was very poor at 20° in *C. quinquepunctata* and was poorer at 20° than at 30° in *P. quatuordecimpunctata.*

A given aphid species may not be equally suitable as prey for several ladybeetle species, and therefore some of the ladybeetles may not have obtained their maximal productivity. *M. persicae* has been observed to be significantly inferior to the rose aphid, *Macrosiphum rosae* (L.), in promoting the egg-laying of *C. septempunctata* (Hämäläinen & Markkula 1972). Rogers et al. (1972) reared *P. quatuordecimpunctata* with seven aphid species and found considerable differences in fecundity.

The total food consumption during larval development was more or less the same in most of the species. The development of the larvae was considerably more rapid at 30° and the daily food intake was correspondingly higher. This accords with Hodek's (1973, 138) conclusion, based on the reports of various authors, that the total food consumption of coccinellid larvae is more or less stable irrespective of the temperature. However, Gurney & Hussey (1970) noted a considerable increase in the amounts of aphids eaten at lower temperatures by *Coleomegilla maculata* (De G.) and *Cycloneda sanguinea* (L.), and Weismann et al. (1971) reported that *Coccinella undecimpunctata* L. larvae consumed more at a higher temperature. These results were obtained at constant temperatures; Hodek (1957) found that the total voracity was almost doubled at naturally fluctuating temperatures.

The literature contains a great amount of information on the numbers of prey insects consumed by the larvae of different ladybeetle species. It is rather futile to compare the numerical data, because the results were obtained by different methods, and because different species of prey are concerned. Even if the same prey is used in similar conditions, the results may be totally different, depending on the developmental stage of the prey and its abundance. For instance, *C. septempunctata* larvae have been reported to consume an average of 173 *M. persicae* at 21° (Gurney & Hussey 1970) and 619—750 at 22° (Shands & Simpson 1972), but we recorded 1310 at 20°.

The data on voracity obtained by keeping larvae in small glass vials or petri dishes in laboratory conditions naturally do not reveal how many aphids they would consume in more natural conditions, but they do give an idea of the relative capacity of different species; *C. septempunctata* may be presumed to be two or three times more voracious than *P. quatuordecimpunctata,* and significantly more voracious than *A. bipunctata.* A conflicting result was obtained by GURNEY & HUSSEY (1970).

According to preliminary control results (MARKKULA et al. 1972, and unpublished), ladybeetles are most conveniently introduced into glasshouses as eggs or fecund adults. In both cases the actual control is expected to be performed by the larvae. If beetles are introduced, they must lay great numbers of eggs for the larval population to be sufficient. On the other hand, if eggs are used, a new batch must be introduced in a few weeks, in case the emerged adults do not lay a sufficient number. Therefore we can conclude from the present test that *C. septempunctata* and *A. bipunctata* are more suitable for the control of *M. persicae* than the other two species, because they are potentially more fecund or voracious. The usefulness of *C. quinquepunctata* is decreased by its uncertain egg-laying, and that of *P. quatuordecimpunctata* by its small voracity.

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