RELEASE OF Coccinella undecimpunctata L. AND Chrysoperla carnea (STEPH.) AS A BIOLOGICAL CONTROL TOOL OF THE COTTON APHID, Aphis gossypii GLOVER ON TOMATO PLANTS UNDER FIELD CAGE CONDITIONS. Abdel-Salam, A. H.; M. E. Ragab; L. A. El-Batran, and A. R. Ahmed Economic Entomology Department, Faculty of Agriculture, Mansoura University, Mansoura 35516, EGYPT.

ABSTRACT
This study was outlined to declare the effect of releases of Coccinella undecimpunctata (larvae and adults) and Chrysoperla carnea (larvae) at different predator: prey ratios (P: p) to control the cotton aphid, Aphis gossypii, on tomato plants under field cage conditions during summer season of 2003.

Effective control of A. gossypii was gained after one day from introducing the larvae of the coccinellid predator when the P: p ratio was 1:15 or 1:30, meanwhile at higher ratios (1:60 and 1:75), the aphid numbers decreased after seven days from the release.

The cotton aphid numbers decreased by 96.7 and 77.5% at 1:15 and 1:30 P: p ratios, respectively when adults of the coccinellid released. The number of aphids remained zero for a period of 13 days after the release. At the predator: prey ratio of 1:45, the reduction percentage of aphid densities was 47.8 and 86.1% after one and four days. Whereas, at the higher ratios (1:60 and 1:75), the reduction percentage was 37.1 and 33%, 77.1 and 62%, and 92.1 and 88% after one, four, and seven days from the release, respectively.

Chrysoperla carnea larvae at a P: p ratio of 1:15 yielded excellent control of A. gossypii with the reduction percentage 88.3% after one day from the release. There was a drastic drop in the aphid populations after chrysopid larvae release at the P: p ratios of 1:30 and 1:45. The reduction percentages were (64.2 and 39.4%), and (96.7 and 81.7 %), respectively after one and four days from the release.

According to regression analysis between P: p ratios of C. undecimpunctata (larvae and adults) and larvae of C. carnea and reduction percentage of the cotton aphid, there were negatively high relationship of both predators, which means that the reduction rate was increased with lower P:p ratios and vice versa.

Keywords: Coccinella undecimpunctata, Chrysoperla carnea, predator: prey ratio, Aphis gossypii.

INTRODUCTION
In recent years, the cotton aphid, Aphis gossypii (Hemiptera: Aphididae) has become a serious pest of several economic vegetable crops including tomato. Reduced plant vigor, stunting and deformed plant parts are common symptoms of aphid infestations. In some cases, it is the production of honeydew or presence of sooty mold that alerts the gardener to an aphid outbreak. In addition, aphids are excellent transmitters of several viral diseases such as the mosaic viruses, that cause leaves to shrivel and that infect a wide range of hosts. In some cases, it is the appearance of virus symptoms that indicate aphid activity (Ebert and Cartwright, 1997).

Rising costs of insecticides, widespread insecticides resistance and increasing restrictions on insecticides use have spurred interest in an insect management by other means, including biological control. Biological control is
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the cornerstone in every satisfactory program in an integrated pest management. Control of insect pests by predators is operationally defined as the action of predators that maintains a pest population at a lower level than would occur in the absence of the predators. It involves the manipulation of trophic interactions to achieve a reduction in pest density (Ehler, 1996). Theory and practice of biological control suggest that generalist predators can be effective control agents. Field studies show that generalist predator species can reduce pest numbers by a significant degree and in some cases reduce or prevent crop damage. This evidence is mainly from semi-field conditions (field cage) and providing that predator: prey ratios and the timing of releases are optimized (Symondson et al., 2002). Generalist insect predators are frequently abundant in annual crops including vegetable crops and have been identified as important in suppression populations of damaging insects (Rosenheim et al. 1995).

Several methods have been used to measure the effect of predators on aphid populations (Hodek et al., 1972). One common technique is to use field cage conditions to enclose known numbers of predatory species with artificially known numbers of aphid species. Shands et al. (1972) used this technique and found that releases of Chrysopa spp., Coccinella septempunctata L., and Coccinella transversoguttata Brown larvae reduced Myzus persicae (Sulz.) populations.

The coccinellid, Coccinella undecimpunctata (Coleoptera: Coccinellidae) and the green lacewing, Chrysoperla carnea (Neuroptera: Chrysopidae) are considered as generalist predators. C. undecimpunctata is one of the most important predators encountered in Egyptian fields. It is being considered as a potential agent for biological control of aphids, cotton leafworm, whiteflies and other soft bodied insects. Detailed studies on their role against several insect pests have been studied extensively (Ghanim and El-Adl, 1987; Eraky and Nasser, 1993; Abdel-Salam, 1995; Zaki et al., 1999; Al-Eryan et al., 2001).

The green lacewing has relatively short generation times, larvae have a relatively broad range of acceptable preys (Hydron and Whitcomb 1979), and they are amenable to mass-rearing, release, and manipulation in the field (Hasegawa et al. 1989, Tauber and Tauber 1993). The role of C. carnea in controlling different aphid species on various crops has been studied by several investigators (Hassan et al., 1985; Hagley 1989; Al-Arnaouty and Sewify, 1998). Ebert and Cartwright (1997) reported that C. carnea was able to cause an overall reduction in aphid abundance when caged on field grown cotton. The relative occurrence and population densities of both C. undecimpunctata and C. carnea as main predators of A. gossypii were also investigated on some tomato varieties at Mansoura region (Ragab et al., 2002)

Therefore, the aims of the current study were: 1) to compare the effect of released larvae versus adults of C. undecimpunctata, 2) to evaluate the optimal predator: prey ratio for the release of larvae or adults, and 3) to compare the effectiveness of C. undecimpunctata versus C. carnea for controlling the cotton aphid, A. gossypii on tomato plants under field cage conditions.
MATERIAL AND METHODS

The experimental traits were conducted at the farm of Economic Entomology Department, Faculty of Agriculture, Mansoura University during the summer of 2003. The tomato variety was Castle Rock. The tomato plants were transplanted on the 15th of June, 2003. The plants received the normal agricultural practices.

Adults of *C. undecimpunctata* and *C. carnea* were collected from the experimental farm of the Economic Entomology Department. The eggs laid by each female of both predators were removed daily and monitored until hatching. The hatched larvae were reared individually to avoid cannibalism on the cotton aphid, *A. gossypii* in petri-dishes (12 cm. in diameter) until the second instar or adult emergence.

Twenty four cages (100x180x70 cm) were covered with muslin and prepared with one meter long zipper to facilitate counting of the pest and predator stages. Tomato plants under cages were sprayed with Malathion 57%. E.C. to kill any insects on the plants before releasing the predators. Three weeks after spraying, artificial infestation from the cotton aphid nymphs was made at the following numbers: 15, 30, 45, 60, and 75/plant. The introduction of aphid nymphs was done by fine camel brush.

The coccinellid predator was released into the cages as early second instar larvae or as newly emerged adults; meanwhile, the chrysopid was introduced as early second instar larvae from laboratory rearing. The following predator: prey ratios: 1:15, 1:30, 1:45, 1:60, and 1:75 were used for each stage. Four replicates were used at each predator: prey ratio and four replicates for check (without releasing). The number of aphids and the predator stages were carefully counted every three days to measure the success of the release rate.

Data analysis:

Aphid numbers at predator: prey ratios were subjected to one way analysis of variance (ANOVA), and the means separated using Duncan’s Multiple Range Test (Costat, 1990). In addition, simple linear regression between predator: prey ratio and reduction percentage was run.

RESULTS

1. Release of *C. undecimpunctata* larvae

An effective control of the cotton aphid populations was achieved after one day from release of the coccinellid larvae with the predator: prey ratio of 1:15 and 1:30 (Table 1). The reduction percentage of these ratios was 93.3 and 71.7%, respectively. It was observed that the number of aphids at these ratios remained zero for a period of 13 days after release of the predator larvae.

When the predator: prey ratios was 1:45, the reduction percentage was 52.8 and 82.8% after one and four days from introducing the predator larvae, then the aphid numbers remained zero after seven days from release. Whereas, at 1:60 and 1:75, the aphids reduced by 34.6 and 32% after one day, 73.6 and 61% after four days, and 90.8 and 86% after seven days from release of the predator larvae (Table 1).
From the above results, effective control of *A. gossypii* was gained after one day from introducing the larvae of the coccinellid predator when the P:p ratio was 1:15 or 1:30, while at higher ratios (1:60 and 1:75) of *C. undecimpunctata* larvae, the aphid numbers decreased after seven days from release.

The statistical analysis showed that there was a significant decrease of the cotton aphid numbers at the different predator: prey ratios and days after release of *C. undecimpunctata* larvae.

The regression equations between predator: prey ratios of the coccinellid larvae (as independent variable X) and reduction percentages of aphid numbers (as dependent variable Y) were derived: Reduction rate (Y)=103.08-1.0117 predator: prey ratio (X), Y=114.8-0.696X, and Y=106.52-0.248X, respectively (Fig. 1). These equations indicated that there was a highly negative relationship between P: p ratios and reduction rates which mean that the reduction rate was increased with lower P: p ratios and vice versa.

Table 1: Reduction percentages of *A. gossypii* after release of *C. undecimpunctata* larvae at different predator: prey ratios under field cage conditions on tomato plants.

<table>
<thead>
<tr>
<th>Days after release</th>
<th>P: p ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:15</td>
</tr>
<tr>
<td>1</td>
<td>93.30</td>
</tr>
<tr>
<td>4</td>
<td>100.00</td>
</tr>
<tr>
<td>7</td>
<td>100.00</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
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<tr>
<td>13</td>
<td>-</td>
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</table>

2. Release of *C. undecimpunctata* adults

The results of released adults with the predator: prey ratios of 1:15 and 1:30 showed that the coccinellid adults were successful in decreasing the cotton aphids after one day from the release (Table 2). The number of cotton aphids decreased by 96.7 and 77.5% at 1:15 and 1:30 P: p ratios, respectively. It was noticed that the number of aphids remained zero for a period of 13 days after the release. At the predator: prey ratio of 1:45, the reduction percentage of aphid densities was 47.8 and 86.1% after one and four days. Whereas, at the higher ratios (1:60 and 1:75), the reduction percentage was 37.1 and 33.0%, 77.1 and 62.0%, and 92.1 and 88.0% after one, four and seven days from the release, respectively (Table 2). The best control of aphid populations was achieved using the lower predator: prey ratios (1:15 and 1:30) after one day from adults release. According to data analysis, there were significant variations among the different predator: prey ratios and days after the release of *C. undecimpunctata* adults.

Based on simple linear regression between P: p ratios of *C. undecimpunctata* adults and reduction percentage of the cotton aphid, there were negatively strong relationship after one, four and seven days from the release of the coccinellid adults. The regression equations were: Y=108.76-1.1187X, Y=114.71-0.6593X, and Y=105.59-0.2127X, respectively. The values of R² were 0.9253, 0.9381, and 0.80 in succession (Fig. 2).
Fig. 1: Simple linear regression between predator: prey ratios (X) and the reduction percentages (Y) of *C. undecimpunctata* larvae under field cage conditions.
After 1 day
\[ Y = 108.76 - 1.1187x \]
\[ R^2 = 0.9253 \]

After 4 days
\[ Y = 114.71 - 0.6593x \]
\[ R^2 = 0.9381 \]

After 7 days
\[ Y = 105.59 - 0.2127x \]
\[ R^2 = 0.8 \]

Fig. 2: Simple linear regression between predator: prey ratios (X) and the reduction percentages (Y) of *C. undecimpunctata* adults under field cage conditions.
Table 2: Reduction percentages of *A. gossypii* after release of *C. undecimpunctata* adults at different predator: prey ratios under field cage conditions on tomato plants.

<table>
<thead>
<tr>
<th>Days after release</th>
<th>P: p ratio</th>
<th>1:15</th>
<th>1:30</th>
<th>1:45</th>
<th>1:60</th>
<th>1:75</th>
</tr>
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<tr>
<td>1</td>
<td>1:15</td>
<td>96.70</td>
<td>77.50</td>
<td>47.80</td>
<td>37.10</td>
<td>33.00</td>
</tr>
<tr>
<td>4</td>
<td>1:30</td>
<td>100.00</td>
<td>100.00</td>
<td>86.10</td>
<td>77.10</td>
<td>62.00</td>
</tr>
<tr>
<td>7</td>
<td>1:45</td>
<td>-</td>
<td>-</td>
<td>100.00</td>
<td>92.10</td>
<td>88.00</td>
</tr>
<tr>
<td>10</td>
<td>1:60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100.00</td>
<td>100.00</td>
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<tr>
<td>13</td>
<td>1:75</td>
<td>-</td>
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</tbody>
</table>

3. Release of *C. carnea* larvae.

Larvae of the chrysopid predator at a P: p ratio of 1:15 yielded good aphids control with the reduction percentage 88.3% after one day from the release (Table 3). From the data in Table (3), there was a drastic drop in the aphid populations after released larvae at the P:p ratios of 1:30 and 1:45. The reduction percentage was (64.2 and 39.4%), and (96.7, and 81.7 %) for the above ratios, respectively, after one and four days from the release.

After one, four, and seven days from the release, the reduction percentage of aphid numbers was 32.5 and 29.0, 70.4 and 60.0 and 87.9 and 82.0%, respectively for the P: p ratios of 1:60 and 1:75. Based on ANOVA analysis, there were significant differences among the P: p ratios and days after release of chrysopid larvae.

There was highly negative relationship between P: p ratios of *C. carnea* larvae and reduction percentage *A. gossypii* (Fig. 3). The values of $R^2$ were 0.8944, 0.9754, and 0.80 for one, four and seven days after the release, respectively.

The results in Table (4), clearly indicate that at the low predator: prey ratios (1:15, 1:30, and 1:45), there was a non-significant difference between the coccinellid larvae and adults, or chrysopid larvae, whereas, at the higher ratios (1:60 and 1:75), there was a significant variation between the predatory stages (adults versus larvae).

Table 3: Reduction percentages of *A. gossypii* after release of *C. carnea* larvae at different predator: prey ratios under field cage conditions on tomato plants.

<table>
<thead>
<tr>
<th>Days after release</th>
<th>P: p ratio</th>
<th>1:15</th>
<th>1:30</th>
<th>1:45</th>
<th>1:60</th>
<th>1:75</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1:15</td>
<td>88.30</td>
<td>64.20</td>
<td>39.40</td>
<td>32.50</td>
<td>29.00</td>
</tr>
<tr>
<td>4</td>
<td>1:30</td>
<td>100.00</td>
<td>96.70</td>
<td>81.70</td>
<td>70.40</td>
<td>60.00</td>
</tr>
<tr>
<td>7</td>
<td>1:45</td>
<td>-</td>
<td>100.00</td>
<td>100.00</td>
<td>87.90</td>
<td>82.00</td>
</tr>
<tr>
<td>10</td>
<td>1:60</td>
<td>-</td>
<td>-</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>13</td>
<td>1:75</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>
Fig. 3: Simple linear regression between predator: prey ratios (X) and the reduction percentages (Y) of *C. carnea* larvae under field cage conditions.
Table 4: Average number of A. gossypii per plant after release of C. undecimpunctata and C. carnea at different predator: prey ratios under field cage conditions on tomato plants.

<table>
<thead>
<tr>
<th>P: p ratio</th>
<th>C. undecimpunctata</th>
<th>C. undecimpunctata</th>
<th>C. carnea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>larvae</td>
<td>adults</td>
<td>Larvae</td>
</tr>
<tr>
<td>1:15</td>
<td>0.33 a</td>
<td>0.17 a</td>
<td>0.58 a</td>
</tr>
<tr>
<td>1:30</td>
<td>2.83 a</td>
<td>2.25 a</td>
<td>3.92 a</td>
</tr>
<tr>
<td>1:45</td>
<td>9.67 a</td>
<td>9.92 a</td>
<td>11.83 a</td>
</tr>
<tr>
<td>1:60</td>
<td>20.17 b</td>
<td>18.75 c</td>
<td>21.83 a</td>
</tr>
<tr>
<td>1:75</td>
<td>30.25 b</td>
<td>29.25 b</td>
<td>32.25 a</td>
</tr>
</tbody>
</table>

Means followed by the same small letter in a row or capital letter in a column are not significantly different at the 1% level of probability (Duncan’s Multiple Range Test).

In the check cages (without predator release), the number of cotton aphids increased 100% after one day from initial artificial infestation at 15, 30, 45, 60, and 75 aphids/plant. After four days, the aphid increased rapidly to 140, 150.8, 155, 167, 158 aphids/plant. Up to 1000%, increasing rate of cotton aphids occurred after 13 days from initial artificial infestation (Fig. 4). The number of aphids increased sharply and heavily damaged the tomato plants. These results confirmed the effect of the two predators in suppressing the number of cotton aphids. Based on the regression analysis, there was a highly negative relationship between initial artificial infestation of A. gossypii and average final of increasing number of the cotton aphid. The value of R² was 0.8488 (Fig. 5).

DISCUSSION

Biological control has a great potential for use against the cotton aphid, A. gossypii based on successes of biological control against other aphid species and the abundance of biological control agents (Ebert and Cartwright, 1997; Zaki et al., 1999; Al-Eryan et al., 2001). Many potential predators have been identified against A. gossypii including C. undecimpunctata and C. carnea. Both predators are active aphidophagous in Egyptian fields due to their highly prey consumption rates, highly fecund, and highly searching rates (Ghanim and El-Adl, 1987; Eraky and Nasser, 1993; Abdel-Salam, 1995; Al-Arnaouty and Sewify, 1998; Zaki et al., 1999; Al-Eryan et al., 2001).
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Fig. 4: Average of increasing numbers of *A. gossypii* under field cage conditions on tomato plants. Plants were initially inoculated with 15, 30, 45, and 75 aphids/plant.

Fig. 5: Simple linear regression between the initial number (X) and final average numbers (Y) of *A. gossypii* under field cage conditions.
Naturally, occurring predators are usually not sufficient to control aphid populations and so augmentation release of predators into the agro-ecosystem would be necessary to gain successful biological control (Hagley 1989; Abdel-Salam, 1995; Ebert and Cartwright, 1997; Al-Arnaouty and Sewily, 1998; Acheampong and Stark, 2004). However, their food resources affect the performance of bio-control agents. Therefore, a proper predator:prey ratio should be determined. The results of the current study clearly demonstrated that the effective P:p ratios were 1:15 and 1:30 for the coccinellid predator, C. undecimpunctata larvae or adults after one day of release under field cage conditions. Moreover, the release of the predator at the rate of 1:75 could not possibly keep the population of aphids down to a satisfactory level after seven days. Whereas, after ten days, the reduction percentage was 100%. On the other hand, the predator: prey ratio at 1:15 could suppress the aphid populations down to a satisfactory level, but there was not enough prey left for the predators to build up its populations. These results are in completely agreement with the following reports. Gurney and Hussey (1970) gained good control of M. persicae by releasing second instar larvae of the coccinellid, Cycloneda sanguinea L. at a P:p ratio of 1:20. In contrary, Adashkevich (1975) reported that best control of aphids gained in 10 days when first instar larvae of Coccinella septempunctata L. were released against A. gossypii at P:p ratio of 1:50 and 1:100. Meanwhile, a similar trend with our results was obtained by Hamalaninen (1977) who found that larvae of Adalia bipunctata L. at ratio of 1:5 yielded a good control of M. persicae. By a release ratio 1:10, A. bipunctata larvae were also decreased aphid numbers by half in 10 days. Whereas, a release ratio of 1:20 was inadequate to prevent aphid increase. The cotton aphid could be successfully controlled by releasing H. axyridis at the predator: prey ratio of 1:100-200 in cotton fields without the need to apply insecticides (Dong, 1988). Raupp et al., (1994) mentioned that a field release of the coccinellid, Hippodamia convergens Guerin-Mineville was followed by reduced aphid populations. Release of the first instar larvae of Harmonia dimidiate (F.) is a highly effective against Macrosiphum euphorbiae Thom. on cucumbers at the predator: prey ratio varying from 1:50 to 1:100 (Semyanov, 1997). Zaki et al. (1999) reported that a single release of C. undecimpunctata (1:50 predator: aphids) resulted in 99.97% reduction of A. gossypii. Al-Eryan et al. (2001) indicated that results of releasing C. undecimpunctata against A. gossypii at predator: prey ratios of 1:100, 1:50 and 1:25 resulted in reduction of aphid populations by about 99.6, 99.4 and 99.4%, respectively, within 28 days. Zibai and Hatami (2001) pointed out that the predator:prey ratios of 1:30 and 1:90 significantly reduced the population of A. gossypii. At 1:30, there was no difference in efficacy between the use of the predators alone or in combination. At 1:90, control using Hippodamia variegata (Goeze) alone, or in combination with C. carnea was equally effective. Omkar and James (2003) noted that the predator:prey ratio of 1:50 may be considered optimum for the augmentative release of Coccinella transversalis Fabricius for the biological control of A. gossypii. Biological control agents were used in a ratio
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of 1:50 predator: aphid. The use of *C. septempunctata* resulted in a 58% reduction in the level of aphid infestation (Acheampong and Stark, 2004).

Our results assured that the proper ratios were 1:15 and 1:30 for the chrysopid, *C. carnea* larvae after one day of release under field cage conditions. In addition, when the ratio of 1:75, it was clearly seen that there was a surplus of prey population that could not be controlled by the chrysopid within seven days, whereas, the reduction percentage was increased to 100% after ten days from the release. These results are in completely agreement with those of Bondarenko and Moiseev (1972) who evaluated the effectiveness of chrysopids in control of aphids. As a result of a further release of 200 larvae of *Chrysopa* at the rate of one per 40 plants, increase of aphids was prevented until the end of the season. In addition, Ishankulieva (1980) reported that at a ratio of 1:50 or 1:55, *C. carnea* reduced numbers of *A. gossypii* by 99.5%, whereas the untreated population of *A. gossypii* doubled in size. Radzivilovskaya (1980) suggested that *C. carnea* was most effective against aphids on cotton at a ratio of 1:10. Meanwhile, at a ratio of 1:25, aphid numbers were not reduced and a ratio of 1:50, the populations of aphid increased. According to Shuvakhina (1983), second instar larvae of *C. carnea* were effective only when released at 1:20. In addition, Hassan et al. (1985) reported that control of *M. persicae* on sugarcane by *C. carnea* for 5-6 weeks when predator: prey ratios were 1:5 and 1:10. At higher predator: prey ratios (1:20 and 1:40), control was adequate for 3-4 weeks only. Also, Hagley (1989) stated that greater reduction in *Aphis pomi* DeGear numbers by releasing *C. carnea* at the predator: prey ratio 1:10 and 1:19. The similar results were obtained by Sazonov et al. (1990) who noted that releases of *C. carnea* at a 1:10 predator: prey ratio resulted in over 90% reduction in aphid numbers within about a week. Al-Arnaouty and Sewify (1998) demonstrated that successful control (reduction by at least 95%) was obtained by releases of *C. carnea* second instar larvae. Also, Zaki et al. (1999) concluded that double releases of *C. carnea* (1:5 predator:aphids) achieved 100% reduction in *A. gossypii* after 12 days. Whereas, release of *C. carnea* at 1:50 ( predator: prey ratio) was found to be more effective in suppressing the aphid population than at 1:100 (Venkatesan et al., 2000). Meanwhile, Zibai and Hatami (2001) recorded that the predator:prey ratios of 1:30 and 1:90 significantly reduced the population of *A. gossypii*. At 1:30, there was no difference in efficacy between the use of the predators alone or in combination. At 1:90, control using *H. variegata* alone, or in combination with *C. carnea* was equally effective.

Based on regression analysis between P: p ratios of *C. undecimpunctata* (larvae and adults) and larvae of *C. carnea* and reduction percentage of the cotton aphid, there were negatively strong relationship after one, four and seven days from the release of both predators. The reduction rate increased with lower P: p ratios and vice versa. This result closely matches with those of Rautapaa (1977) who indicated that there was a significantly negative relationship between P: p ratio of *C. septempunctata* and aphid indices and that a 50% decrease in the aphid, *Rhopalosiphum padi* (L.) is achieved when the initial P: p ratio is at least 1: 5.

In conclusion, *C. undecimpunctata* (larvae and adults) and *C. carnea* (larvae) could be employed as the biological control agents against *A.
gossypii under field cage conditions at the predator: prey ratios of 1: 15 and 1: 30.

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