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# Population Dynamics Pattern of Green Peach Aphid (Homoptera: Aphididae) and Its Predator Complex in a Potato System

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**Green peach aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae), interacts with many predatory insects in potato fields during the summer. The concept of the predator complex associated with green peach aphids was applied to explain the interactions between the aphid and its predators. The predator power of the predator complex was determined by two factors: the number of predators and the relative feeding capacity. The dynamics of the green peach aphid population was expressed by the number of individuals while the predator power was used to characterize the predator complex. Cumulative degree-days for green peach aphids were used as a time scale to analyze phenology and dynamics patterns of the aphid and its predator complex. The patterns of population changes in aphids were similar during the period of study (1993-1995) although the highest density of aphids fluctuated significantly from year to year. However, the predator power appeared more stable than the green peach aphid population over the three year period. The results indicated that the predator complex plays an important role to suppress the aphid populations during the latter part of the season and that the applications of control measures for green peach aphids in between the initiation and the peak timing of aphid populations are critical to minimize the damage on potatoes.**

Beneficial insects in potato fields include several species of predators and parasitoids. Both predators and parasitoids are also important in limiting pest populations on secondary hosts, thus reducing the numbers that eventually invade potato fields (Western regional IPM Project, 1992). However, native parasitoids seldom reduce the number of aphids in crops although they also occur in the system (Biever, 1995). In addition, many species of spiders were commonly found. Spiders, however, apparently have no substantial impact on aphid density (Tamaki and Long, 1978).

The predator complex has been an essential concept in developing methods for predicting the impacts of beneficial insects on pest populations (Bombosch, 1963; van Emden, 1966; Tamaki et al., 1974; Tamaki and Long, 1978; Tamaki et al., 1981; Scheller, 1984; Chambers and Aikman, 1988). Previous studies have demonstrated the important role of the predator complex in suppressing populations of the green peach aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae), on vegetable crops (Tamaki and Weeks, 1973; Tamaki et al., 1974; Smilowitz, 1984; Tamaki, 1984). The predator complex on potato in Washington (WA), USA consists of six families: Nabidae, Anthocoridae, Lygaeidae, Hemerobiidae, Chrysopidae, and Coccinellidae (Ro, 1995). Predators can be classified into one of three groups based on their consumption rates (Tamaki, 1984): Class 1 - general predators (Anthocoridae, Nabidae and Lygaeidae); Class 2 - aphidophagous predators (Chrysopidae and Hemerobiidae); and Class 3 - voracious predators (Coccinellidae). Class 2 predators have a feeding capacity of four times those in Class 1, while voracious predators consume approximately eight times more aphids than those in Class 1 (Goodarzy and Davis, 1958; Tamaki and Long, 1978). These feeding differences are reflected in the concept of predator power (Tamaki et al., 1974; Tamaki and Olsen, 1977). Predator power of the predator complex is determined by two factors: the number of predators and the relative feeding capacity of the class. Predator power ($P_n$) is defined as

$$P_n = \sum N_i C_i$$

where $N_i$ is the number of predators in class $i$, and $C_i$ is the relative feeding capacity of that class. Predator power was used to evaluate the dynamics of the predator complex in a potato system during the summer.

This quantitative analysis of the predator complex is needed to appraise predator effectiveness (Chambers

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and Aikman, 1988). Discussions of biological control often refer to the predator complex, but its actual role in the control of a specific pest such as the green peach aphid in potato has not been fully exploited. It is essential to develop a reliable model that will explain the interactions between a pest population and its predator complex, if biological controls are to be used as primary components in integrated pest management (IPM) programs. To accomplish this goal, we studied the dynamics and phenology of green peach aphid populations and their predator complex in the potato system. In the present study, we focused on the biological structure that included species abundance, temporal changes, and interactions between the green peach aphid and the predator complex.

## Materials and Methods

From 1993 through 1995, weekly insect samples were taken from an insecticide-free experimental potato field in Othello (Washington State University Othello Research Station), Adams Co., WA. Commercial potato and other irrigated crops (i.e. wheat, bean, alfalfa, mint, etc.) surrounded the station. A black beating tray (70 × 70 cm) was placed below and to one side of two potato plants; potato foliage was struck eight times with a stick (49 × 4.5 cm) (Ro et al., 1998). Insects that fell onto the tray were collected with a portable vacuum or an aspirator, and brushed into vials. Each year, 36 sampling sites were selected randomly among potato cultivars. For each sample, insects were identified and counted in the laboratory.

Automated solar powered weather stations of the Washington Public Agriculture Weather System were located near the sampling plots in the research station. This independent weather station recorded daily maximum and minimum ambient temperatures and transmitted the data every 15 minutes to a central computer located at the Washington State University Irrigated Agriculture Research and Extension Center in Prosser, WA. Developmental degree days (DDD) were calculated as the difference between the arithmetic mean air temperature and base temperature of the green peach aphid (Pruess, 1983; Funderburk et al., 1984; Fatzinger and Dixon, 1996; Long et al., 1996; Ro et al., 1998):

$$DDD = [(T_{max} + T_{min})/2 - T_b],$$

where $T_{max}$ is the daily maximum air temperature (℃), $T_{min}$ is the daily minimum temperature (℃), and $T_b$ is the base temperature for green peach aphid development (4℃). Accumulated DDD were calculated by summation of DDD beginning 1 January of each year.

## Results and Discussion

### *Predator complex and its abundance*

The predator complex on green peach aphids in potato consisted of 10 species (Table 1). Five species that belong to the families Nabidae (2 species), Anthocoridae (1) and Lygaeidae (2) comprised Class 1 predators. One species from each of 2 families in Neuroptera (Hemerobiidae and Chrysopidae) comprised Class 2 predators. Class 3 predators include 3 species of Coccinellidae. Table 2 shows the average number of individuals in each family of the predator complex that were collected on each sample date. Class 1 predators were commonly found in potatoes from June through August. They were most abundant between late July and mid-August. In 1993 and 1995, the densities of lygaeid and anthocorid predators were higher than those for nabids. However, nabid predators were more abundant than anthocorids in 1994. Neuropteran larvae in Class 2 predators were found only occasionally during the period of study (Table 2). The Class 3 predators were found about 3 weeks later than Class 1 predators, and were commonly found during July and August except in 1995.

**Table 1.** Predatory species of the predator complex associated with green peach aphid in potato fields in Othello, Washington during 1993 - 1995

| Taxon | Stage[1] | Class |
|---|---|---|
| Hemiptera | | |
| Nabidae | | |
| *Nabis alternatus* Parshely | N, A | 1 |
| *Nabis americoferus* Carayon | N, A | 1 |
| Anthocoridae | | |
| *Orius tristicolor* (White) | N, A | 1 |
| Lygaeidae | | |
| *Geocoris bullatus* (Say) | N, A | 1 |
| *Geocoris pallens* Stål | N, A | 1 |
| Neuroptera | | |
| Hemerobiidae | | |
| *Hemerobius* sp. | L | 2 |
| Chrysopidae | | |
| *Chrysopa carnea* Stephens | L | 2 |
| Coleoptera | | |
| Coccinellidae | | |
| *Coccinella transversogutta* Falderman | L, A | 3 |
| *Coccinella septempunctata* L. | L, A | 3 |
| *Hippodamia convergens* Guérin-Meneville | L, A | 3 |

[1]N: nymphs, L: larvae, and A: adults.

### *Dynamics of the aphid and its predator complex*

The dynamics of the green peach aphid populations and predator power of the predator complex over the three year period are presented in Fig. 1. In the central basin of Washington, green peach aphids first appear on potatoes in mid to late June. Populations of aphids on potato consist of both alate and apterous forms, however, the majority of aphids are apterous nymphs. Green peach aphid populations started expanding in June. Aphids were continuously collected until mid-August, but their population size was very small during August (Fig. 1). The aphid population densities in potato fields usually fluctuate from year to year because green peach aphids are migratory insects and have many alternative hosts (Ro, 1995). Their population sizes and the timing of phenological events depend on abiotic factor (i.e. weather patterns and

Table 2. Average number of individuals in each family of the predator complex collected per beating tray

| Date (Julian day) | Lygaeidae | Nabidae | Anthocoridae | Hemero and Chrys[1] | Coccinellidae |
|---|---|---|---|---|---|
| 1993 | | | | | |
| 23 June (174) | 0.91 | 0.12 | 0.15 | - | - |
| 1 July (182) | 0.64 | 0.24 | 0.48 | - | - |
| 8 July (189) | 0.67 | 0.42 | 0.61 | - | - |
| 15 July (196) | 1.00 | 1.21 | 0.76 | 0.39 | 0.15 |
| 22 July (203) | 0.85 | 0.94 | 0.76 | 0.85 | 0.55 |
| 29 July (210) | 0.85 | 0.58 | 0.42 | 0.52 | 2.00 |
| 4 Aug. (216) | 1.64 | 1.79 | 1.73 | 0.88 | 2.79 |
| 12 Aug. (224) | 2.15 | 1.52 | 2.15 | 1.67 | 2.82 |
| 18 Aug. (230) | 1.94 | 1.48 | 1.55 | 1.64 | 2.42 |
| 24 Aug. (236) | 1.12 | 0.94 | 1.91 | 1.48 | 2.85 |
| 1994 | | | | | |
| 7 June (158) | 1.70 | 0.17 | 0.43 | 0.03 | - |
| 14 June (165) | 1.43 | 0.13 | 0.04 | 0.04 | - |
| 21 June (172) | 1.43 | 0.25 | 0.04 | 0.04 | - |
| 28 June (179) | 1.59 | 0.57 | 0.27 | 0.00 | 0.05 |
| 6 July (187) | 1.61 | 0.34 | 0.34 | 0.18 | 0.13 |
| 12 July (193) | 0.62 | 0.72 | 1.31 | 0.15 | 0.26 |
| 19 July (200) | 5.67 | 1.95 | 0.82 | 0.23 | 0.46 |
| 26 July (207) | 8.11 | 2.20 | 1.40 | 0.11 | 0.69 |
| 16 Aug. (228) | 7.79 | 2.41 | 0.72 | 0.00 | 1.17 |
| 1995 | | | | | |
| 17 June (168) | 0.17 | 0.08 | 0.08 | - | - |
| 22 June (173) | 0.17 | 0.42 | 0.17 | - | - |
| 29 June (180) | 0.33 | 0.67 | 0.50 | - | - |
| 5 July (186) | 1.08 | 0.08 | 1.00 | 0.08 | 0.08 |
| 11 July (192) | 2.17 | 0.17 | 1.42 | 0.25 | 0.08 |
| 18 July (199) | 2.67 | 0.83 | 5.33 | 1.50 | 1.00 |
| 27 July (208) | 2.17 | 0.67 | 5.17 | 0.00 | 0.67 |
| 3 Aug. (215) | 0.33 | 1.83 | 0.83 | 0.00 | 0.00 |

[1]Hemerobiidae and Chrysopidae were pooled into a guild to simplify the data because of no differences in feeding capacity and their low density.

temperature) (Ro et al., 1998). Class 1 predators continue to inhabit potatoes even after green peach aphids disappear or fall to very low densities (Table 1; Fig. 1). One reason for this persistence is that they have various alternative prey (i.e. leafhoppers, psyllids, mites, thrips, caterpillars and the eggs of Colorado potato beetle) (Western regional IPM Project, 1992). Another reason may be delayed feedback in the green peach aphid-predator complex interaction.

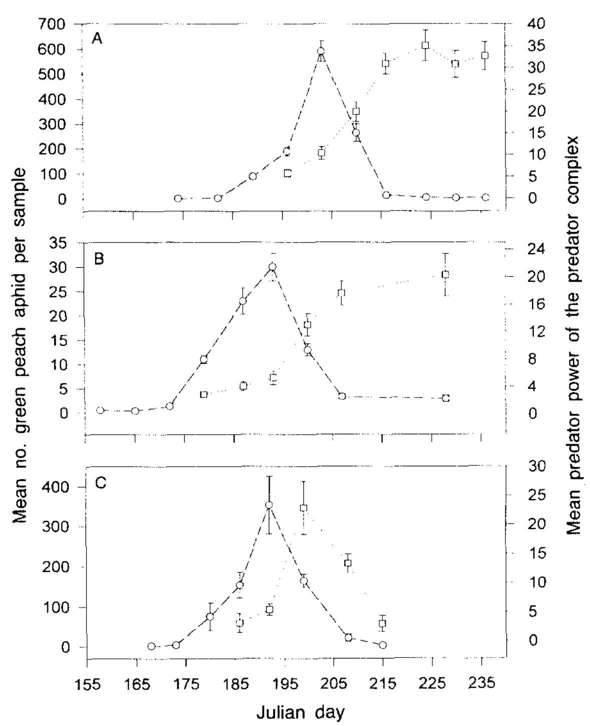


**Fig. 1.** The dynamics of the green peach aphid population (○) and the predator complex (□). Mean green peach aphid ± SE and mean predator power ± SE per beating tray from Othello in 1993 (A), 1994 (B) and 1995 (C).

The patterns of the green peach aphid population dynamics were similar during the three years, although the population size varied significantly between years (Fig. 1). However, the predator complex, in terms of predator power, appeared more stable than the green peach aphid population because it showed stable population densities in the latter part of season (1993 and 1994), and its highest predator power ranged from 20 to 35 over the three years. In 1995, predator power of the predator complex in the latter part of season decreased. This seems to have resulted from the low densities of Class 2 and Class 3 predators, which had higher relative feeding capacities, in late July and early August (Table 2). Although each class of predators appears at a different time during the season, all six predator families were present in the potato system three weeks after the first green peach aphid appeared (i.e. 15 July (1993), 28 June (1994) and 5 July (1995)) (Fig. 1; Table 2).

*Generalization of dynamics patterns*

Chronologically the timing of phenomena such as the first appearance, peak density and local extinction of the green peach aphid population and predator complex

**Table 3.** Comparison of the chronological time and cumulative developmental degree days for phenological events for the green peach aphid population and the predator complex in potato fields at Othello, Washington over a 3 year period

| | First appearance of aphid population | | First occurrence of predator complex | | Peak density of aphid population | |
|---|---|---|---|---|---|---|
| Year | Date | DDD[1] | Date | DDD | Date | DDD |
| 1993 | Jun 23 | 899 | Jul 15 | 1190 | Jul 22 | 1282 |
| 1994 | Jun 7 | 830 | Jun 28 | 1108 | Jul 12 | 1322 |
| 1995 | Jun 17 | 864 | Jul 5 | 1132 | Jul 11 | 1230 |
| Mean ±SD | | 864 ±35 | | 1143 ±42 | | 1278 ±46 |

[1]Developmental degree days for green peach aphid ($T_b$=4℃)

varied among the three years. However, we can generalize timings of the first appearance of both the green peach aphid population and the predator complex unit using degree day information. Table 3 shows the time of the first appearance of both green peach aphids and the predator complex. The difference of the first appearance of green peach aphids on potatoes over three years was 16 days, on a chronological time scale. In developmental degree days, the first appearance of green peach aphids in potato fields was monitored when degree days reached 864±35 (mean ±sd). The difference of the first appearance of all six families in the predator complex over three years was 17 calendar days. The average number of degree days required for the first occurrence of the predator complex was 1143±42. In terms of chronological time, the differences of the above two phenological events (16 and 17 days, respectively) are out of the range of our weekly sampling. In the fields, the average daily DDD increment was 15 - 17 during the summers of 1993 - 1995. If we assumed daily increases of 16 degree days, then 112 degree days represents approximately seven calendar days - the sampling period used in this study. Therefore, the deviations (35 and 42 degree days) indicate that we can predict the timing of the first appearance of green peach aphid and its predator complex within five or six days of their occurrence as these errors were within our seven-day sampling period. We also obtained a reliable temporal data in generalizing the time of peak density of aphid populations as the deviation was 46 degree days (Table 3), indicating an error of less than seven days, again within our weekly sampling period.

Fig. 2 shows the generalized dynamics pattern of green peach aphid populations and predator power of the predator complex on potatoes using a physiological, or developmental degree day, time scale during the three-year study. The pattern of population dynamics can be divided into three phases. Phase I is early growth of the green peach aphid population. It usually takes two to three weeks from its first appearance in the potato system, before the predator complex is completely constituted in Phase II. Greatly increased growth of the aphid population occurs in Phase II due to massive immigration of alates and production of their apterous offspring. Early in Phase II, Class 1 predators increases in densities and the immigration of coccinellid species begins. Adult coccinellids oviposit during Phase II, so that in Phase III, the coccinellid population size increases due to the emergence of larval progeny (Table 2; Fig. 2), in support of observation by Tamaki (1984). Furthermore, the population size of chrysopid larvae also increases during Phase II-III. Some species in the predator complex, such as coccinellids and chrysopids, are attracted to a large number of aphids, causing more reduction of the pest at high population densities (Tamaki and Long, 1978). Consequently, more green peach aphids are consumed, and the aphid population begins to decrease because of the continued growth of the predator complex in Phase III. In addition, the immigration of winged summer aphids declines sharply after their peak flight into potato fields (Ro, 1995). These facts appear to be the main reason for the quick decrease in the green peach aphid population size.

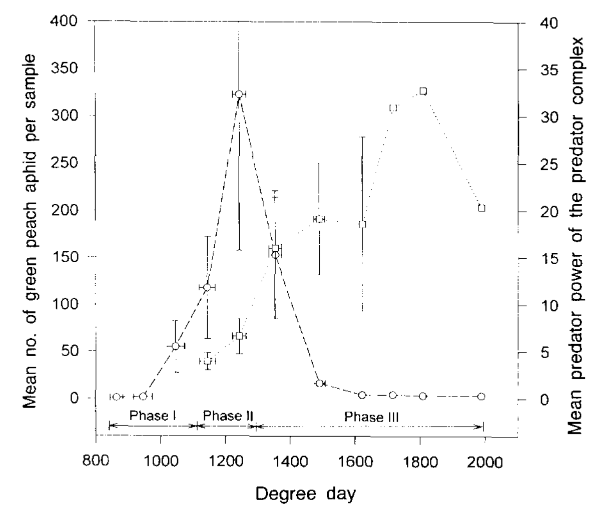


**Fig. 2.** A dynamics pattern of the green peach aphid population (○) and the predator complex (□) on potatoes in the central basin of Washington during the summer. Mean green peach aphid ± SE and mean predator power ± SE per beating tray were calculated from the mean values of each year represented in Fig. 1. Degree-days (mean ± SE) calculated for green peach aphid ($T_b$=4℃) from January 1 of each year.

*Predator complex as a single unit*

An earlier study in Pennsylvania (Smilowitz, 1984) reported that green peach aphid densities in field plots where natural enemies were eliminated ranged from fifteen- to a thousand-fold greater than those plots where natural enemies were conserved. This study is supported by our results that show a great impact of the predator complex on the green peach aphid population in potato fields during the summer. Earlier studies on quantifying the effects of predators on cereal aphids also show significant impacts of various natural enemies on the aphid density (Chambers and Aikman, 1988). In the single species approach, voraciousness, density-dependent action, and numerical or functional responses are used in evaluating predator effectiveness. In the predator complex approach, all species of predators attacking the pest at a given time are considered as a single unit. Thus in the predator complex approach, coccinellids may not be any more important than geocorids in the overall effect on the population growth curve of *M. persicae* (Tamaki, 1984).

Agroecosystems can be more susceptible to pest damage due to the lack of diversity in species of plants and insects. Thus, it is critical in pest management to recognize the existence of complex biological systems (Luckman and Metcalf, 1982). The application of predator power is very useful to evaluate the dynamics of predator complex, and the utilization of the predator complex concept as a single unit can simplify the interactions between the green peach aphid and its natural enemies in potato fields. Our results underscore the importance of the predator complex in its ecological interaction with green peach aphids in the potato systems in Washington. The effect of predators on the green peach aphid population growth is considered sufficient to warrant their incorporation into the IPM program (Smilowitz, 1984). Although green peach aphid populations increase rapidly early in the season, levels depend on the number of summer migrants and are suppressed by the predator complex during the latter part of the season. This indicates that the critical period for controlling the aphid is between its initiation and the timing of peak aphid populations. During this period, the application of a selective chemical or an effective biological control agent, or the integration of both, will minimize the damage to potatoes by green peach aphids without seriously disturbing the impact of the predator complex on aphids. This is an important consideration in developing integrated pest control methods that are in harmony with ecological interactions of the predator complex and green peach aphids.

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