Research Institute of Crop Production, Praha-Ruzyně

Factors affecting the distribution of larvae of aphid predators (Col., Coccinellidae and Dipt., Syrphidae) in cereal stands

By A. Honěk

Abstract

Coccinellids *(Coccinella septempunctata, C. quinquepunctata, Propylaea quatuordecimpunctata),* and the complex of syrphid larvae (mainly *Epistrophe balteata)* were sampled out from small areas placed within selected field cereal stands, and their abundance was realated to plant density and aphid abundance. These factors accounted together for up to 49.0 % of variance in abundance of particular species. Plant density substantially affected predator abundance. The effects were perhaps due to microclimatic differences between stands. Significant (at $p < 0.1$) partial correlations between predator abundance and plant density were obtained in 9 out of 12 predator species x year sets of data. The *Coccinella* species were negatively influenced by increasing plant density and the larvae were limited mostly to sparse stands. *P. quatuordecimpunctata* and especially syrphids preferred dense plant stands. Thermal requirements of *Coccinella,* and preference for increased relative humidity in Syrphidae determined perhaps these differences. The effects of aphid density were, in most cases, less conspicuous. Significant partial correlations were obtained only in 4 out of 12 predator species x year sets of data, and appeared in *C. septempunctata, P. quatuordecimpunctata,* and Syrphidae, while *C. quinquepunctata* was insensitive to aphid density. The time of maximum growth in *C. septempunctata* larvae was well synchronized with peak density of aphid populations. The retarded larvae suffered from hunger and gave rise to small adults. In 1982 only about 1 % of total resulting adult population suffered from conquences of heavy starvation.

1 Introduction

In earlier studies (Honěk 1979, 1982) we investigated factors that affect distribution in field stands of adults of most important aphid predators of the family Coccinellidae. In cereal fields plant density and, sometimes, aphid abundance were important determinants of their abundance. Coccinellids lay eggs at places of their searching and feeding activity. Thus the factors affecting distribution of larvae will perhaps largely parallel the factors affecting adults. In 1980–1982 we investigated effects of plant desity and aphid abundance on distribution of immature stages of three species of Coccinellidae. In our study we included further the complex of larvae of several species of Syrphidae, which are also significant predators of aphids in cereal fields.

2 Material and methods

The material was collected in 1980–1982 at a number of localities of central Bohemia, within 70 km of Praha, in 150–700 m a.s.l. The study was performed on three species of Coccinellidae (Coleoptera), *Coccinella septempunctata* L, *C. quinquepunctata* L., and *Propylaea quatuordecimpunctata* (L.), and the complex of Syrphidae (Diptera), which consisted of several species (see 3.1). Larvae of last two instars and pupae were sampled by hand picking from an area of 5–10 m^2 of

U.S. Copyright Clearance Center Code Statement: 0044-2240/83/9504-0336 $ 02.50/0
Z. ang. Ent. 95 (1983), 336–345

ISSN 0044-2240 / InterCode: ZANEAE

field. These samples were taken at places within evenly developed stands of wheat, barley or oats, with characteristic height and density. The places were selected deliberately to cover the possibly largest range of plant density and aphid abundance. Since the young larvae are not easy to find, the collecting was performed at the time when maximum proportion of immature predator populations was present as late larvae or pupae. Due to climatic differences between years the data of sampling varied approx. by one month. The samples were collected at July 25–30, 1980 (in this year aphids were counted at the same places on July 3–11), June 28 – July 9, 1981, and July 8–15, 1982. Plant density and aphid abundance were measured at every collecting place. In 1981–1982 plant density was estimated as leaf area index (LAI, leaf area per unit of field area), in 1980 as dry weight of above ground parts of plants without ears per 1 m^2 of field area. Density of tillers was counted at 20–25 randomly placed areas of 0.03 m^2. Aphid population density was estimated by counting aphids on 3 × 50 tillers. The data were subjected to multiple correlation and regression analysis. The amount of variance in abundance of predators explained by partial (r) and multiple (R) correlations with plant density and aphid abundance was estimated by coefficients of determination (r^2, R^2), given in % ($r^2 \times 100$, $R^2 \times 100$). These figures appear in text but are not included in table 1. Since the number of investigated samples was small we accepted $p < 0.1$ as a criterion of statistical significance of results. The size of *C. septempunctata* adults was measured as the diameter of hind margin of the scutum. Measurements were made with optical micrometer, with accuracy of 0.0175 mm.

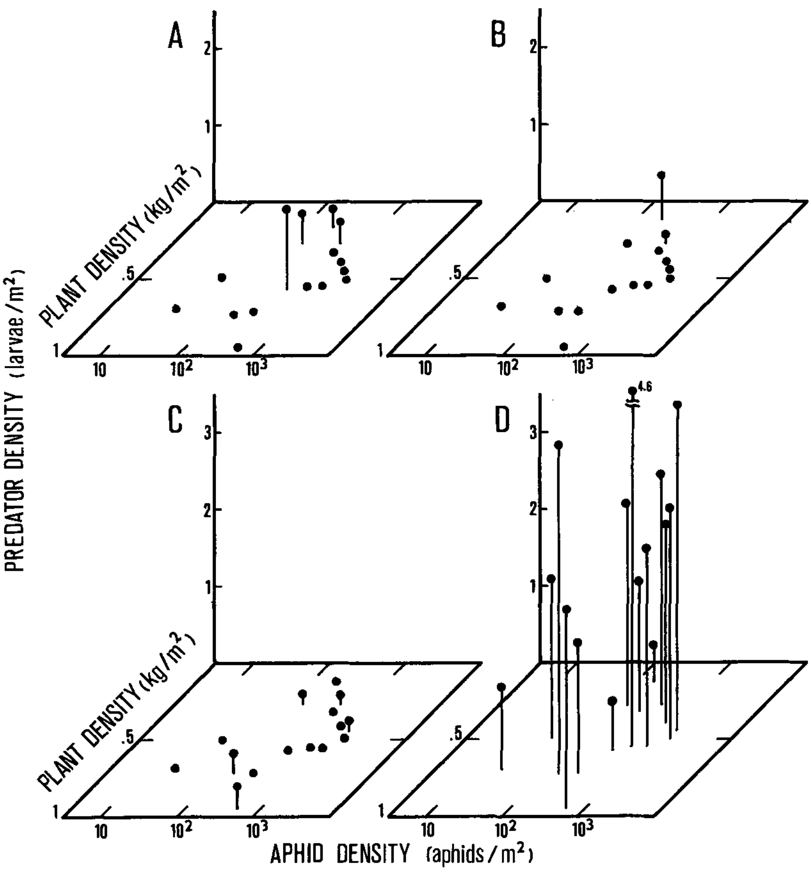

Fig. 1. The effect of aphid abundance and plant density on abundance of larvae of aphid predators, in 1980. A: *Coccinella septempunctata.* B: *C. quinquepunctata.* C: *Propylaea quatuordecimpunctata.* D: complex of syrphids

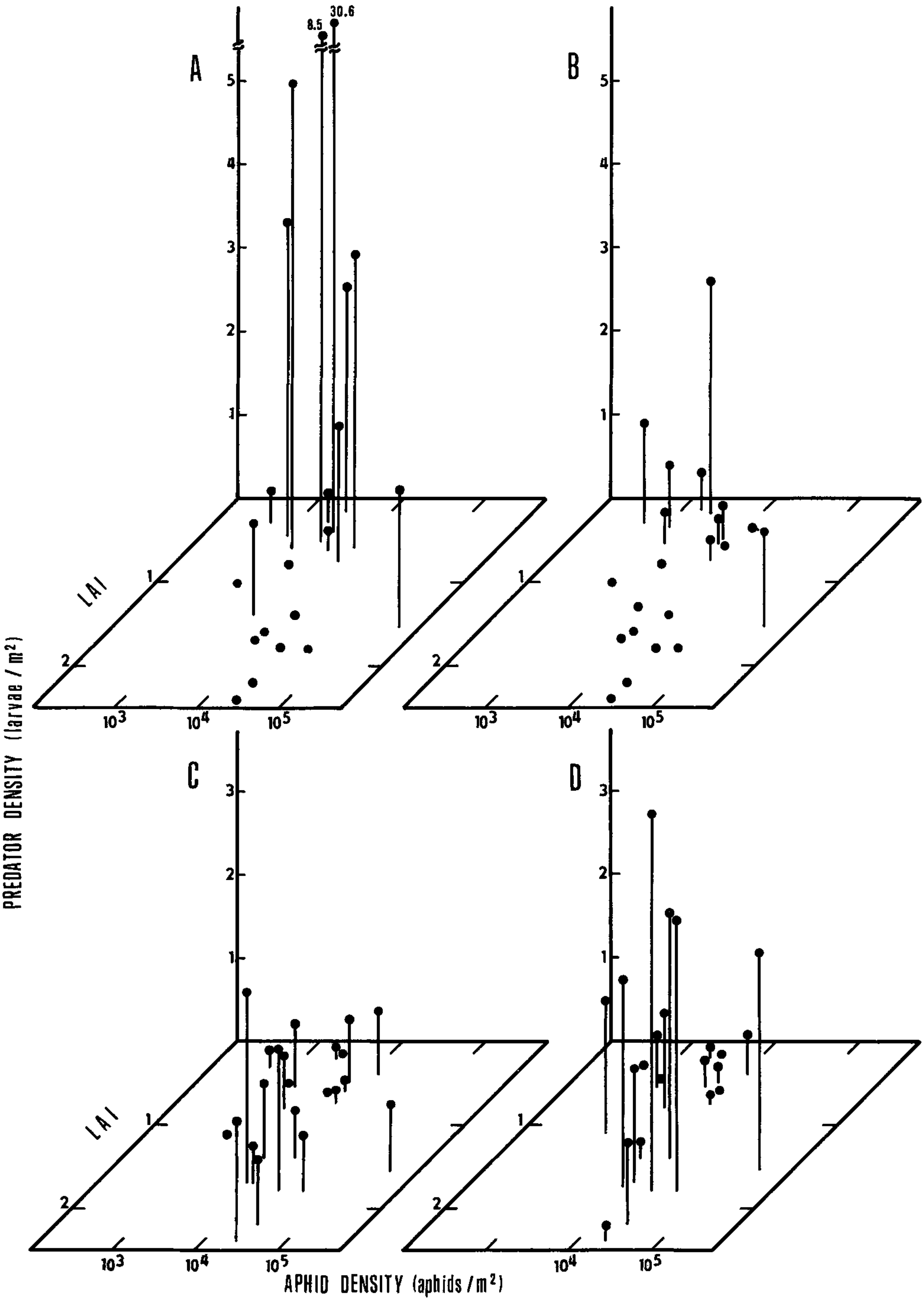

Fig. 2. The effect of aphid abundance and plant density (LAI) on abundance of larvae of aphid predators, in 1981. (For Abbrev. see Fig. 1)

3 Results

3.1 Annual changes in abundance of predator larvae

Mean abundance of coccinellid larvae varied dramatically between the years. It was extremely small in 1980 and increased by about 1 magnitude in next two

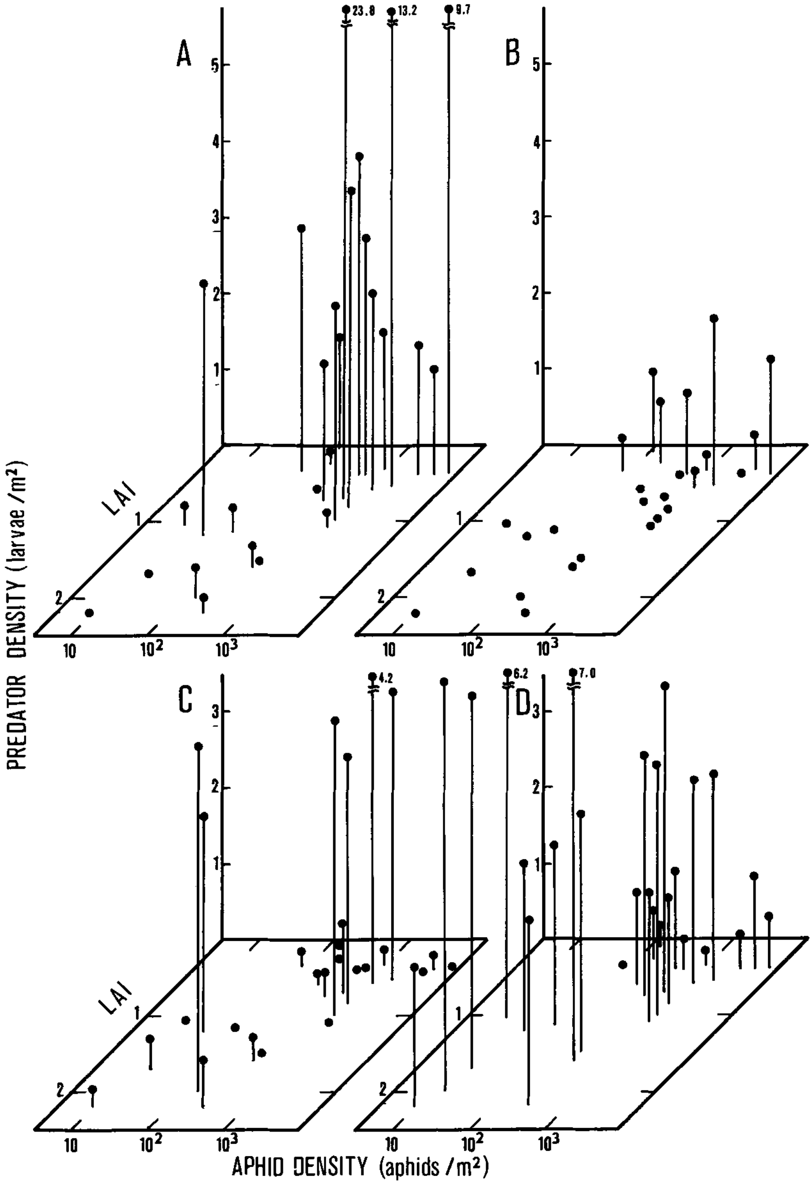

Fig. 3. The effect of aphid abundance and plant density (LAI) on abundance of larvae of aphid predators, in 1982. (For Abbrev. see Fig. 1)

years, when it was similar (tab. 1, figs. 1A–C, 2A–C, 3A–C). The low population density of coccinellid larvae in 1980 was apparently caused by adverse weather conditions. Mean June and July temperatures (16.8 and 16.4 °C resp.) were by 0.6 and 2.8 °C below the 50 year average, and duration of sunshine (178,6 and 174.5 h) was by 26.9 and 41.1 % below the 50 year average (data from meteorological station at Praha-Karlov). In 1981 and 1982 these meteorological characteristics were slightly above the 50 year average.

Population density of aphids varied also substantially between the years, but its effect on coccinellid larvae was far from dramatic. Although population density of aphids was by about 2 magnitudes greater in 1981 than in 1982, the coccinellid abundance was approx. the same. The fact that coccinellid populations did not largely increase was probably caused by the paucity of overwintered parental generations. Since the females were scarce, few eggs were laid despite the favourable trophic conditions, and the number of larvae in field stands was perhaps far below the carrying capacity of the environment.

The annual fluctuations in mean abundance of syrphid larvae (tab. 1, figs 1D, 2D, 3D) were smaller than in coccinellids. The abundance of syrphid larvae was least in 1981, in spite of large prey density. This could be perhaps caused by relatively warm and dry weather conditions in the year. The species composition of syrphid complex varied slightly between the years. The dominant species was *Epistrophe balteata* (DeGeer), which formed 90, 76 and 84 % of total syrphid population in 1980–1982 resp. Another important component of the complex was *Scaeva pyrastri* (L.), which accounted for 4, 7, and 3 % of population in 1980–1982 resp. At least five species were ascertained in the rest of syrphid populations (6, 17 and 14 % in 1980–1982 resp.): *Melanostoma mellinum* (L.), *Platychirus angustatus* (Zett.), *Sphaerophoria menthastri* (L.), *Sp. scripta* (L.), and *Syrphus corollae* (F.). They were determined as adults leaving the collected pupae. Thus the complex of Syrphidae appeared more stable component of larval communities of aphid predators than coccinellids.

3.2 Effects of plant density and aphid abundance on different species

In both species of the genus *Coccinella*, increasing plant density negatively influenced the abundance of larvae (figs. 1A–3A, 1B–3B). The larvae of *C. septempunctata* were limited to sparse stands with LAI < 1 (or < 0.4 kg dry matter/m^2), and *C. quinquepunctata* preferred still sparser stands. In 1980–1981, partial linear correlations with plant density explained 48.9 and 43.4 % of variance in *C. septempunctata* abundance, and 26.0 and 23.7 % in *C. quinquepunctata* resp. (table).

In 1980–1981 aphid abundance did not significantly influence the populations of *Coccinella* larvae, neither when low (1980 – average 351 aphids/m^2), nor when high (1981 – average 6,918 aphids/m^2). In 1982 the correlations with aphid density were significant. This was due to the fact that aphid abundance and plant density were negatively intercorrelated ($r = -.427$) and sparse stands contained dense aphid populations. Thus the increase of *Coccinella* density in sparse stands appeared as the effect of aphid abundance. Multiple correlation coefficients explained 32.9–49.0 % of variance in abundance of *C. septempunctata*, and 25.4–27.3 % in *C. quinquepunctata*.

Abundance of *P. quatuordecimpunctata* (figs 1C–3C) was not systematically influenced by both determinants. Relatively dense as well as zero

Effects of plant density and aphid abundance on abundance of larvae of aphid predators

		1980 n = 15				1981 n = 21				1982 n = 26			
		$\bar{x}$	b	r	R	$\bar{x}$	b	r	R	$\bar{x}$	b	r	R
C. septempunctata	PD	.040	$-.2252^{c}$	$-.699^{c}$	$.7002^{b}$	.317	$-.5107^{c}$	$-.660^{d}$	$.6641^{c}$	.417	$-.1174$	$-.248$	$.5783^{b}$
	AA		$-.0257^{b}$	$-.246$			$.3031^{c}$	$.417^{a}$			$.2304^{c}$	$.433^{b}$	
C. quinquepunctata	PD	.017	$-.1279^{b}$	$-.510^{a}$	.5105	.102	$-.1400^{b}$	$-.487^{b}$	$.5224^{a}$	.087	$-.0772^{b}$	$-.385^{a}$	$.5038^{b}$
	AA		$-.0126$	$-.132$			$.0466^{b}$	.162			$.0368^{b}$	.187	
P. quatuordecimpunctata	PD	.027	.0856	.428	.4281	.192	$.1367^{c}$	$.545^{b}$	$.6673^{c}$	.224	.0852	.213	.3793
	AA		.0066	.082			.0132	.055			$.1665^{c}$	$.377^{a}$	
Syrphidae	PD	.513	.3342	$.453^{a}$	$.5651^{a}$	.251	$.1726^{b}$	$.443^{a}$	$.6382^{c}$	.475	$.1529^{c}$	$.448^{b}$	$.5196^{b}$
	AA		$.1551^{a}$	$.473^{a}$			$.0762^{c}$	.189			$-.0314$	$-.098$	

PD: plant density (1980: dry weight of above ground parts without ears/m^2, 1981–1982: LAI); AA: aphid abundance (aphids/m^2); n: number of samples analyzed in the year; $\bar{x}$: mean population density of predator larvae (individuals/m^2); b: partial regression coefficient; r: partial correlation coefficient; R: multiple correlation coefficient. Results statistically significant at: a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: $p < 0.005$.

populations of this species were found both in dense and sparse stands, and under whole range of aphid population density. There was a general tendency to increase of larval abundance in dense stands, which was statistically significant in 1981 (tab. 1). An indication of preference to high aphid density was obtained in 1982. Multiple correlation coefficients explained 14.4–44.5 % of variation in abundance of this species.

The complex of syrphid larvae (figs. 1D–3D) had rather constant and relatively high abundance. In all years population density of larvae increased with inreasing plant density (significant at $p < 0.1$–0.05, tab. 1). The regression of syrphid abundance on this factor was significant only in 1981 and 1982, years with relatively dry and warm weather. In cool and wet summer 1980 the regression was not significant. These results indicate perhaps some preference to humid and relatively cool microclimatic conditions of dense crop stands. Important correlation between syrphid abundance and aphid density was observed only in 1980. It was surprising that slugish larvae were able to find sufficient prey even in stands with sparse aphid populations. Multiple correlation coefficients explained 27.0–40.7 % of variance in syrphid abundance.

3.3 Changes in size of newly moulted *C. septempunctata* adults in the course of season

C. septempunctata larvae select places with particular environmental conditions. This behaviour, however, would not assure optimum conditions, if the life cycle were not synchronized with temporary aphid occurrence. Sharp decline of aphid abundance was observed usually about the time when larvae completed their development. A fraction of population survived starvation. These larvae gave rise to undersized adults with reduced fitness.

During the 1982 season we observed the course of production of adults with different size (fig. 4). At Praha-Ruzyně well developed adults of new generation (mean scutum diameter 3.65 and 3.84 mm in ♂ and ♀ resp.) appeared from about July 12, in fields with different aphid density (300–3,500 aphids/m^2). These "full sized" adults originated from well fed larvae. From about July 28 smaller individuals became to appear, as a consequence of decline of aphid density between July 20–25. Mean size of adults decreased by about 10 % on July 30, and finally by 25 % on Aug. 5. The rate of production of new adults was estimated by determining the abundance of freshly moulted (soft and yellowish) individuals. Their average density was 35.0, 14.3 and 1.3

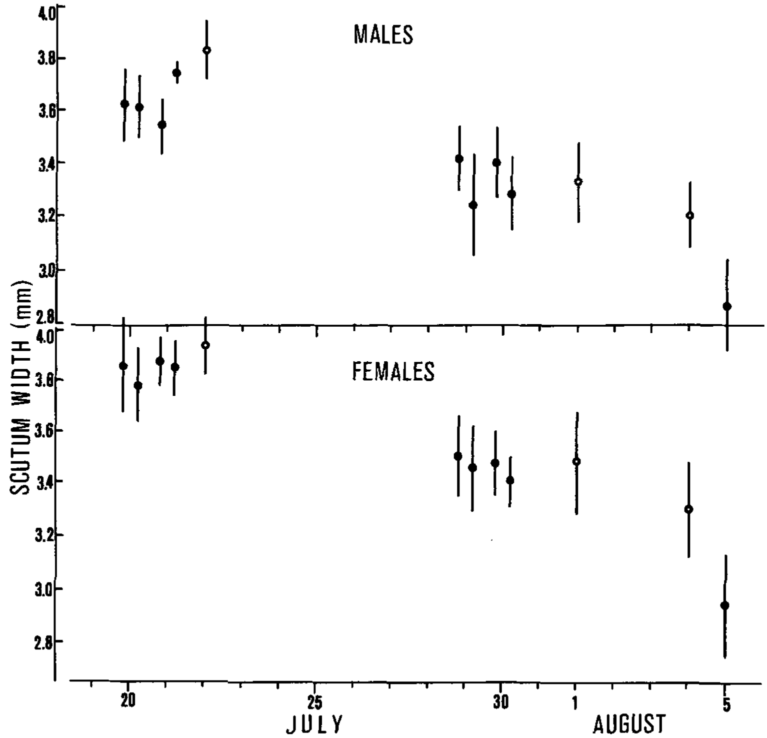

Fig. 4. The course of decrease of size (diameter of hind margin of the scutum) in freshly moulted adults of *C. septempunctata*, in 1982. Populations of ● Praha-Ruzyně and ○ Votice. Mean ± SD

individuals/100 sweeps on July 20, July 29 and Aug. 5 resp. From these figures and the duration of periods of production of adults with particular size we calculated that about 85 % of adults of new population were "full sized" individuals, about 14 % had slightly (by 10 %) reduced size, and 1 % were very small individuals (25 % reduction of size).

4 Discussion

The choice of appropriate habitat (in terms of microclimate and prey availability) is the first prerequisite, and the synchronization between predator development and prey occurrence is the second one, of successful production of predator offspring.

By modifying the microclimate within the stands, plant density influenced substantially the distribution of coccinellid and syrphid larvae. Few studies indicated that density or taxonomic composition (connected perhaps with different density) of stands may influence the abundance of coccinellid or syrphid larvae (MAYSE 1978; IPERTI 1978; HORN 1981; TAMAKI et al. 1981; cf. ALTIERI and TODD 1981). In the genus Coccinella preference to sparse stands is perhaps caused by thermoregulatory behaviour, earlier demonstrated in adults (HONĚK 1979). By contrast, syrphid larvae prefer dense stands (cf. MAYSE 1978). The integument of larvae is soft and weakly sclerotized. Therefore syrphids may be more susceptible to desiccation and thus committed to humid microclimate of dense plant stands. Optimum relative humidity for syrphid larvae is 70–90 % (WNUK 1978).

Numerical responses of predator larvae to aphid abundance were demonstrated several times (e.g. NEUENSCHWANDER et al. 1975; TAMAKI and LONG 1978; CAPINERA and ROLTSCH 1981). This effect seems obvious since increased density of aphids enhances the quantity of deposited eggs (WRIGHT and LAING 1981; IVES, 1981) and adults prefer to deposit eggs near to clumped aphid populations (SAKURATANI 1977; ITO and IWAO 1977; SANDERS 1979). A threshold aphid density is essential for survival of larvae (DIXON 1970; WRATTEN 1973).

We, similary to SAKURATANI (1977), failed in most cases to demonstrate the relation between abundance of predator larvae and aphids. The causes of this failure may be complex. One reason was perhaps insufficient differentiation of aphid abundance between the stands. GALECKA (1962) ascertained a relation between coccinellid and aphid abundance only in years, when aphid populations were abundant. General scarcity of predators may also smooth the differences. In 1981, greater differences in abundance of coccinellid larvae would probably arise, if parental generation which overwintered from 1980 were abundant and therefore egg output of this generation were unlimited. Also plant density may compensate for the effects of aphid abundance.

The degree of preciseness of synchronization between predator development and prey occurrence is a part of species strategy. EVANS (1982) demonstrated different strategies in generalist and specialist predator species. Development of a specialist was well synchronized with its prey, and most adults developed to nearly optimum body size. Generalist species was less constrained to a narrow time period at a cost of suffering from food scarcity. But it was tolerant to food shortage and major part of population developed to small individuals of subnormal size. *C. septempunctata* has a strategy of a typical specialist. The synchronization of development with aphid populations is precise and the majority of individuals develop to optimum sized adults. Feeding rate appears the main factor reducing the size (cf. SMITH 1965; MILLS 1981), while temperature is perhaps of little importance. For C. septempunctata this strategy is important. Reduced size appears associated with reduced fitness, manifest e.g. as greater risk at the pre-hibernation and hibernation periods (cf. ADYLOV 1965; MINORANSKII 1972).

Zusammenfassung

Zur Verteilung der Larvenstadien von Blattlaus-Prädatoren (Col., Coccinellidae und Dipt., Syrphidae) in Getreidefeldern

In den Jahren 1980–1982 wurden die Verteilung und Populationsdichte der Entwicklungsstadien der wichtigsten Blattlaus-Prädatoren in Getreidefeldern in Mittelböhmen untersucht. Die Larven und Puppen von 3 Marienkäferarten *(Coccinella septempunctata, C. quinquepunctata* und *Propylaea quatuordecimpunctata)* und des Komplexes der Schwebfliegen (vor allem von *Epistrophe balteata)* wurden auf kleinen Parzellen inmitten ausgewählter Getreidefelder gesammelt. Der Einfluß der Dichte des Pflanzenbestandes und der Abundanz der Blattläuse auf die Abundanz der Prädatoren wurde mit Hilfe der Korrelationsanalyse untersucht. Beide Faktoren haben in einzelnen Fällen (Kombinationen von Prädatorenart × Jahrgang) bis 49,0 % Varianz entsprochen. Der wichtigste Faktor, der die Populationsdichte der Prädatoren beeinflußte, war die Pflanzendichte. Diese Wirkung wurde wahrscheinlich durch das unterschiedliche Mikroklima in dichteren oder dünneren Pflanzenbeständen verursacht. Statistisch signifikante ($p < 0,1$) Partialkorrelationen zwischen der Abundanz von Prädatoren und der Pflanzendichte wurden in 9 von 12 Fällen festgestellt. Die Arten der Gattung *Coccinella* wurden mit zunehmender Pflanzendichte negativ beeinflußt; sie lebten fast ausschließlich in sehr dünnen Pflanzenbeständen. *P. quatuordecimpunctata* und besonders die Schwebfliegenlarven bevorzugten dagegen dichte Pflanzenbestände. Diese Unterschiede sind vermutlich durch die Thermo-Preferenz der *Coccinella*-Arten sowie die Luftfeuchtigkeits-Preferenz der Schwebfliegenlarven zu erklären. Die Wirkung der Blattlausabundanz war meistens wenig sichtbar. Statistisch signifikante Partialkorrelationen wurden nur in 4 von 12 Fällen festgestellt, und zwar bei *C. septempunctata, P. quatuordecimpunctata* und Schwebfliegen – bei *C. quinquepunctata* aber niemals. Die Periode des größten Wachstums der Larven der Prädatoren fiel mit der Periode der größten Populationsdichte der Blattläuse zusammen. Die in der Entwicklung verspäteten Larven hungerten in den letzten Stadien der larvalen Entwickung und wandelten sich schließlich in kleinere Vollkerfe um. 1982 wurden in der Imaginalpopulation der neuen Generation nur etwa 1 % solcher vom Hunger betroffenen Individuen festgestellt.

References

ADYLOV, Z. K., 1965: Overwintering of predaceous coccinellids in Uzbekistan. Trudy Sredneaziat. nauch. – issl. Inst. Zashch. Rast. Tashkent *7*, 98–102 (In Russ.).

ALTIERI, M. K.; TODD, J. V., 1981: Some influences of vegetational diversity on insect communities of Georgia soybean fields. Protect. Ecol. *3*, 333–338.

CAPINERA, J. L.; ROLTSCH, W. J., 1981: The predatory ant Formica neoclara: effect of within-field bean aphid distribution, and activity on relation to thermal conditions. J. Kans. ent. Soc. *54*, 578–586.

DIXON, A. F. G., 1970: Factors limiting the effectiveness of the coccinellid beetle, *Adalia bipunctata* (L.) as a predator of the sycamore aphid, *Drepanosiphum platanoides* (Schr.). J. anim. Ecol. *39*, 739–751.

EVANS, E. W., 1982: Timing of reproduction by predatory stinkbugs (Hemiptera, Pentatomidae) – patterns and consequences for a generalist and a specialist. Ecology *63*, 147–158.

GALECKA, B., 1962: Influence of patches of wood in fields on changes in numbers of potato aphids and the predatory Coccinellidae. Ekol. pol. Ser. A. *10*, 21–44.

HONĚK, A., 1979: Plant density and occurrence of *Coccinella septempunctata* and *Propylaea quatuordecimpunctata* (Coleoptera, Coccinellidae) in cereals. Acta ent. bohemoslov. *76*, 308–312.

— 1982: Factors which determine the composition of field communities of adult aphidophagous Coccinellidae (Coleoptera). Z. ang. Ent. *94*, 157–168.

HORN, D. J., 1981: Effect of weedy backgrounds on colonization of collards by green peach aphid, *Myzus persicae*, and its major predators. Env. Ent. *10*, 285–289.

Iperti, G., 1978: Coincidence spatiale des coccinelles et des pucerons. Ann. Zool. Ecol. anim. *10*, 373–375.

Ito, K.; Iwao, S., 1977: Oviposition behavior of a syrphid, *Episyrphus balteatus*, in relation to aphid density on the plant. Jap. J. appl. Ent. Zool. *21*, 130–134.

Ives, P. M., 1981: Feeding and egg production of two species of coccinellids in the laboratory. Can. Ent. *113*, 999–1005.

Mayse, M. A., 1978: Effects of spacing between rows on soybean arthropod populations. J. appl. Ecol. *15*, 439–450.

Mills, N. J., 1981: Some aspects of the rate of increase of a coccinellid. Ecol. Ent. *6*, 293–299.

Minoranskii, V. A., 1972: Distribution of developmental stages of *Coccinella septempunctata* in the course of the season. Ekologia vrednykh i poleznykh nasekomykh, Voronezh. P. 8–17 (In Russ.).

Neuenschwander, P.; Hagen, K. S.; Smith, R. F., 1975: Predation on aphids in California's alfalfa fields. Hilgardia *43* (2), 78 pp.

Sakuratani, Y., 1977: Population fluctuations and spatial distribution of natural enemies of aphids in corn fields. Jap. J. Ecol. *27*, 291–300.

Sanders, W., 1979: Das Eiablageverhalten der Schwebfliege *Syrphus corollae* Fabr., in Abhängigkeit von der Größe der Blattlauskolonie. Z. ang. Zool. *66*, 217–232.

Smith, B. C., 1965: Differences in *Anatis mali* auct. and *Coleomegilla maculata lengi* Timberlake to changes in the quality and quantity of the larval food. Can. Ent. *103*, 1115–1120.

Tamaki, G.; Annis, B.; Weiss, M., 1981: Response of natural enemies to green peach aphid in different plant cultures. Env. Ent. *10*, 375–378.

— Long, G. E., 1978: Predator complex of the green peach aphid on sugarbeets: expansion of the predator power and efficacy model. Env. Ent. *7*, 835–842.

Wnuk, A., 1978: Predatory Diptera. In: Boczek, J.; Lipa, J. J. (eds.), Biologiczne metody walki ze szkodnikami roslin. PWN. Warszawa. P. 267–285, (In Polish).

Wratten, S. D., 1973: The effectiveness of the coccinellid beetle, *Adalia bipunctata* (L.), as a predator of the lime aphid, *Eucalipterus tiliae* L. J. anim. Ecol. *42*, 785–802.

Wright, J. E.; Laing, J. E., 1980: Numerical response of coccinellids to aphids in corn in southern Ontario. Can. Ent. *112*, 977–988.

Author's address: Dr. Alois Honěk, Výzkumný ústav rostlinné výroby, oddělení entomologie, 161 06 Praha 6 – Ruzyně 507, CSSR

Institute of Entomology, Czechoslovak Academy of Sciences, České Budějovice

Genetic polymorphism in *Aphidius ervi* Hal. (Hym., Aphidiidae), an aphid parasitoid on *Microlophium carnosum* (Bckt.)

By V. Němec and P. Starý

Abstract

Genetic polymorphism in the nettle aphid *Microlophium carnosum* (Bckt.) and its internal parasitoid *Aphidius ervi* Hal. was determined by disc gel electrophoretic analysis. Field populations of parthenogenetic aphids were found homogeneous. In the parasitoid, only seven types in the females and six types in the males have been identified; the dominant type was more frequent in the males than in females.

U.S. Copyright Clearance Center Code Statement: 0044-2240/83/9504-0345 $ 02.50/0
Z. ang. Ent. 95 (1983), 345–350

ISSN 0044-2240 / InterCode: ZANEAE