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POPULATION DENSITY OF APHIDS AT THE TIME OF SETTLING AND OVARIOLE MATURATION IN *COCCINELLA SEPTEMPUNCTATA* [*COL.* : *COCCINELLIDAE*]

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In 1978 and 1979 in Central Bohemia the census of aphid populations on bean, sugar beet, cereals, maize, and alfalfa were taken at the time when overwintered *Coccinella septempunctata* L. (1) settled and (2) the ovarioles of females ripened. Settling occurred immediately after aphid immigration. Minimum aphid density required for settling was estimated to about 10 aphids per 1 m^2 of field area. The aphid density at the time of ovariole ripening equaled 1 aphid per 200-400 cm^2 of leaf area.

In *Coccinella septempunctata* L. the abundance of adults in the field and the start of their reproductive activity depend on density of aphid population (HONĚK, 1978a). We tried to determine, under field conditions, the aphid abundance (1) at the time of settling of overwintered adults in the fields and (2) at the time of ovariole maturation.

MATERIAL AND METHODS

The investigations were carried out in 1978 and 1979 at 3 localities of Central Bohemia : Čáslav (200 m altitude), Praha-Ruzyně (350 m), and Miličín (600 m). From early May the fields with various crops were visited regularly at short intervals and *C. septempunctata* adults were counted visually along a transect of a given length (HONĚK, 1978b; GREENSTONE, 1979). At sunny but cool hours the adults bask in the sunshine. Most specimens can be counted by a person who inspects the stands in the direction of sunrays, i.e. having the sun at his back. In 1978 and 1979 virtually no coccinellids were present on fields which were not occupied by aphids. Three to 6 adults appeared per 100 m transect provided the aphids were present. At this moment the density of aphids was investigated. It is referred to as the density of aphids at the time of settling of *C. septempunctata* adults. Thereafter the infested fields were visited in 2-5 day intervals and when mature coccinellids appeared, the aphid density was determined anew.

The aphids were counted either directly or sampled by beating from a known number of tillers. The mean number of tillers per unit area, mean number of leaves, and mean leaf area per tiller were determined. Aphid species dominant on the crops were : *Acyrthosiphon pisum* HARRIS (alfalfa, bean in 1979), *Aphis fabae* SCOP. (bean in 1978, sugar beet),

Sitobion avenae (FABR.), *Metopolophium dirrhodum* (WALK.), and *Rhopalosiphon padi* (L.) (cereals, the 2 latter species also on maize). We used 4 criteria of aphid density : (A) Number of aphids per 1 m² of field area ; (B) number of plants per aphid ; (C) number of leaves per aphid ; (D) leaf area per aphid. While the characteristic (A) indicates the relation of aphid density to the area of field surface, the characteristics (B) to (D) indicate the area or the number of spatial items (stems, twigs, and leaves) that should be investigated by randomly searching animal before encountering the prey.

RESULTS AND DISCUSSION

The census of aphid populations were taken at 2 important moments of *C. septempunctata* life history mentioned in the introduction. The time of settling of coccinellids nearly coincided with that of aphids. For example, in 1978 at Praha — Ruzyně, coccinellids appeared in cereals and beans 1 day after aphid alighting. At this period the aphid populations in the field were of fairly low density.

When comparing different crops (table 1) the number of aphids per unit area of the field appeared the least variable characteristic. About 10 aphids per 1 m² or slightly less were sufficient to fix a certain number of *C. septempunctata* adults to fields. The only exception were cereals in 1978, where the initial number of immigrant alatae aphids was perhaps greater than the minimum one required for the settling of coccinellids. Other characteristics gave less consistent results. This was due to differences in the plant stature in different crops at the time of coccinellid settling.

TABLE 1

Aphid densities at the time of settling of C. septempunctata *populations*

Crop	Date of observation	N	Aphid density (a) A	B	C	D
	1978					
Bean	May 22	1	3.7	5.5	16.5	408.0
Sugar beet	May 24	3	3.5 (2.4-4.1)	5.2 (4.0-7.5)	29.1 (22.6-41.0)	251.2 (110.3-347.8)
Maize	June 19	2	1.2 (0.9-1.4)	7.5 (5.8-9.1)	27.8 (23.7-51.8)	553.7 (256.6-850.0)
Cereals	May 22-29	4	23.6 (8.4-35.5)	33.0 (7.1-66.8)	134.0 (31.4-256.7)	507.3 (126.6-790.0)
Alfalfa	April 19-May 15	5	7.8 (4.2-11.3)	97.5 (44.2-165.9)	636.2 (413.3-978.5)	2,549.2 (776.6-5,483.7)
	1979					
Bean	May 24-28	3	0.7 (0.5-1.3)	52.2 (23.3-83.3)	195.6 (72.2-262.5)	3,476.0 (782.9-5,380.0)
Cereals	May 10-June 12	6	8.7 (5.1-12.9)	70.8 (25.0-133.0)	283.3 (85.0-513.2)	1,789.2 (610.0-2,344.8)
Alfalfa	May 11-17	6	10.4 (1.7-21.3)	74.7 (27.8-258.9)	631.2 (50.1-2,097.2)	3,211.3 (583.8-10,252.4)

(a) Mean and (range).

N : number of observations ; A : number of aphids per 1 m² of the field area ; B : number of plants per aphid ; C : number of leaves per aphid ; D : leaf area per aphid (cm²).

In coccinellid larvae the prey is sought apparently by random (with respect to the position of the aphids) searching and captured after the direct encounter between the larva and the aphid (KADDOU, 1960; BÄNSCH, 1964; KESTEN, 1969; WRATTEN, 1976; STORCH, 1976). The prey searching behaviour of adults has not been studied with equal intensity but the mechanism might be similar (HODEK, 1973). If so, we could suppose that, with similar numbers of aphids per unit area of field surface, the probability of finding the prey (and being fixed on a given place) would be smaller in dense, ramified, richly leaved stands than in "clear" ones. There is, however, little relation between the settling of coccinellid adults and B to D indices which refer to aphid populations in relation to the "complexity" of plant stands. This may indicate that the adults possess some sense capacities which enable distant perception and directed orientation towards the infested stands.

After some time spent by feeding on aphid population, the coccinellid females begin to reproduce. As revealed previously (HONĚK, 1978a) the ovarioles do not ripen before the density of a aphids increases to a certain threshold value, which is greater than that required for settling. Prolonged feeding on subthreshold density of aphids does not enable the ovariole ripening. The proportion of simultaneously ripening females varied largely. The populations contained 2-70 % of these females.

At the time when ripe females were found (table 2) the numbers of aphids per 1 m^2 field surface varied greatly. By contrast, the densities of aphids as expressed by B to D indices were more similar. Particularly the values of leaf area per aphid (D) varied little between crops. If the latter characteristic is taken as a measure of population density of the aphids, about 1 aphid per 200-400 cm^2 of the leaf area is required for ovariole ripening in *C. septempunctata* in all crops investigated. Accordingly, in dense, ramified crops

TABLE 2

Aphid densities at the start of ovariole maturation in C. septempunctata

Crop	Date of observation	N	Aphid density (a) A	B	C	D
	1978					
Bean	May 29-June 5	4	9.2 (4.2-15.8)	3.9 (1.7-6.5)	13.0 (6.9-21.9)	260.3 (141.1-363.8)
Sugar beet	May 30	2	19.7 (5.4-34.0)	3.0 (0.3-5.6)	16.3 (2.0-30.6)	193.6 (26.1-361.1)
Cereals	May 31-June 2	3	88.3 (68.6-113.8)	9.5 (6.3-12.5)	35.1 (20.3-50.3)	334.6 (187.9-441.6)
Alfalfa	June 1-6	3	161.3 (119.7-214.7)	2.7 (1.6-3.8)	20.8 (15.0-26.2)	196.2 (98.0-318.8)
	1979					
Cereals	June 11-15	3	74.5 (40.0-93.1)	9.0 (6.1-13.3)	38.3 (31.7-47.9)	222.2 (134.8-299.3)
Alfaalfa	May 24	3	84.9 (74.3-100.0)	3.9 (2.8-4.0)	49.3 (34.6-69.5)	234.8 (169.9-287.4)

(a) Mean and (range).
The meaning of symbols A, B, C, D, and N as in table 1.

with great number of leaves there are more aphids per unit area of field surface than in sparse and clear ones. The attainment of certain density of aphids with respect to plant surface appears to determine the ovariole maturation in *C. septempunctata*.

The dependence of ovariole maturation on a certain threshold of prey density helps to assure favourable nutritive conditions for larval progeny. The observed aphid densities required for ovariole maturation are presumably equal (or slightly lower) to the minimum densities needed for survival of coccinellid larvae (DIXON, 1970). Since the critical density is attained at the time of rapid increase of aphid population, in most cases the hatched coccinellid larvae will meet favourable feeding conditions.

The relation between aphid density and settling and ovariole ripening in *C. septempunctata* involves perhaps very complicated processes of behavioural and demographic nature. The threshold densities, however, are rather constant characteristics which appear, with slight variation, every year.

RÉSUMÉ

Densité de population des pucerons au moment de l'arrivée dans les champs et de la maturation des ovaires de *Coccinella septempunctata* [*Col.* : *Coccinellidae*]

En 1978 et 1979 on a procédé, en Bohème Centrale, au dénombrement des populations de pucerons sur haricot, betterave sucrière, céréales, maïs et luzerne, lorsque *Coccinella septempunctata* L. en hivernage (1) colonise les cultures et (2) que les ovarioles des femelles mûrissent. L'arrivée des coccinelles intervient aussitôt après l'immigration des pucerons. La densité minimum en pucerons à cette époque a été évaluée à environ 10 pucerons par m^2 de champ ; cette densité au moment de la maturation des ovarioles de la coccinelle équivaut à 1 puceron pour 200 à 400 cm^2 de surface foliaire.

REFERENCES

BÁNSCH, R. — 1964. Vergleichende Untersuchungen zur Biologie und zum Beutefangverhalten aphidivorer Coccinelliden, Chrysopiden und Syrphiden. — *Zool. Jb. Syst.*, 91, 271-340.

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.

GREENSTONE, M. H. — 1979. A line transect density index for wolf spider (*Pardosa* spp.), and a note on the applicability of catch per unit effort methods to entomological studies. — *Ecol. Entomol.*, 4, 23-29.

HODEK, I. — 1973. Biology of *Coccinellidae*. — *Academia*, Praha.

HONĚK, A. — 1978 a. Trophic regulation of postdiapause ovariole maturation in *Coccinella septempunctata* [*Col.* : *Coccinellidae*]. — *Entomophaga*, 23, 213-216.

— 1978 b. The losses of *Coccinella septempunctata* L. populations during the first cutting of forage leguminosae. — *Sbornik UVTIZ, Ochr. Rostl.*, 14, 233-236.

KADDOU, I. K. — 1960. The feeding behavior of *Hippodamia quinquesignata* (KIRBY) larva. — *Univ. Calif. Publ. Entomol.*, 16, 181-232.

KESTEN, U. — 1969. Zur Morphologie und Biologie von *Anatis ocellata* (L.) [*Coleoptera, Coccinellidae*]. — *Z. Angew. Entomol.*, 63, 412-445.

STORCH, R. H. — 1976. Prey detection by fourth stage *Coccinella transversoguttata* larvae [*Coleoptera* : *Coccinellidae*]. — *Anim. Behav.*, 24, 690-693.

WRATTEN, S. D. — 1976. Searching by *Adalia bipunctata* (L.) [*Coleoptera* : *Coccinellidae*] and escape behaviour of its aphid and cicadellid prey on lime (*Tilia vulgaris* HAYNE). — *Ecol. Entomol.*, 1, 139-142.