neem seed components with insecticidal activity. Proc. 2nd Int. Neem Conf., Rauischholzhausen, 1983, 103–114.

JACOBSEN, M.; REED, D. K.; CRYSTAL, M. M.; MORENO, D. S.; SODERSTROM, E. L., 1978: Chemistry and biological activity of insect feeding deterrents from certain weed and crop plants. Entomol. exp. appl. *24*, 448–457.

KENNEDY, J. S., 1965: Mechanisms of host plant selection. Ann. Appl. Biol. *56*, 317–322.

LADD, T. L. JR.; JACOBSEN, M.; BURIFF, C. R., 1978: Japanese beetles: extracts from neem tree seeds as feeding deterrents. J. econ. Ent. *71*, 810–813.

MEISNER, J.; ASCHER, K. R. S.; ALI, R., 1981: The residual effect of some products of neem seeds on larvae of *Spodoptera littoralis* in laboratory and field trials. Proc. 1st Int. Neem Conf., Rottach-Egern 1980, 157–170.

PRADHAN, S.; JOTWANI, M. G., 1968: Neem as an insect deterrent. Chem. age India *19*, 756–760.

SAXENA, R. C.; LIQUIDO, J.; JUSTO, H. D., 1981: Neem seed oil a potential antifeedant for the control of the rice brown planthopper, *Nilaparvata lugens*. Natur. Proc. 1st Int. Neem Conf., Rottach-Egern 1980, 171–188.

SHARMA, R. N.; NAGASAMPAGI, B. A.; BHOSLE, A. S.; KULKARNI, M. M.; TUNGIKAR, V. B., 1984: "Neemrich": The concept of anriched particulate fractions from neem for behavioral and physiological control of insects. Proc. 2nd Int. Neem Conf., Rauischholzhausen 1983, 115–128.

SOMBATSIRI, K.; TIGVATTANONT, S., 1984: Effects of neem extracts on some economic insect pests of Thailand. Proc. 2nd Int. Neem Conf.; Rauischholzhausen, 1983: 95–100.

STEETS, R., 1975: Die Wirkung von Rohextrakten aus den Meliaceen *Azadirachta indica* und *Melia azedarach* auf verschiedene Insektenarten. Z. ang. Ent. *77*, 306–312.

THORSTEINSON, A. J., 1960: Host selection in phytophagous insects. Ann. Rev. Entomol. *5*, 193–218.

WARTHEN, J. D., JR.; REDFERN, R. E.; UEBEL, E. C.; MILLS, G. D., JR., 1978: An antifeedant for fall armyworm larvae from neem seeds. U.S. Dep. Agric. Res. Results ARR-NE-1.

ZWÖLFER, H.; HARRIS, P., 1971: Host specificity determination of insects for biological control of weeds. Ann. Rev. Entomol. *16*, 159–178.

Authors' addresses: Dr. CARSTEN HELLPAP, Institut für Phytopathologie und Angewandte Zoologie, Justus-Liebig-Universität, Ludwigstr. 23, D-6300 Gießen; JULIO C. MERCADO, Seccion Control Biologico, DGA-MIDINRA, Managua, Nicaragua

---

Research Institute of Plant Production, Department of Entomology, Praha-Ruzyně, Czechoslovakia

Production of faeces in natural populations of aphidophagous coccinellids (Col.) and estimation of predation rates

By A. HONĚK

Abstract

The production of faeces (PF) was investigated in natural populations of adults of several aphidophagous coccinellid species, since it was thought to be roughly proportionate to the quantity of the food eaten. Immediately after the capture, males and females were placed separately into the small petri dishes, and allowed to produce faeces for 24 h at the temperature 24 ± 1 °C. The relation between PF and the abundance of aphids, and the seasonal and annual variation of PF were studied in *Coccinella septempunctata*. With aphid abundance ≤ 0.005 aphids/cm^2 of plant surface, PF was not influenced by the variation of aphid density. Above this

U.S. Copyright Clearance Center Code Statement: 0044-2240/86/0205-0467 $ 02.50/0
J. Appl. Ent. 102 (1986), 467–476

ISSN 0044-2240

threshold, PF increased proportionately to aphid abundance. With aphid abundance ≥0.8 aphids/cm^2, the adults were likely to be satiated, and PF in females (0.97 ± 0.30 mg/day) was significantly greater than in males (0.67 ± 0.19 mg/day). The relationship between PF and aphid abundance was identical in the overwintered pre-reproductive and reproducing adults, and diapausing individuals of the new generation. However, PF varied substantially in the course of the season, along with variation of aphid density. In 1985 on herbaceous stands, average PF in reproducing adults was 60–95 %, before and after the period of reproduction only 30–60 %, of the PF in "satiated" populations. In *C. quinquepunctata*, the relationship between PF and aphid abundance was similar to *C. septempunctata*, but the increase of PF with aphid abundance was less conspicuous. Tentative estimates of average predation rates in natural populations of *C. septempunctata* were made. The difficulties in interpreting the PF in terms of predation rates are discussed. With low aphid abundance, small *C. quinquepunctata* may be relatively more efficient predator than the large *C. septempunctata*, while with high aphid abundance perhaps the reverse is true.

1 Introduction

To evaluate the impact of predators on aphid populations, predation rates should be estimated under natural conditions (Baumgaertner et al. 1981). Predators may be excluded from (or introduced to) an isolated part of a field stand, and differences in aphid abundances against the outside noted (e.g. Chambers et al. 1980). The results are difficult to generalize, as the contribution of different predator species to the total effect remain unknown. Direct observation of predation is laborious, and the insides of dense crop stands are not accessible. By this method we investigated the predation of *C. septempunctata* adults in selected crop stands (Honěk 1985). Differences in predation behaviour between males and females were established, and daily consumption of aphids estimated.

Weighing the faeces may be an alternative method for the estimation of the quantity of the food eaten. Studies of food utilization in phytophagous insects revealed that dry weight of the faeces may represent about 40–60 % of the dry weight of the food eaten. The variation in the fraction of food egested as faeces is caused by differences in digestibility of different kinds of food (House 1974). It appeared from the present study that the variation due to different digestibility should be about 30–40 fold smaller than the variation in the average quantity of faeces produced by coccinellid populations. Thus the production of faeces (PF) appeared, at the present level of the precision of the study, a useful indicator of the quantity of food eaten. We investigated PF of adult coccinellid populations in the field, and discuss difficulties connected with its interpretation in terms of predation rates.

2 Material and methods

The samples of coccinellids were collected in 1982, 1984 and 1985 at several localities of Bohemia, mostly at Praha-Ruzyně. Data were collected mostly for *Coccinella septempunctata*, but *C. quinquepunctata* and some other species were investigated, too. Adults sampled from plant stands or hibernation sites were immediately put into the glass petri dishes (diam. 4 cm), in groups of 5–15 individuals. At least 10 males and 10 females from each locality were collected and held for 24 h at room temperature of 24 ± 1 °C, without the access to food or water. The adults were then removed, the dishes with faeces dried for 4 h at 60–80 °C, the faeces weighed (with accuracy of 0.1 mg), and the average production of faeces (PF) per male or female per 24 h calculated. During the first 24 h after the capture a substantial part of the gut content was emptied. Males captured in the stands with abundant aphids (2 replicates) produced in the first 24 h of incubation 58.7–64.7 %, on the second day 21.5–28.5 %, and on the third day 13.2–13.8 % of the total amount of faeces. Ovipositing females laid some eggs during the 24 h incubation period. These eggs were not always removed, and were consumed by other females. This cannibalism may increase PF of the females, but a significant increase was observed only in 1982 (see 3.3). The comparisons between PF in reproductive and non-reproductive populations were more reliable in males than in females. Aphid abundance was expressed as the numbers of aphids/cm^2 of the surface of the host plant. Host plant surface area was measured as leaf area (in some cases also inflorescence area) in 5–40 herb plants or tillers, or the area of 30–100 tree leaves. Aphids were counted at 5–30 plants or tillers, or at 50–500 leaves.

3 Results

3.1 Body size and production of faeces

In pre-reproductive adults of seven coccinellid species PF was directly proportionate to the average body weight (fig. 1). The coccinellid populations were apparently satiated, as they fed on dense (0.306 aphids/cm^2) populations of *Euceraphis punctipennis* Zett., on birches. The regression line indicated 0.067 mg increase of PF per 1 mg increase in dry body weight. The ratio of PF to dry body weight predicted by the regression line was 0.046 and 0.064 for coccinellids of 2.0 and 15.0 mg dry body mass, resp. Thus the large species had relatively greater PF than the small ones.

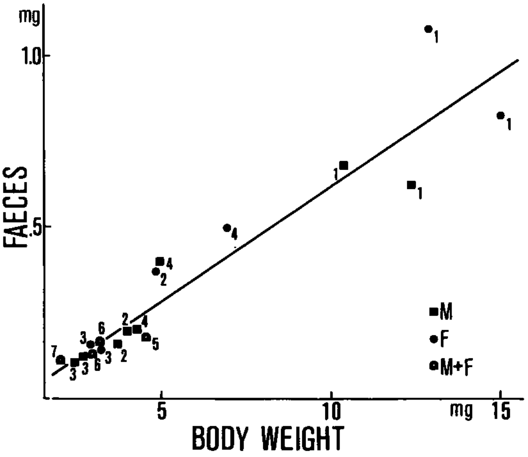

Fig. 1. Average production of faeces per individual (mg/day) in relation to the mean dry body weight of adults of seven coccinellid species. "Satiated" populations of coccinellids on birch infested with *Euceraphis punctipennis* Zett. (0.306 aphids/cm^2), May 6 and 8, 1985. M = males, F = females, M + F = mixed samples of males and females. 1 = *Coccinella septempunctata* L., 2 = *C. quinquepunctata* L., 3 = *Propylea quatuordecimpunctata* (L.), 4 = *Calvia quatuordecimguttata* (L.), 5 = *Adalia bipunctata* (L.), 6 = *A. decempunctata* (L.), 7 = *Aphidecta obliterata* (L.)

3.2 Aphid abundance and the production of faeces in *C. septempunctata*

The PF in relation to the density of aphid populations was studied in 1985 (fig. 2). We evaluated separately the results of post-hibernation pre-reproductive (late April–May) and reproductive (June–July) populations, and diapausing populations of the new generation (August–October). As aphid abundance and intensity of *C. septempunctata* oviposition were mostly low, female PF in the period of reproduction was not significantly affected by egg cannibalism.

PF in adults preying on sparse aphid populations did not increase with aphid abundance. The mean values of this "basal" PF were similar for males (0.23 and 0.26 mg in pre-reproductive and new generation populations, resp.) and females (0.28 and 0.31 mg). The slopes of regression lines of PF on aphid abundance, calculated for $\log_{10}$ aphid abundance $\leqslant -2{,}2$, were minimum,

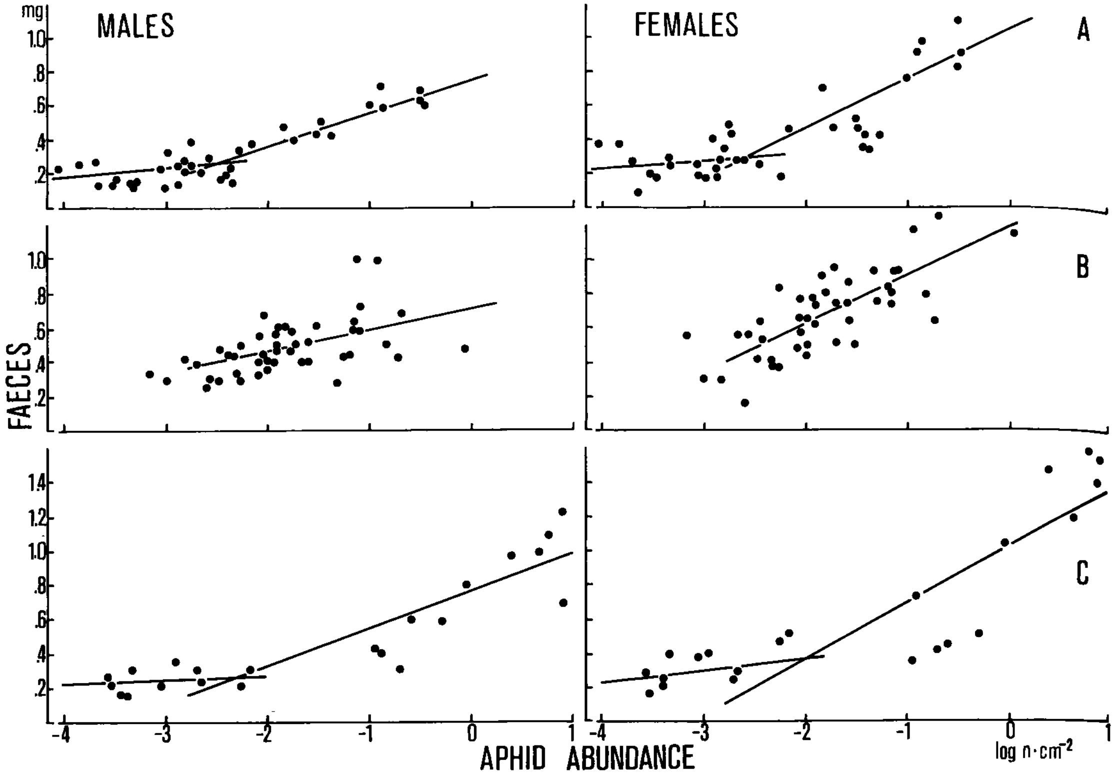

Fig. 2. Production of faeces per *C. septempunctata* adult (mg/day) in relation to aphid abundance ($\log_{10}$ no. of indiv./cm^2 of plant surface). Regression lines calculated separately for $\log_{10}$ aphid abundance $\leqslant -2.2$ and $\geqslant -2.8$. A = postdiapause pre-reproductive populations (April 22–June 14, 1985), B = postdiapause reproducing populations (June 5–July 24, 1985), C = diapausing populations of the new generation (July 30–Sept. 5, 1985)

0.0262–0.0838 (fig. 2A, C). The food requirements needed for the maintenance of basal PF were perhaps partly covered by the alternative prey. We observed predation on *Thysanoptera* spp. (April 21) and springtails of the genus *Sminthurus* (May 25); vegetable particles (pollen and fungi) were perhaps eaten, too.

In adults preying on abundant aphid populations PF increased with aphid density. The point of intersection of regression lines for scarce and dense aphid populations (average for data in fig. 2A, C was $\log_{10} = -2.27$, i.e. 0.005 aphids/cm^2) may indicate prey density above which aphids become an important component of *C. septempunctata* food, and their quantity determine the PF. The slopes of regression lines calculated for $\log_{10}$ aphid density $\geqslant -2.8$, were significantly ($p < 0.05$) steeper in females (0.2796–0.3271) than in males (0.1240–0.2266). This differences was not due to egg cannibalism during the 24 h experiment incubation, since the same differences were observed both in ovipositing reproductive, and not ovipositing pre-reproductive and diapausing females. Females thus may eat more aphids than males when preying on dense aphid populations The relationship between aphid abundance and PF was the same in pre-reproductive, reproducing, and diapause populations. Thus onset of reproduction, or diapause did not affect PF (and perhaps food consumption).

The average PF for adults preying on dense aphid populations ($\log_{10} \geqslant -0.1$) was calculated. The PF in these populations was perhaps near the maximum, as the slopes of regression of PF on aphid density for these data were low (0.0462 in males, and 0.0183 in females). These "satiated" populations (n = 21) had PF 0.67 ± 0.19 in males, and 0.97 ± 0.30 in females ($p<0.01$).

The daily variation in PF was studied in 1982. In stands with abundant aphid populations (barley, oats and bean) the adults were sampled 3–4 times a day, between 06.00–18.00. Although there was some variation between the samples of the same day and stand (average coefficient of variance was 8.8 % in males and 3.7 % in females), there were no definite circadian trends in PF. This indicated that PF was not sensitive to daily changes of *C. septempunctata* predation intensity caused by variation of temperature and insolation (cf. HONĚK 1985).

3.3 Seasonal changes in the production of faeces in *C. septempunctata*

Seasonal variation in PF was compared in three years with different aphid abundances: 1982 when aphids were generally abundant, and 1984 and 1985 when they were generally scarce (fig. 3).

Seasonal trends were demonstrated in 1985. In the spring, PF of the overwintered adults at herbaceous stands was low and increased slowly up to the late May. At the same time, however, PF in adults from trees was 2.6–2.7 times greater, and abundant *C. septempunctata* populations appeared at trees with dense aphid populations. Coccinellid females, however, did not lay eggs before late May, despite the high aphid abundance at some tree stands. In June–July, PF increased further, and oviposition started in populations from herbaceous stands. At the same time, *C. septempunctata* disappeared from the trees, although dense aphid populations were still present here. The adults apparently moved to herbaceous stands when these offered aphid populations of convenient density. Thus spring preference of the adults for trees had perhaps largely trophic motives. Highest PF was observed in late July – early August in diapausing adults of the new generation preying on dense aphid populations of wild herbaceous plants (mainly *Heracleum*). Thereafter PF fell to a medium level, slowly decreasing towards the autumn. In late Oct., PF was low although coccinellids were sampled from alfalfa stands with high aphid abundance (0.066 aphids/cm^2). The low temperatures apparently limited the predation.

The availability of food may substantially change the seasonal trends in PF among different years. In 1982 when abundant aphid populations appeared in late May–June on barley, oats and bean, PF at these herbaceous stands was up to four times greater than in 1985.

The PF in adults from hibernation sites was below the PF in non-overwintering populations, even those from places with nearly zero aphid abundance. However, the guts of adults from hibernacula were not empty, both before and after the winter. Alternative food (perhaps fungi or lichens) was probably accepted when temperature was favourable.

We calculated monthly averages of PF for aphid populations of fig. 3 (table). They were below the values calculated for "satiated" *C. septempunc-*

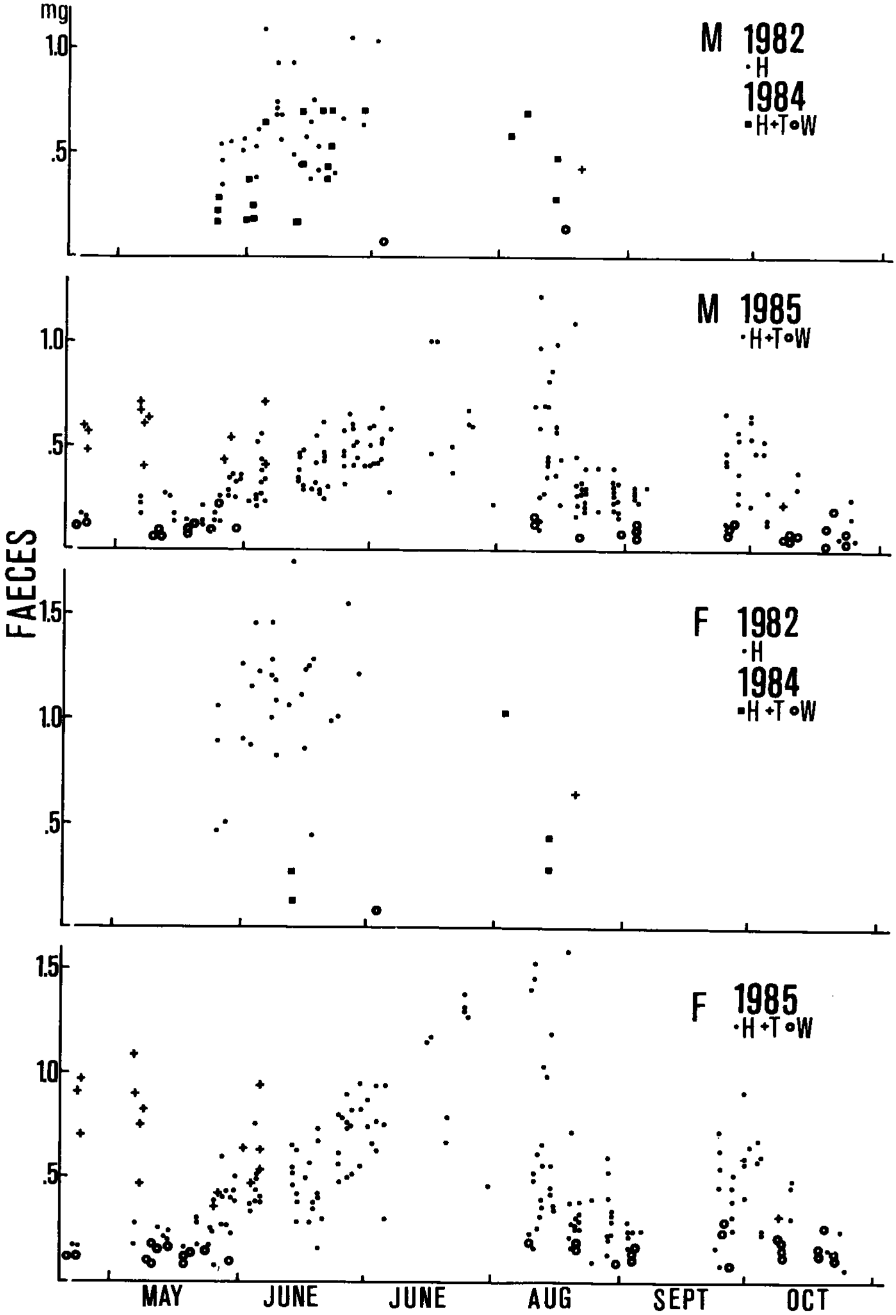

Fig. 3. Seasonal variation of the production of faeces per *C. septempunctata* adult (mg/day). Sampled from herbaceous and tree host plant stands, and from hibernation sites. M = males, F = females, H = herbaceous stands, T = trees, W = hibernation sites

Average production of faeces in populations of *C. septempunctata* from the open

	Production of faeces – mg (%)[a]							
	1982		1984		1985			
	herbs		herbs		herbs		trees	
	males	females	males	females	males	females	males	females
April					0.15 (22.3)	0.18 (18.6)	0.46 (68.7)	0.69 (71.1)
May	0.47 (70.1)	0.87 (89.7)	0.25 (37.1)		0.22 (32.7)	0.28 (28.9)	0.58 (86.2)	0.75 (77.3)
June	0.64 (95.5)	1.21 (124.7)	0.44 (65.4)		0.41 (60.9)	0.55 (56.7)	0.55 (81.7)	0.68 (70.1)
July					0.56 (83.2)	0.88 (90.7)		
August			0.51 (75.8)	0.56 (57.7)	0.41 (61.9)	0.50 (51.5)		
September					0.39 (57.9)	0.40 (41.2)		
October					0.27 (40.1)	0.39 (40.2)	0.22 (32.7)	0.32 (33.0)

[a] mg: arithmetic mean of the production of faeces (mg per individ./day) in different populations for a given period; (%): the above mean expressed as the percentual proportion from the average production of faeces in "satiated" population.

tata populations (see 3.2). In 1984 and 1985, average PF in pre-reproductive and diapausing populations of herbaceous stands attained only 30–50 % of the PF in "satiated" populations, in reproduction period it was 60–95 %. On trees, PF in pre-reproductive period was 70–85 % of the PF in "satiated" populations. In June 1982, PF in females was >100 % of the average for "satiated" populations, due perhaps to cannibalistic feeding of the eggs laid during the 24 h experiment incubation.

3.4 Production of faeces in *C. quinquepunctata*

Results similar to *C. septempunctata* were obtained for *C. quinquepunctata* males (fig. 4). Average PF in males from sparse aphid populations (≤ 0.005 aphids/cm^2) was 0.12 ± 0.02 mg. On abundant aphid populations PF increased with aphid density, but the slope of regression line (0.0358) was significantly smaller ($p < 0.01$) than in *C. septempunctata.*

4 Discussion

We may positively conclude that, for large part of the season and most host plant stands, *C. septempunctata* adults were far from being satiated. At least this was true in 1985, a year of low aphid abundance. In years of great aphid abundance satiation may be more universal. The starvation was caused by aphid scarcity, not by inclement weather. Only enduring autumn decrease of temperature negatively influenced the satiation of *C. septempunctata* populations. Incomplete satiation of predator populations over large periods of their life is perhaps a general phenomenon (cf. SOTA

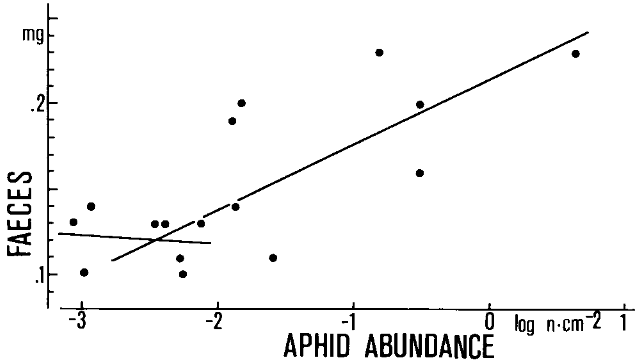

Fig. 4. Production of faeces per *C. quinquepunctata* male (mg/day) in relation to aphid abundance ($\log_{10}$ no. of aphids/cm^2 of plant surface). Regression lines calculated as in fig. 2

1985). Aphidophagous coccinellids appear physiologically adapted to the starvation, in contrast to phytophagous species whose food is usually in excess (Tanaka and Ito 1982).

In *C. septempunctata* the differences in PF confirmed the existence of different food consumption in males and females, earlier observed in a behavioural study (Honěk 1985). If the PF were proportional to the quantity of food consumed (see below) than, with 1.0 aphid/cm^2, the females will eat 1.47 times more food than the males. (This calculation is based on mean values predicted from regression lines in fig. 2 for $\log_{10}$ aphid density = 0, where PF equals to 1.09 mg in females and 0.74 mg in males.) Also the lack of differences in PF between diapausing, postdiapause pre-reproductive, and reproducing individuals appears real. It is paralleled by the lack of differences in food consumption of postdiapause and new generation individuals of other species, e.g. *Hippodamia convergens* (Karner and Manglitz 1985).

Although the food quality and ambient temperature influence the digestibility of food (Merkel 1977; cf. Scriber and Lederhouse 1983), variation of PF from these sources will be probably small compared with variation caused by different food consumption. Nevertheless it appears difficult to transform directly the data on PF to predation rates, i.e. food consumption per unit time. Comparing populations of the same species, we should take into account that the faeces egested within 24 h at constant temperature may be accumulated over different time periods whose duration was determined by the weather (mainly temperature and insolation). Comparing different species, we should take into account that the rate of passage of the food through the alimentary canal could differ among the species. Thus 24 h starvation during the experiment incubation will affect more the species with a rapid passage of food through the alimentary canal than those with a slow one. In addition, acceptance of non-aphid food is perhaps universal among aphidophagous coccinellid adults. As yet we are not able to estimate the proportion of non-aphid items in different periods. Without additional information on the mechanism of digestion and its effects on predation, it appears impossible to convert PF to numbers or weights of aphids consumed per a given time (cf. Mills 1982).

However, PF may be perhaps used as a trace of the quantity of food consumption known from studies made by other methods. The known predation rates could be proportionate to PF, although the weight of faeces egested per 24 h will not be the same as the quantity of the remnants of the prey ingested per the same time. Assume that a *C. septempunctata* female from a "satiated" population may eat about 40 *Aphis fabae*/day (HONĚK 1985), and this consumption correspond to PF 0.97 mg/day (see 3.2). Using the data of 1985 (table), average food consumption of females from populations resident on herbaceous stands was calculated at 22.7–36.3 equivalents of *A. fabae*/day, in the period of reproduction (June–July). In pre-reproductive period (April–May) and pre-hibernation period (Aug.–Oct.), average female consumption was 7.4–20.6 equivalents of *A. fabae*/day. In males, the consumption in above periods could be estimated at 16.9–23.1 and 6.2–16.9 equivalents of *A. fabae*/day, resp. On trees in pre-reproductive period the consumption may be 28.0–30.9 and 19.0–23.9 equivalents of *A. fabae*/day in males and females, resp.

We observed specific differences in PF between the small *C. quinquepunctata* and the large *C. septempunctata* adults. These differences became apparent when PF per 1 mg of dry body weight of a coccinellid (specific PF) was calculated. Averages from original data at low aphid densities, and data predicted by regression lines for density of 1.0 aphids/cm^2 (see 3.2) were compared, in males. With abundance of ≤ 0.006 aphids/cm^2, specific PF in *C. septempunctata* was 0.021, in *C. quinquepunctata* 0.030, i.e. 1.43 times greater in the latter. With aphid abundance 1.0 aphids/cm^2 specific PF in *C. septempunctata* was 0.067, in *C. quinquepunctata* 0.053, i.e. 1.23 times greater in the former. The reversal of the ratio of specific PF at high aphid abundance was due to greater increase of PF with aphid abundance in *C. septempunctata* (slope of regression line 0.1805) than in *C. quinquepunctata* (slope 0.0358). These results (with reservations specified above) may indicate that *C. quinquepunctata* was the more effective predator than *C. septempunctata* at low aphid densities, while at high aphid densities the relationship of efficiencies of these species was the reverse. This result appeared concordant with our earlier observation that *C. quinquepunctata* tolerated low aphid density while *C. septempunctata* preferred a high one (HONĚK 1982).

Zusammenfassung

Zur Kotabgabe der aphidophagen Marienkäfer in Freilandpopulationen und ihre Verwendung zur Abschätzung der Prädationsaktivität

Es wurde die Kotabgabe der Imagines von aphidophagen Coccinellidenarten in Freilandpopulationen untersucht, wobei vorgegeben wurde, daß die Menge des abgegebenen Kotes in Beziehung zum Verbrauch der Beute steht. Direkt nach dem Fang im Freiland wurden die Männchen und Weibchen der Marienkäfer in Petrischalen 24 h bei 24 °C gehalten. Die durchschnittliche individuelle Kotproduktion im Laufe dieser Zeitspanne wurde dann festgestellt.

Die Beziehungen zwischen der Kotabgabe und der Populationsdichte der Blattläuse sowie auch die saisonalen und jährlichen Schwankungen der Kotabgabe wurden bei *C. septempunctata* untersucht. Bei niedriger Blattlausabundanz (≤ 0.005 Individuen/cm^2 Pflanzenoberfläche) war die Kotabgabe mit der Blattlausdichte nicht korreliert und hielt sich auf einem konstanten niedrigen Niveau. Bei größerer Blattlausdichte nahm die Kotabgabe proportional mit der Blattlausabundanz zu. Dort wo die Blattlausdichte größer war als 0.8 Indiv./cm^2, fanden die Marienkäfer ihre Beute offensichtlich im Überfluß. In solchen „gesättigten" Populationen betrugen die mittleren Kotabgaben beim Weibchen 0.97 mg und beim Männchen 0.67 mg pro Tag. Die Beziehungen zwischen der Kotabgabe und der Blattlausdichte änderten sich im Verlauf des Jahres nicht. Auch die Diapause und die Sexualaktivität wiesen keinen Einfluß auf. Die Kotabgabe in Freilandpopulationen schwankte aber sehr in Abhängigkeit von der Blattlausabundanz. Diese Schwankungen wurden im Jahre 1985 eingehend untersucht. Während der Brutperiode (Juni–Juli) hielt sich die mittlere Kotabgabe der Freilandpopulationen in einer Höhe von etwa 60–95 % derjenigen der oben genannten „gesättigten" Populationen, früher oder später in der Saison erreichte sie jedoch

nur 30–60 %. Ähnliche Beziehungen zwischen Kotabgabe und Blattlausabundanz wurden auch bei *C. quinquepunctata* festgestellt. Diese Art unterschied sich jedoch durch eine allmählichere Steigerung der Regressionslinie zwischen beiden Größen.

Eine direkte Umrechnung der Kotabgabe-Daten in die Daten der Prädationsaktivität ist ohne zusätzliche Experimente nicht möglich. Jedoch wurde versucht, eine vorläufige Schätzung der Prädationseffizienz im Freiland mit Hilfe der früher (Z. ang. Ent. *100*, 399) während der Verhaltensbeobachtungen von *C. septempunctata* gesammelten Daten zu erreichen. Die kleineren Arten, wie z.B. *C. quinquepunctata*, können vermutlich bei geringer Blattlausdichte effektiver sein als die größeren Arten wie *C. septempunctata*, während es bei hoher Blattlausdichte umgekehrt zu sein scheint.

References

Baumgaertner, J. U.; Frazer, B. D.; Gilbert, N.; Gill, B.; Gutierrez, A. P.; Ives, P. M.; Nealis, V.; Raworth, P.; Summers, C. G., 1981: Coccinellids (Coleoptera) and aphids (Homoptera). Can. Ent. *113*, 975–1048.

Chambers, R. J.; Sunderland, K. D.; Wyatt, I. J.; Vickerman, G. P., 1983: The effects of predator/exclusion and caging on cereal aphids in winter wheat. J. appl. Ecol. *20*, 209–224.

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

— 1985: Activity and predation of *Coccinella septempunctata* adults in the field (Col., Coccinellidae). Z. ang. Ent. *100*, 399–409.

House, H. L., 1974: Digestion. In: The physiology of Insecta. Ed. by Rockstein, M. Vol. 5. New York: Academic Press. pp. 63–117.

Karner, M. A.; Manglitz, G. R., 1985: Effects of temperature and alfalfa cultivar on pea aphid (Homoptera: Aphididae) fecundity and feeding activity of convergent lady beetle (Coleoptera: Coccinellidae). J. Kans. ent. Soc. *58*, 131–136.

Merkel, G., 1977: The effects of temperature and food quality on the larval development of *Gryllus bimaculatus* (Orthoptera, Gryllidae). Oecologia *30*, 129–140.

Mills, N. J., 1982: Satiation and the functional response: a test of a new model. Ecol. Ent. *7*, 305–315.

Scriber, M. J.; Lederhouse, R. C., 1983: Temperature as a factor in the development and feeding ecology of tiger swallowtail caterpillars, *Papilio glaucus* (Lepidoptera). Oikos *40*, 95–102.

Sota, T., 1985: Limitation of reproduction by feeding condition in a carabid beetle, *Carabus yaconinus*. Res. Popul. Ecol. *27*, 171–184.

Tanaka, K.; Ito, Y., 1982: Different response in respiration between predaceous and phytophagous lady beetles (Coleoptera: Coccinellidae) to starvation. Res. Popul. Ecol. *24*, 132–141.

Author's address: Dr. A. Honěk, Research Institute of Plant Production, Department of Entomology, 161 06 Praha 6-Ruzyně 507, Czechoslovakia

Population dynamics of *Saissetia oleae* (Oliv.) (Homoptera, Coccidae) on the olive tree[1]

By C. Pucci, M. Dominici, G. Prosperi and A. Forcina

Abstract

This study reports some data from periodic surveys of vegetation in a typical Umbrian olive grove (Central Italy) over a two-year period, 1983–84.
The descriptive analysis of the data shows that:
- the insect population present on leaves is always higher than that on twigs;
- the ratio between the number of living and dead insects increases with the age of the coccid even

---

[1] Research work supported by CNR, Italy. Special grant I.P.R.A. – Sub-project 1. Paper N. 781.

U.S. Copyright Clearance Center Code Statement: 0044-2240/86/0205-0476 $ 02.50/0
J. Appl. Ent. 102 (1986), 476–483

ISSN 0044-2240