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BIONOMY AND ECOLOGY OF *AMPHOROPHORA IDAEI* (BÖRN.) ON RASPBERRY

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Abstract: The bionomy and ecology of *Amphorophora idaei* (Bőrn.) on raspberry was studied under insectary conditions and in two rasberry farm plantations in 1997–2002. In 2001 and 2002 the development and fecundity of *A. idaei* under controlled conditions were also observed.

Key words: bionomy, ecology, *Amphorophora idaei*, raspberry, Poland

INTRODUCTION

Raspberry is widely cultivated on farm plantations, plots and in gardens. At present it is also popular crop grown near processing and refrigerating plants since raspberries are valuable maerial for jam, juice and chilled fruits production.

Poland is one of the major raspberry producer, taking almost 13% of the world's total output. The constantly growing competition on the world's market requires the producers to improve the quality of the fruit which is presently one of the major aims of the Polish program of raspberry cultivation (Danek 2002).

There are many pests contributing to reduction of crop and fruit quality on raspberry plantations in Poland. The most dangerous are the following species as: *Tetranychus urticae* Koch., *Byturus tomentosus* Degeer, *Anthonomus rubi* Herbst, *Resseliella theobaldi* Barnes and *Aphis idaei* v.d. Goot (Łabanowska and Gajek 2001).

Raspberry plants are also susceptible to virus diseases, the spread of which results mainly from reproduction the infected plants. Aphids also play a significant role in virus transmission. There are two aphid species on raspberry in Poland: *Aphis idaei* (Borowiak-Sobkowiak 2005) and *Amphorophora idaei* (Cichocka 1980). There is presently only limited information concerning their bionomy which hinders forecasting of the pest appearance and their control. The aim of this paper was to study the bionomy of *Amphorophora idaei* v. d. Goot, determination of a hatching time in the spring, the number of generations per season, the length of developmental periods as well as aphid fecundity in the individual generations. The field research was carried

out to estimate the increase of aphid infestation on raspberry productive plantations and minor crops located near the City of Poznań. Demographic factors of the studied species were determined by observation of aphids under controlled conditions.

MATERIALS AND METHODS

The research was carried out in insectary conditions in the garden of the Department of Entomology of the Agricultural University in Poznań in 1997–2002, and on two raspberry productive plantations in Poznań and Popkowice (near the City of Poznań). The bionomy of *A. idaei* was observed during five vegetation seasons in 1997–2001. For this purpose aphids were reared on isolated raspberry shoots. Individual wingless virginoparae were isolated under bolting-cloth. The first larvae gave origin to a new generation. Emerged females were transferred to a new isolator cage where their fecundity and the length of their individual developmental periods (prereproduction, reproduction and postreproduction) were observed. For each generation the development of five females was studied. Observations were carried out five times a week.

The fecundity and development of *A. idaei* under controlled conditions were studied in the 2001–2002 season. The aphids were reared in a climate chamber at constant temperature of 20°C and relative air humidity of 70%. To determine the demographic parameters of aphid populations the development of 100 larvae was observed, assessing larvae and adult mortality and longevity. Fecundity was determined on the basis of observation of 30 females.

A level of aphid infestation was estimated in raspberry productive plantations. A hundred shoots of each raspberry species was selected at random, noting down the number of adults and larvae. The survey was carried out in monthly intervals from spring to autumn.

RESULTS AND DISCUSSION

Large raspberry aphid (*A. idaei*) has a pale-green or green body. In the summer their bodies can also be light, pale-yellow and pale-pink. The specimens of this species tend to be large. Body length of the wingless virginoparae is on average 3.29 mm, while that of oviparous aphids – 3.05 mm and males – 2.58 mm, on average. Most often this species settles individually young shots or raspberry leaves. Small colonies are set up by a single virginoparae and the larvae born by them.

In Polish conditions the fundatricae of *A. idaei* hatched at the end of March and the beginning of April. The earliest larvae were recorded on March 3, 1998. The percentage of fundatricae larvae hatching was large and amounted to 70%.

In subsequent years of the research the development of 8–10 generations of *A. idaei* per plant growth season was observed. First winged virginoparae of the large raspberry aphid appeared at the end of April which was in the first generation of funadtrigeniae (Table 1). The longest pre-reproductive period occured in fundatrices. This period was shortened in the subsequent summer generations and then in the autumnal generations again prolonged (Fig. 1).

The length of the pre-reproductive period was changeable in various generations and years of observation. Only in the 1999 plant growth season its length in the fundatricae generation was longer than in females of the remaining generations (Fig. 2).

Females of the fifth generation in the 2000 plant growth season took the longest time to be born (39 days).

Table 1. Time of subsequent generations of *Amphorophora idaei* rearing uder insectary conditions in 1997–2000

Year	Generation								
	I	II	III	IV	V	VI	VII	VIII	IX
wingless virginoparae aphids									
1997		18.06	23.06	8.07	16.07	25.07	12.08	25.08	15.09
1998	3.03	23.04	11.05	31.05	16.06	7.07	30.07	31.08	
1999	20.04	7.06	17.06	2.07	14.07	2.08	23.08	13.09	
2000	2.04	24.04	8.05	29.05	12.06	14.07	1.08	21.08	11.09
winged virginoparae aphids									
		I	II	III					
2000		24.04	10.05	29.05					

The post-reproductive period usually ranged from 1 to 5 days however, even a 20-day aging phase was observed (Fig. 3). The highest fecundity was usually found in females of the second generation (Table 2).

Table 2. Fecundity of parthenogenetic of the *Amphorophora idaei* subsequent generation uder insectary conditions in the 1997–2000 growing season

Year	Number of born larvae								
	generation								
	I	II	III	IV	V	VI	VII	VIII	IX
wingless virginoparae aphids									
1997		28.4 (7–69)	40.2 (25–80)	67.6 (5–154)	67.6 (28–115)	44.2 (6–74)	52.8 (32–83)	26.6 (11–42)	6.7 (0–7)
1998	36.8 (27–54)	47.6 (34–60)	28.2 (18–38)	30.6 (9–49)	14.6 (6–30)	11.2 (2–25)	12.4 (2–21)	12.2 (9–16)	
1999	63 (12–105)	49.4 (6–91)	32.2 (9–58)	49.6 (28–76)	20.4 (3–29)	15.4 (8–24)	10.4 (2–23)	14.4 (7–19)	
2000	43.2 (28–53)	50.2 (18–83)	19.2 (11–24)	11.8 (5–27)	29.4 (5–89)	28.6 (6–47)	26.8 (11–44)	26.6 (19–39)	25.6 (2–44)
winged virginoparae aphids									
2000	26.4 (7–39)	24.6 (10–43)	6.6 (2–13)						

The maximum fecundity per single aphid was 154 larvae. Only in 1999, the fecundity of the fundatrices exceeded that of the virginoparae of the following generations (Fig. 4). While comparing the fecundity of females of subsequent generations, it decreased the most often in the last generations, that was particularly visible during the 1997–1999 plant growth seasons (Fig. 4).

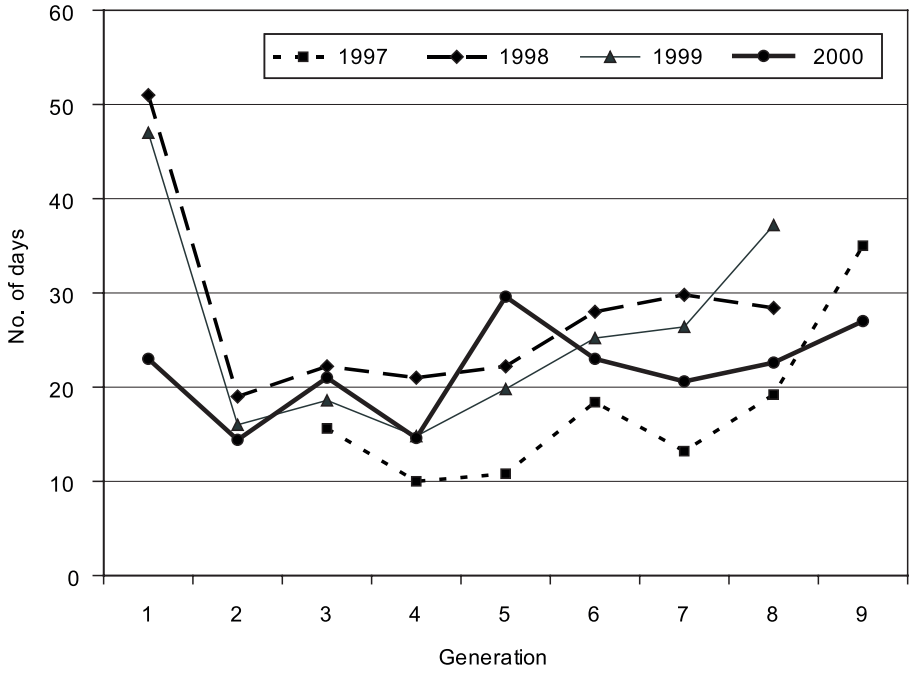

Fig. 1. Average length of pre-reproduction period of virginoparae of subsequent generations of *Amphorophora idaei* in 1997–2000

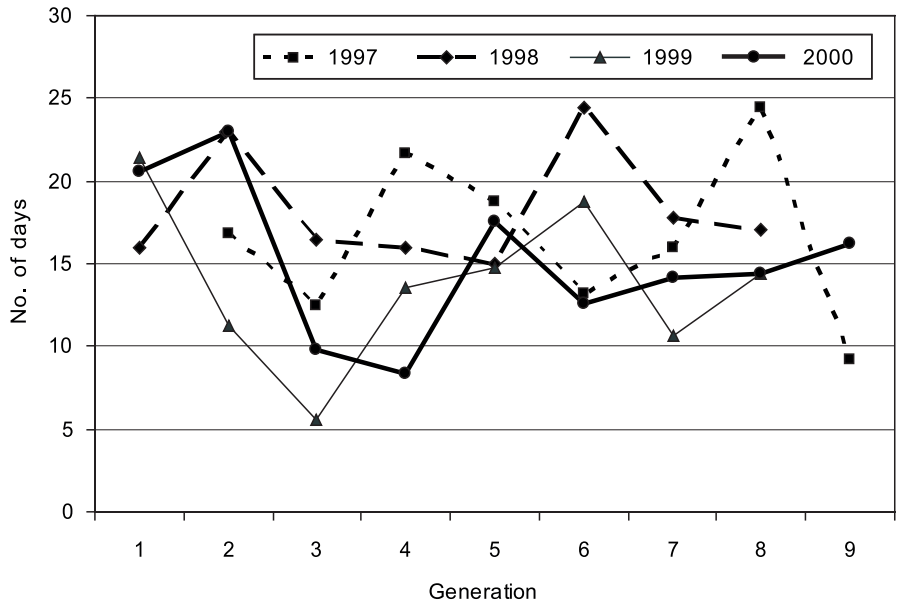

Fig. 2. Average length of reproduction period of virginiparae of subsequent generations of *Amphorophora idaei* in 1997–2000

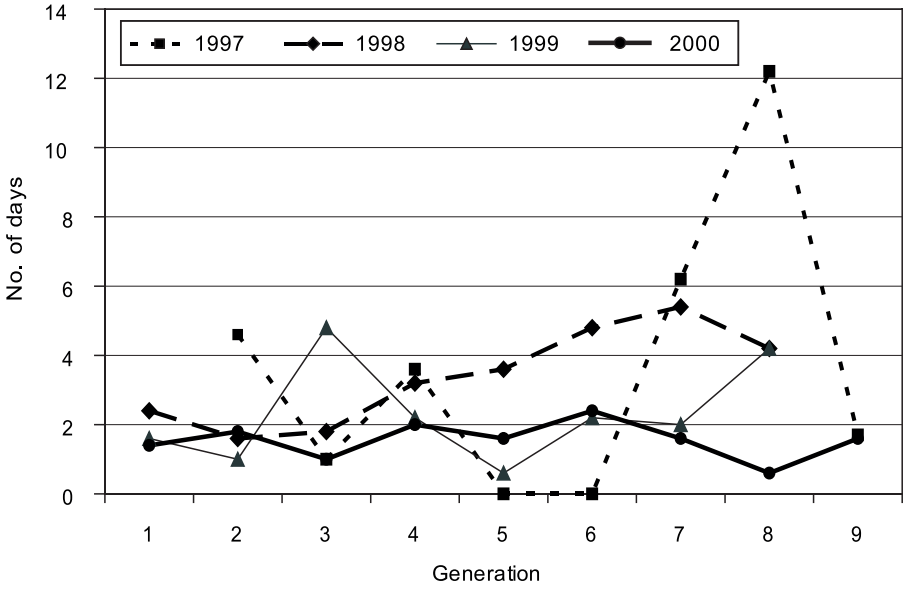

Fig. 3. Average length of post-reproduction period of virginoparae of subsequent generations of *Amphorophora idaei* in 1997–2000

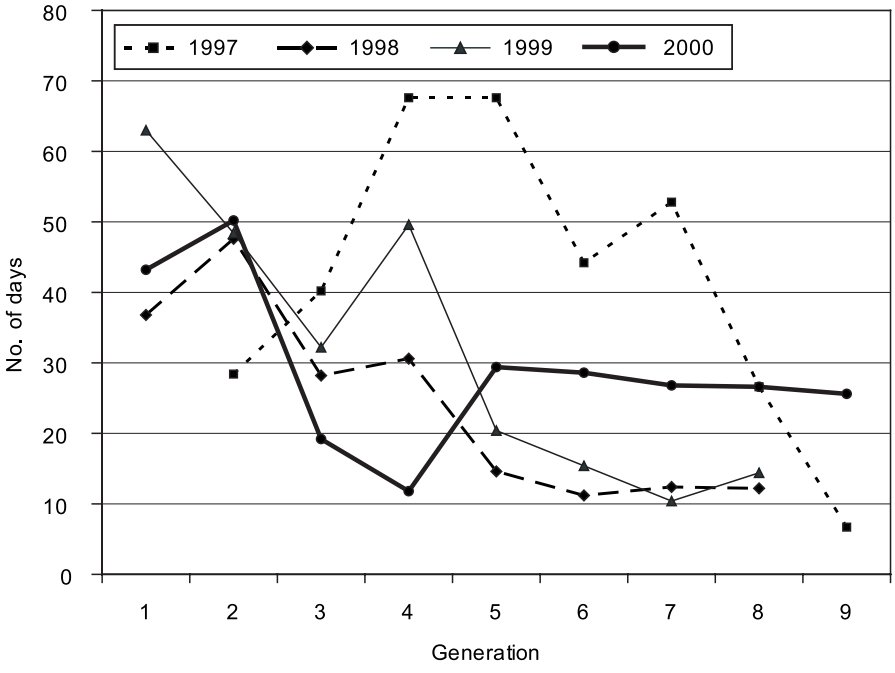

Fig. 4. Average fecundity of wingless virginoparae and winged morphs of *Amphorophora idaei* under insektary condition in 1997–2000

Observations on sex of offspring of the sexuparae females of *A. idaei* did not provide explicit results. The females of the sexuparae generation usually born virginoparae, then males and finally oviparous females. Also females that gave the birth to oviparous females only and females which first gave the birth to males and then to oviparous females or virginoparae or males were observed. In late autumn specimens which gave the birth exclusively to virginoparae females were recorded in the plantations (Table 3).

Table 3. Fecundity of parthenogenetic of the *Amphorophora idaei* sexuparae generation and succession of giving birth to larvae of sexual generation under insectary condition in the 2000 season

Date of larvae birth	Replication						
	1	2	3	4	5	6	7
2.10.2000			10♀v			10 ♀v	
3.10.2000			5 ♀v			10 ♂	5 ♀v
4.10.2000		4 ♀o	1 ♂				6 ♂
5.10.2000		2 ♀o	4 ♂			2 ♀o	
6.10.2000		4 ♀o	1 ♂				7 ♂
9.10.2000		5 ♀o	1 ♂	1 ♀v	1 ♀v	5 ♀o	8 ♀o
11.10.2000		2 ♀o	4 ♂	6 ♀v	1 ♀v		6 ♀o
13.10.2000		8 ♀o	3 ♂				4 ♀o
16.10.2000	5 ♂	8 ♀o	3 ♂	3 ♂			
17.10.2000	2 ♂	1 ♀o	4 ♂				
19.10.2000	3 ♂	1 ♀o	1 ♂				
24.10.2000	5 ♂	4 ♀o	7 ♂	5 ♀o			
26.10.2000	3 ♂	1 ♀o					
30.10.2000	3 ♀o	1 ♀o					
2.11.2000	3 ♀o						
6.11.2000	1 ♀o						
9.11.2000	1 ♀o						
No. born larvae	26	41	44	15	2	27	36
No. oviparous females	8	41	0	5	0	7	18
No. males	18	0	29	3	0	10	13
No. virginoparae	0	0	15	7	2	10	5

♀o – oviparous females
♀v – virginoparae females

The ratio of oviparous females to males was 1:1. On the basis of dissection of 50 females, it was found out that oviparous female fecundity was 2–12 eggs.

Data on survival, length of given developmental stages and fecundity of large raspberry aphid was collected in experiment carried out under control conditions.

Low larvae mortality was observed since as much as 75% of the experimental population reached maturity (Fig. 5). The reproductive period, which began on the 13th day of the females' life, lasted as long as 48 days.

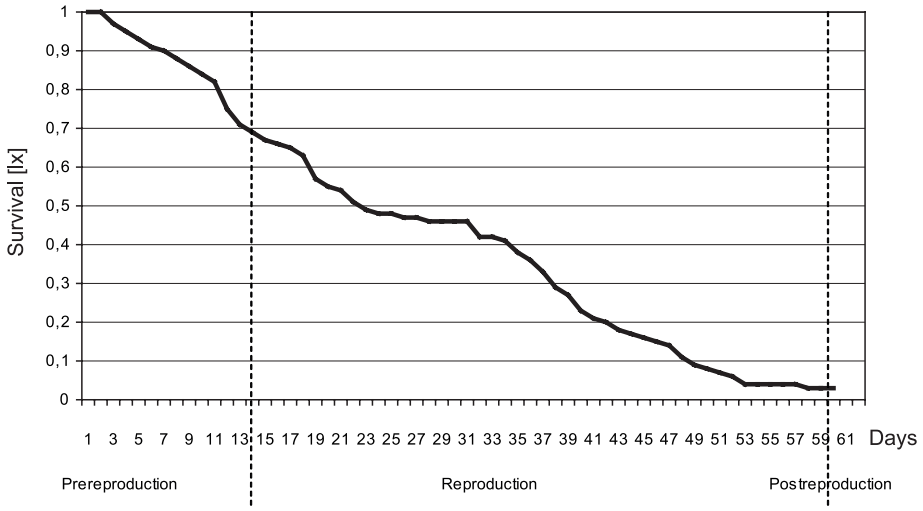

Fig. 5. Survival of *Amphorophora idaei* population under controlled conditions

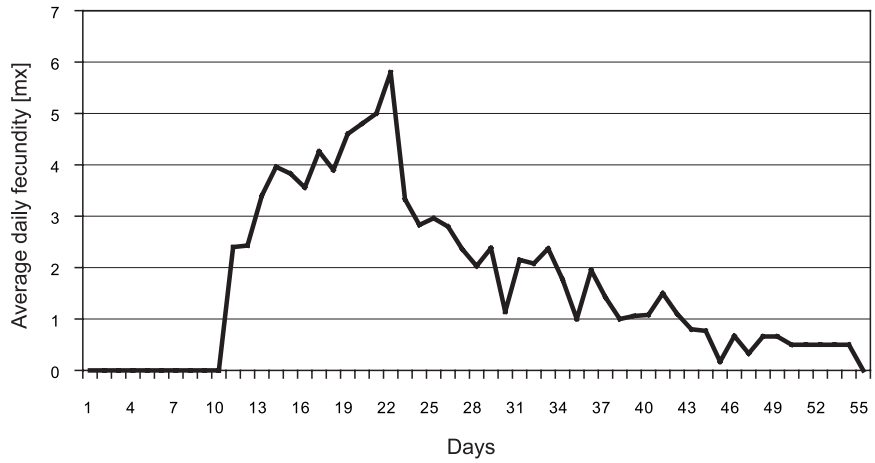

Fig. 6. Fecundity of *Amphorophora idaei* wingless virginoparae under controlled conditions

Wingless virginoparae reached the greatest mean daily fecundity which was equal to 5.8 larvae per female on the 23rd day of their life (Fig. 6).

A comparison was drawn between the development and fecundity of *A. idaei* spring and summer generation developing under controlled conditions. Different biotic potential of aphids of the two generations was recorded. Pre-reproductive and reproductive periods were longer in aphids of the spring generation. Aphids of the spring generation were characterized by higher fecundity (Table 4).

Table 4. Length of developmental stages and fecundity of virginoparae of the spring and summer *Amphorophora idaei* generation under controlled conditions

Year	Replication	Phase length in days				Fecundity – number of larvae
		prereproduction	reproduction	postreproduction	overall longevity	
Spring generation						
2002	1	10	22	2	34	76
2002	2	6	21	3	30	83
2002	3	6	35	5	46	76
2002	4	9	32	1	42	94
2002	5	9	25	3	37	66
Average		8	27	2.8	37.8	79
Summer generation						
2001	1	6	23	5	34	82
2001	2	6	30	1	37	90
2001	3	6	23	9	38	76
2001	4	6	23	1	30	76
2001	5	6	14	1	21	56
Average		6	22.6	3.4	32	76

On the basis of demographic parameters of the *A. idaei*, calculated from bionomic parameters, it follows that during one day their population increased 1.26 times. Development time of one generation was equal to 19.09 days during which the population increased 80.67 times. Under constant temperature of 20°C the inborn tempo of population increase was 0.2299 ♀/♀ a day (Table 5).

Table 5. Demographic parameters of *Amphorophora idaei* population

Species	r_m	Ro	T	λ
Amphorophora idaei	0.2299	80.67	19.09	1.26

r_m – intrinsic rate of population increase
Ro – net rate of reproduction
T – mean generation time
λ – finite rate of population increment

On the raspberry plantation at the Hulewiczów Street in Poznań, aphids settling raspberry plants was highest in 2000 and 2001 as compare to 1997, 1999 and 2002 seasons (Table 6). When analyzing the number of aphids in a given plant growth season it was found out that most aphids occurred usually in September and October (Figs. 7 and 8). The 2002 season was unusual with this respect as the most aphids occurred in July (Fig. 9). On the other raspberry plantation at Popkowice, the degree of aphid infestation on various raspberry cultivars was compared. It was found out that *A. idaei*

was most numerous on the Veten cultivar (Fig. 10). On the Beskid cultivar population of *A. idaei* was not numerous only in the 2002 season (Fig. 10). No aphids were recorded on the Polana cultivar.

Table 6. Number of *Amphorophora idaei* in productive raspberry plantation in Poznań at Hulewiczów Street in season 1997, 1999–2002

Year	*Amphorophora idaei* (No. individuals)
1997	236
1999	150
2000	2.692
2001	1.209
2002	927

The observations referring to *A. idaei* bionomy were previously carried out in Finland by Rautapää (1967a, b). There Rautapää bred seven generations, while in Poland more generations, i.e. 8–10 occurred. First winged virginoparae of the large raspberry aphis were recorded in my studies at the end of April, as opposed to Janiszewska (1963) and Cichocka (1980), who observed winged morphs as late as in June.

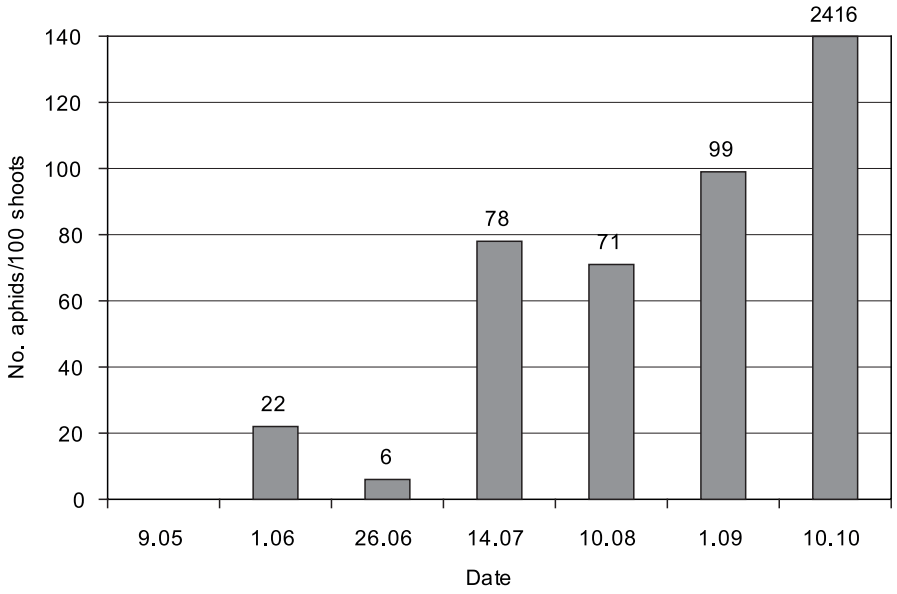

Fig. 7. *Amphorophora idaei* in the productive raspberry plantation in Poznań at the Hulewiczów Street in the 2000 season

The sexual generation of *A. idaei* appeared at the beginning of October. Oviparous females lived much longer (52 days on average) then males (31 days on average). Rautapää (1967a) observed first males of the species as early as at the end of August.

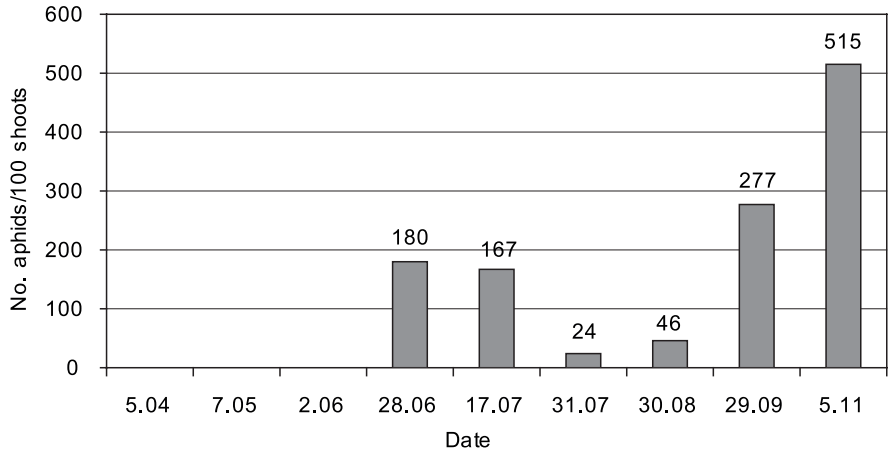

Fig. 8. *Amphorophora idaei* in productive raspberry plantation in Poznań at the Hulewiczów Street in the 2001 season

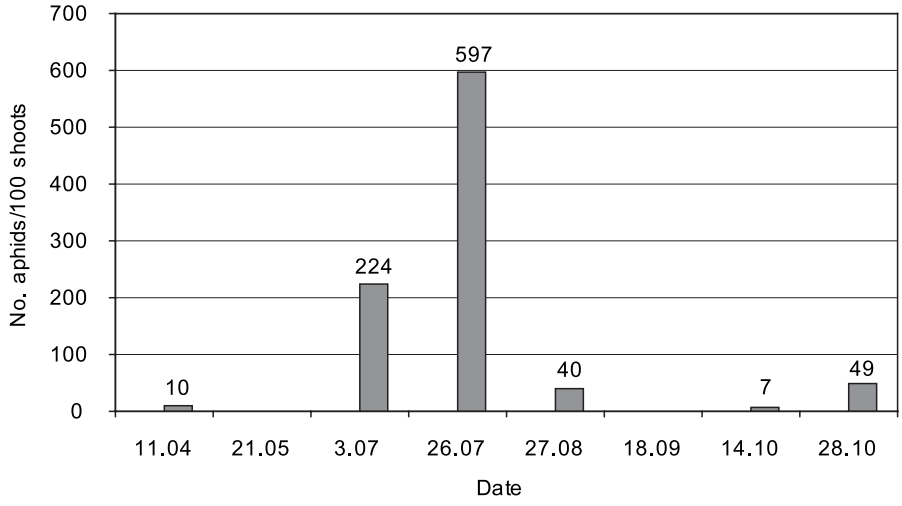

Fig. 9. *Amphorophora idaei* in the productive raspberry plantation in Poznań at the Hulewiczów Street in the 2002 season

Under Polish conditions the highest fecundity was found usually in females of the second generation. The maximum fecundity was 154 larvae. In Finland the highest fecundity was found usually in females of the fifth generation (39.4 larvae on average), whereas the lowest – in females of the second generation (16.3 larvae on average).

The results concerning the sex of the offspring of the sexuparae generation females confirmed the earlier observations made by Rautapää (1967a). Analyzing the offspring of the sexuparae generation *A. idaei* females, Rautapää observed the following order of their appearance: virginoparae females came first and males and oviparous females as the second. Above author claimed also that some of the females gave the birth to virginoparae or oviparous females exclusively.

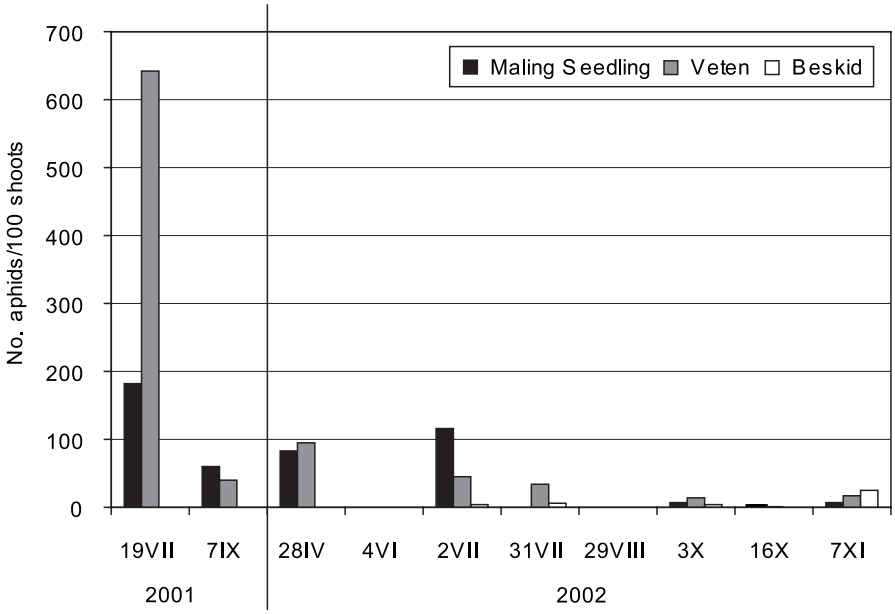

Fig. 10. Infestation of three raspberry cultivars by *Amphorophora idaei* in the productive plantation at Popkowice in the 2001 and 2002 seasons

As a result of our observations carried out in autumn it was found out that the ratio of oviparous females to males approached 1:1. Rautapää (1967a) obtained different results in his research, claiming that there were overwhelmingly more females than males as the ratio was 12:1.

On raspberry farm plantations, *A. idaei* settled the Veten cultivar in greatest number while Beskid cultivar was occupied in significantly lower extent. These observations correspond with the results of research by Danka and Pasiuta (1991), who point out small susceptibility of the Beskid cultivar to the large raspberry aphid infestation.

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POLISH SUMMARY

BIONOMIA I EKOLOGIA *AMPHOROPHORA IDAEI* (BÖRN.) NA MALINIE

Badania dotyczące bionomii *Amphorophora idaei* prowadzono w latach 1997–2002, w ogrodzie Katedry Entomologii Akademii Rolniczej w Poznaniu. Obserwacje prowadzono również na dwóch plantacjach produkcyjnych, gdzie określono nasilenie występowania mszyc na różnych odmianach malin.

Celem badań było poznanie bionomii *A. idaei*, ustalenie terminu wylęgu mszyc z jaj wiosną, wykazanie liczby pokoleń w sezonie, długości rozwoju, a także ustalenie płodności mszyc poszczególnych pokoleń.

Ustalono 8–10 pokoleń tej mszycy w sezonie. Okres prereprodukcyjny najdłuższy był z reguły u założycielek rodów. Okres postreprodukcyjny wynosił najczęściej od 1 do 3 dni. Najwyższą płodnością charakteryzowały się z reguły samice drugiego pokolenia. Samice pokolenia sexuparae rodziły dzieworódki, później samce, a następnie samice amfigoniczne. Obserwowano także samice, które rodziły tylko samice amfigoniczne lub dzieworódki, ale też takie, które najpierw rodziły samce, później samice amfigoniczne lub dzieworódki i samce.

Z obliczonych parametrów demograficznych populacji *A. idaei* wynika, że w czasie jednego dnia populacja tej mszycy powiększała się 1,26 razy. Czas rozwoju jednego pokolenia wynosił 19,09 dni i w tym czasie populacja powiększała się 80,67 razy.

Na plantacjach produkcyjnych malin mszyce występowały w niewielkim nasileniu ze względu na stosowane zabiegi ochrony roślin. Na badanych odmianach malin, największe nasilenie *A. idaei* notowano na odmianie Veten, a najmniejsze na odmianie Beskid.