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The process of aphid egg-laying and the little known role of the Coccinellidae in aphid egg destruction in Poland – preliminary results

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Abstract: No detailed studies have been conducted in Poland with regard to aphid eggs or egg survival in particular. So far, no studies have been conducted concerning the role of ladybird beetles in reducing the number of aphid eggs in spring, before the development of leaves, and in autumn, after the leaves have been shed. At these times, other developmental stages of aphids are unavailable as food for the ladybirds. The paper presents the preliminary results of a three-year study on the process of aphid egg-laying (especially *Chaetosiphon tetrarhodum, Macrosiphum rosae, Metopolophium dirhodum*, and *Maculolachnus submacula*). The paper also deals with the little known role of ladybirds in aphid egg destruction. Research was conducted in Otrębusy (Western Mazovia), Poland, in the years 2008–2010, on the rugosa rose and on the dog rose. In the years 2011–2013, in Otrębusy, the occurrence of *M. submacula* was also observed on the ornamental grandiflora rose. Furthermore, in the years 2003–2004, observations were conducted on the pedunculate oak in Polesie National Park and in the town of Puławy (Lublin Region), Poland. The observations which took place in Puławy focused on egg-laying of aphids representing the genera *Phylloxera* and *Lachnus*. The study investigated aphid oviposition sites. Data was collected on the number of aphid eggs noted on the studied plants. The study also showed, that sometimes winter eggs of aphids could provide nutrition for ladybirds. This was especially true in autumn when ladybird beetles were preparing for hibernation.

Key words: aphid egg destruction, aphid eggs, egg-laying process, ladybirds

Introduction

Aphid eggs are usually overwintering eggs laid by oviparous females (Blackman and Eastop 1994). However, in the subfamilies Phylloxeridae and Adelgidae all generations are oviparous (Heinze 1962; Müller 1976). No detailed studies have been conducted in Poland with regard to aphid eggs or egg survival. So far, other studies have investigated species composition and bionomy of aphids on those plants which a particular study focused on. Where and how many eggs were laid by oviparous females on the plants were only what was noted (Karczewska 1964, 1965, 1969; Huculak 1966; Goszczyński and Cichocka 1978; Cichocka 1980, 1984, 1995, 2007; Barczak 1986; Cichocka and Goszczyński 1991; Barczak *et al*. 1996; Cichocka and Jaśkiewicz 2003; Wilkaniec and Borowiak-Sobkowiak 2003; Wilkaniec *et al*. 2003; Goszczyński and Osak 2007; Lubiarz 2007a, b). In some studies, isolated pieces of information can be found regarding the effect of low temperatures on that developmental stage. So far, no studies have been conducted into the role of ladybird beetles reducing the number of aphid eggs in spring, before the development of leaves, and in autumn, after the leaves have been shed, when other developmental stages of aphids are unavailable as food for ladybirds. On the other hand, much data is available with respect to predation of ladybird larvae and adult ladybirds on mobile stages of aphids, especially in spring and summer. There is also a lot of information available about the possibilities of using ladybird beetles in biological control (Olszak 1974; Hodek and Honěk 1996; Obrycki and Kring 1998; Dixon 2000; Van Emden and Harrington 2007; Mrówczyński and Wachowiak 2009; Obrycki *et al*. 2009; Gospodarek 2012). The role of ladybird beetles as predators of insects other than aphids has also been described by Hodek and Honěk (2009) and Evans (2009).

Olszak (1974) noted that *Coccinella septempunctata* Linnaeus 1758, *Adalia bipunctata* (Linnaeus 1758) and *Propylea quatuordecimpunctata* (Linnaeus 1758), occurring in large numbers in orchards during the autumn, fed on the bisexual aphid generation. But Olszak (1974) did not provide information on how long the ladybirds remained on the orchard trees and whether they were interested in aphid eggs. He noticed, however, that the number of ladybirds in an orchard in autumn might even equal 60,000 individuals per 1 ha. Cichocka (1995) noted that ladybird beetles might appear in apple orchards in autumn and destroy oviparous females. Thus, the number of laid winter eggs would be reduced.

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In autumn, oviparous aphid females usually lay eggs on young shoots which are in close proximity of the buds of trees and shrubs as well as on scars left by shed leaves and twigs that have been cut. Sometimes eggs are laid in bark crevices on thick tree branches or even on the tree trunk. There is no rule that a particular aphid species lays eggs in a specific area of a plant. What is more, aphids differ both with respect to the time of egg-laying and the number of laid eggs (Karczewska 1965, 1969; Smolarz 1969; Cichocka 1980).

According to Cichocka (1980, 1995), weather conditions affect the process of egg-laying in aphids. She noted that the number of winter eggs laid by aphids was the highest in the years when rainfall was temperate, and when average July and August temperatures amounted to about 20°C. According to Karczewska (1964, 1969), a warm and dry autumn was conducive to egg-laying, whereas a cool and comparatively wet autumn resulted in a considerably lower number of laid eggs.

The largest number of observations regarding aphid egg-laying, focused on orchard trees and shrubs. However, collected data usually referred to the location where eggs were laid and rarely to the time and duration of the process.

Rhopalosiphum insertum (Walker 1849) lays eggs on thick apple-tree branches and even on the trunks, deep in bark crevices. The eggs can also be found in growth rings of apple trees. *Dysaphis radicola* Mordvilko 1897 also lays eggs on the trunks of apple trees (Cichocka 1980). Egg--laying by oviparous females in the second half of October and the first half of November was observed by Karczewska (1965). During a similar period, the same author also observed the process of egg-laying by *Dysaphis plantaginea* (Passerini 1860), while oviparous females of *D. radicola* moved downwards along tree trunks and hid in bark crevices (Karczewska 1965). The aphid species *Aphis pomi* De Geer 1773 lays eggs on apple trees, earlier than any other species, beginning already at the break of September and October. A female lays from one to four eggs, exclusively on thin apple-tree branches (Karczewska 1965; Cichocka 1980). Egg-laying of *A. pomi* has also been studied in Lithuania (Rakauskas and Rupais 1983). On the other hand, *Dysaphis plantaginea* (Passerini 1860) begins laying eggs in October and continues until the first days of November. Most eggs are laid in the lower parts of the tree crown. The time of egg-laying depends on the weather conditions in respective years (Huculak 1966). Sometimes egg-laying begins as early as towards the end of September, while in other years it begins not earlier than during the third week of October (Karczewska 1969). Egg-laying can last until the first days of November. Cichocka (1984a) noted, that in poorly maintained orchards the number of aphid eggs found on trees was always lower, as during the whole vegetation season a high number of predators were present. In a well-maintained orchard the predators would be destroyed by spraying. On apple trees, the most numerous bisexual generation was observed in the case of *R. insertum*. The number of eggs laid on apple trees depends on the time of the appearance of the gynoparae, the occurrence of ground frost, and the time of leaf shedding (Karczewka 1964). It was noted by Cichocka (1995), that early occurrence of ground frost in autumn destroyed not only oviparous females but also freshly laid eggs. Only after a lapse of 6–7 days from the laying of an egg, does the presence of ground frost not matter. *A. pomi* lays eggs almost a month earlier than other aphid species living on apples trees, thus, its eggs are rarely destroyed by ground frost (Cichocka 1995).

From mid-September until the occurrence of ground frost, *Hyalopterus pruni* (Geoffroy 1762) lays eggs on one--year-old and two-year-old, plum-tree shoots. A female lays from two to five eggs. Unfertilised females do not lay eggs and die out (Smolarz 1969).

From the second half of September until the end of October, *Brachycaudus cardui* (Linnaeus 1758) and *Brachycaudus helichrysi* (Kaltenbach 1843) lay eggs on plum-tree shoots near buds. Freshly laid eggs are green but after a few days they become black and very shiny. Still in autumn, fundatrix larvae hatch from some of the eggs laid by *B. cardui*. Then the aphids overwinter in the first larval stage, usually next to egg cuticles (Cichocka 1980).

As for the freshly laid eggs of *Phorodon humuli* (Schrank 1801), they are also green but after several days become dark brown. This aphid species is the most fertile one among those encountered on plum trees. An oviparous female lays from four to 14 eggs (Cichocka 1980).

Until the end of November, *Myzus cerasi* (Fabricius 1775) lays eggs on cherry trees and sweet cherry trees, one egg at a time, beside buds. One female can lay from one to seven eggs (Cichocka 1980).

Eriosoma ulmi (Linnaeus 1758), *Eriosoma lanuginosum* (Hartig 1839), *Pemphigus bursarius* (Linnaeus 1758), and *Pemphigus spyrothecae* Passerini 1860 lay eggs in the bark of the trunk and thick branches of an elm (Goszczyński and Cichocka 1978; Cichocka 1984). Males and females from the bisexual generation produced by the same female, are called sexupara (Cichocka 1984). After copulation, an oviparous female lays a single egg. In *E. ulmi* the egg fills the whole body of a female. It may happen that the female will die without previously laying the egg. Eggs covered by the bodies of the dead females have the best chances of surviving winter, and the highest numbers of fundatrix larvae hatch from them in spring (Janiszewska--Cichocka 1970; Cichocka 1984). In *E. ulmi*, fundatrix larvae hatch in spring from only 30% of eggs laid in autumn. In 1965, out of 83 observed eggs, only 24 larvae hatched in spring. Out of 72 eggs observed in the following year, only 19 hatched. Just before hatching, the eggs swelled and became shiny. The cuticle burst on one of the egg tips to up to 1/3 of the egg length. The highest percentage of mortality was observed among the earliest laid eggs. No ladybird beetles were observed on elm trunks near the overwintering eggs. However, in the course of one year of the study, it was observed that a freshly laid egg was being sucked out by a predatory mite from the family Bdellidae. Those mites did not forage on aphid eggs which were several days old, probably because the egg cuticle had become harder by then and they were unable to prick it (Janiszewska-Cichocka 1970).

Goszczyński and Cichocka (1978) noted that oviparous females of *Pemphigus phenax* Börner and Blunck 1916

gave birth to 2–20 larvae of the bisexual generation, on the bark of poplar trunks. Larvae of amphigonic females were born first, followed by male larvae. The ratio of females to males was 3 : 1. The bisexual generation could be observed from mid-September to mid-November. The hatched egg was nearly the same size as the female and filled its whole body. Freshly laid eggs were dark yellow. After several days they darkened even more and became dark brown. The eggs were 0.49–0.52 mm long and 0.27––0.31 mm wide (Goszczyński and Cichocka 1978).

Barczak (1986) observed that *Aphis fabae* Scopoli 1763 laid eggs on European spindle, usually in groups of over a dozen eggs, but, in some cases, eggs were laid separately. The eggs were mostly placed in the corners of leaf buds and on young shoots. The number of eggs laid by that aphid species ranged from 0.1/10 cm of a shoot to 12.1/10 cm of a shoot depending on the location where the respective European spindles grew. Similar data were obtained by Barczak (1986), who studied aphids on the guelder rose. On that host plant, the average number of eggs laid by *A. fabae* ranged from 1.3 to 8.6.

Gałecka (1986) noted that *Aphis frangulae* Kaltenbach 1845 laid, on average, 0–0.9 egg/shoot of the alder buckthorn. The lowest number of eggs was noted in environmentally degraded areas of Silesia.

Dysaphis crataegi (Kaltenbach 1843) overwinters as eggs in crevices of the bark on trunks and thick branches of hawthorn trees. Freshly laid eggs are yellow-green and after 5–6 days darken and become green-black. Their surface is covered with wax powder from the abdomen of females (Goszczyński and Cichocka 1978). Goszczyński and Osak (2007) observed *Aphis sambuci* Linnaeus 1758 laying eggs in bark crevices of elderberry branches.

In private gardens of Mazovia, Cichocka (2007) observed larvae of oviparous females of *M. cerasi* moving onto young sweet cherry shoots, where they matured and waited for the appearance of alate males. After copulation, the females laid up to eight eggs on the shoots, next to buds, in bark crevices or on scars left by shed leaves.

Sometimes aphids lay winter eggs on plants which are untypical for them. An example of this was *Myzus persicae* Sulzer 1776 which laid eggs on a wild black cherry. Four to five well-developed eggs were found in the bodies of oviparous females (Wilkaniec and Borowiak-Sobkowiak 2003).

The first aim of the study was to gain insight into the number of eggs laid by aphids on the studied plants (pedunculate oak, dog rose, rugosa rose, tree rose, grandiflora rose). The second aim was to check whether winter eggs of aphids could be a source of nutrition for other arthropods, especially ladybird beetles.

Materials and Methods

Egg-laying by aphids was observed from mid-September to mid-November in the years 2008–2010, in Otrębusy on the rugosa rose (*Rosa rugosa* Thunb.) and on the dog rose (*Rosa canina* L.). In the years 2011–2013, the occurrence of *Maculolachnus submacula* (Walker 1848) on the ornamental grandiflora rose (*Rosa* cv.) was also observed in Otrębusy. Studied roses were planted next to one another so that their branches could touch; each rose species was represented by two plants. From the moment when the first oviparous females appeared, they were observed with respect to their numbers on each rose species, place and number of laid eggs, and the length of the egg-laying period. Leaf shedding was an important phenomenon from the point of view of the study, since eggs were no longer laid by aphids on those rose plants which had shed their leaves. The occurrence of ground frost and the effect ground frost had on autumn generations of aphids was also noted. As the rose plants grew in a private garden, it was possible to conduct regular observations (and notice the occurrence of ladybird beetles). Shoots of the studied roses were divided into 10-cm sections. From each plant, ten 10-cm shoot sections were chosen at random and aphid eggs found on them were counted. The easily distinguishable eggs of *M. submacula*, visibly larger than eggs of the other aphid species laid on the studied rose plants, were counted separately. Mean values from the respective years are given in the tables. Student's t-test was used to check whether differences between the mean values were statistically significant ($p = 0.05$). Simultaneously, the occurrence of the Coccinellidae and their foraging on aphid species were observed. The studied rose plants were observed for 3–5 h using a magnifying glass to note the appearance of ladybird beetles and the beetles' foraging on the eggs. Whenever the beetles did appear, the plant was observed continuously to find out whether they foraged on the aphid eggs. When the ladybirds finished foraging and left the plant either by flying off or walking off, the destroyed eggs were counted. In spring, marked groups of laid eggs were inspected before bud bursting, and again the occurrence of ladybird beetles was noted.

In the years 2003–2004, as part of the present study, observations were also conducted also on the pedunculate oak (*Quercus robur* L.) in Polesie National Park and in Puławy, in Poland. The observation focused on egg-laying of aphids representing the genera *Phylloxera* and *Lachnus*. In the case of *Phylloxera* sp. observations encompassed nearly the whole vegetation season, since all generations of aphids of the family Phylloxeridae were oviparous (Müller 1976; Lubiarz 2007a). The number of eggs surrounding the body of a single female specimen of the genus *Phylloxera*, was counted. In the case of *Lachnus* sp., the time of the occurrence of oviparous females was observed as well as the number of eggs laid by those morphs. Shoots of the studied pedunculate oaks were divided into 10-cm sections. From each plant, ten 10-cm shoot sections were chosen at random and aphid eggs found on them were counted. The mean values from the respective years are given in the tables. Student's t-test was used to check whether differences between the mean values were statistically significant ($p = 0.05$). Additionally, observations were conducted with regard to ladybird foraging on the laid eggs. Population dynamics and some data referring to bionomy of aphids on the pedunculate oak was provided by Lubiarz (2007a, b).

Results and Discussion

Eggs laid by aphids both on the pedunculate oak and the rose plants, had a viscous surface and therefore stuck to

the ground. Several hours after being laid they lost the viscosity and usually changed colour.

Aphids of the genus *Phylloxera* observed on the pedunculate oak, belonged to two species: *Phylloxera coccinea* (von Heyden 1837) and *Phylloxera gabra* (von Heyden 1837) (Lubiarz 2007a). Aphids from summer generations observed by the authors, were very small and their body lengths ranged from 0.7 to 1.2 mm. On leaves, alate and non-alate oviparous females of those species laid yellow eggs which surrounded the females like a wreath (Fig. 1). Similar observations had been made by Börner and Heinze (1957) and Cichocka *et al*. (1990). From two to 121 eggs could be observed around the body of an oviparous female. The number of observed eggs was the highest in 2003 (Table 1). Females preferred oak leaves attacked by *Erysiphe alphitoides* (Briffon & Maubl.). They were also likely to hide under spider webs together with mites of the families Tetranychidae and Phytoseiidae. In urban conditions of Warsaw, Cichocka and Goszczyński (1991) observed from 20 to 89 eggs surrounding a female, i.e. 49, on average.

On 22 October 2004, six females laying eggs in the oak bark were found. Still in October, fundatrix larvae hatched from those eggs and overwintered. Egg-laying lasted until mid-November.

Ladybird beetles were practically absent from the proximity of oviparous females of the genus *Phylloxera*. The presence of the Coccinellidae larvae was noted only once while they were destroying summer generations of *Phylloxera* sp.

During the present study, *Lachnus roboris* (Linnaeus 1758) and *Lachnus longirostris* (Mordvilko 1901) were encountered on one-year-old or two-year-old twigs of pedunculate oaks. During earlier studies, *L. roboris* had been observed in greater numbers (Lubiarz 2007b). Aphids representing the genus usually inhabited thin but ligneous twigs. The first oviparous females were spotted in the second half of September and the last ones on 20 October. During that time interval, alate females of *L. roboris* were also observed. Similar data had been given by Blackman and Eastop (1994). When ground frost occurred late, the egg-laying period lasted up to 30 days. Females laid eggs in large, common clusters on the twigs (Fig. 2). They were able to lay up to 600 eggs on a single twig. The number of eggs laid by *L. roboris* per 10 cm of a twig are given in table 2. There were from 190 to 710 eggs per 10 cm of a twig. Immediately after laying, the eggs were amber-coloured. Then the eggs became dark brown, and after a lapse of a few days they were almost black.

In Polesie National Park, oviparous females were often accompanied by seven-spot ladybirds which foraged on the laid eggs (Fig. 3). The foraging of ladybirds was facilitated by the absence of ants of the genus *Formica*. In summer, the ants accompanied aphids in large numbers. It was observed, that ladybirds preferred to feed on freshly-laid, amber-coloured eggs. In spring, no ladybirds foraging on eggs that overwintered were observed during the study.

Observations of egg-laying on the studied rose plants were conducted in the years in which ground frost rarely occurred in October and November. Only one time, was it –5°C at night, but it did not have an adverse effect on the aphids. Both oviparous females and other morphs present on the rose plants stayed alive.

As for the usefulness of rose plants as hosts for autumn aphids, the rugosa rose was the first to shed leaves (usually until the end of October), which disrupted the settling of those rose plants by oviparous females. On the remaining two rose species (dog rose and grandiflora rose), leaves could still be seen even until the final days of November or the first days of December. Autumn of 2013 was characterized by the total absence of ground frost, and daily temperatures sometimes reached 10°C. As a result, the grandiflora rose not only retained its leaves but also a flower bud appeared on a plant of that rose species. An oviparous generation developed on its leaves but the females did not lay many eggs. In order to lay the eggs they moved along the adjoining twigs to a neighbouring rose plant: a rugosa rose.

In the case of *Chaetosiphon tetrarhodum* (Walker 1849), the first oviparous females appeared on the rose plants toward the end of September. As for the first oviparous females of *Metopolophium dirhodum* (Walker 1849), they appeared on the rose plants in mid-October, but single females could still be observed towards the end of November, when the roses had already shed leaves. The first oviparous females of *Macrosiphum rosae* (Linnaeus 1758) appeared on the rose plants at the beginning of October but in 2008 their occurrence was noted towards the end of October or in the first days of November. This was due to a very warm October 2008, which resulted in a later appearance of the morphs of the sexuales generation of that species.

Observations on the number of eggs laid by respective aphid species foraging on the rose plants were conducted mainly in the years 2008–2010. Eggs were found directly on the bark of rose shoots, beside leaf buds, beside thorns, and sometimes even on thorns (Fig. 4 and 5). The aphids preferred to lay eggs on those shoots of *R. rugosa* which had a diameter of about 0.5 cm. They rarely chose shoots which were either thicker or thinner. The numbers of aphid eggs (except *M. submacula*) found on the shoots of the studied rose plants in the years 2008–2010, are given in table 3. *M. submacula* was omitted because eggs of this aphid species were easy to distinguish from others, and therefore, were counted separately. Data on eggs of *M. submacula* are compiled in table 4.

An average number of aphid eggs on 10 cm of a rugosa rose shoot ranged between 0.7 and 14.4 (Table 3). The high number of eggs in 2009 could be connected with the abundant presence of such aphid species as *M. rosae* and *M. dirhodum*. However, it is difficult to clearly explain the high number of eggs in 2008. Maybe in a rather unpolluted environment such as the site in Otrębusy Ogród, oviparous morphs were characterized by longer survival? Maybe it was due to the fact that October 2008 was much warmer than the remaining years of the study?

Fewer eggs were noted on the dog rose than on the rugosa rose. Their average number per 10 cm of a shoot ranged from 0.5 to 3.3 (Table 3).

In Lublin, Kot and Golan (2009) observed overwintering stages of arthropods on plants from the family Ro-

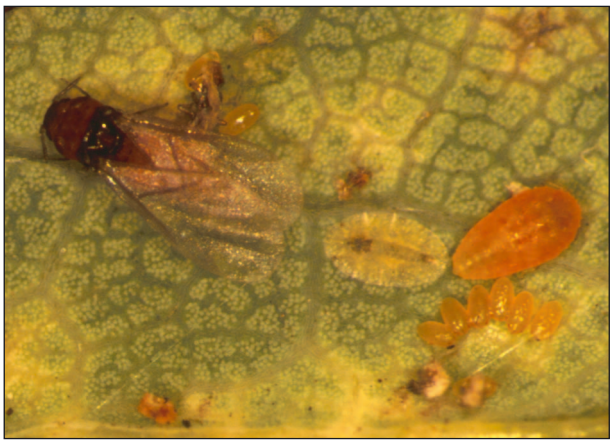

Fig. 1. Females of *Phylloxera* sp. on a leaf of the pedunculate oak

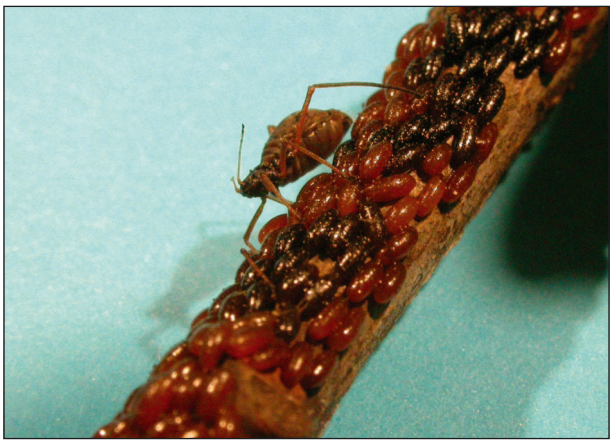

Fig. 2. An oviparous female of *L. roboris* on a shoot of the pedunculate oak

Fig. 3. A seven-spot ladybird foraging on the eggs of *L. roboris*

Fig. 4. Aphid eggs on the rugosa rose

Fig. 5. Two eggs of *M. submacula* and one egg of another aphid species on the dog rose

Fig. 6. Oviparous females of *M. submacula* and their eggs laid on a tree rose

saceae: *Sorbus aucuparia* L., *Malus* x*purpurea* Rehder, *Crataegus leavigata* (Poir.) D.C., *R. rugosa*, and *Prunus domestica* subsp. *syriaca* (Borkh.) Janch. On the rugosa rose, the most numerous overwintering aphids were found on the plant growing on a housing estate (Kot and Golan 2009). Furthermore, Jaśkiewicz (1986) noted that during winters in the years 1973–1979, she found from seven to 26 aphid eggs per 1 m of a rugosa rose shoot, i.e. from 0.7 to 2.6 per 10 cm of a shoot.

In the years 2008–2010, warm weather in October and November made it possible for aphids to lay eggs for a comparatively long period of time over the area where the studies were conducted. It is also worth noting, that the aphids preferred to lay eggs on the rugosa rose even

Table 1. The number of eggs observed around one female of *Phylloxera* sp.

Number of eggs around a female	2002	2003
Highest	87	121
Lowest	6	2
Average ±SD	46.5±26.5	61.5±33.8

Table 2. The number of winter eggs of *L. roboris*

Number of eggs/ /10 cm of a twig	2003	2004
Highest	640	710
Lowest	190	210
Average ±SD	410.8±152.4	495.0±177.5

Table 3. The number of winter aphid eggs on the dog rose and rugosa rose

Number of eggs/ /10 cm of a shoot	Dog rose			Rugosa rose		
	2008	2009	2010	2008	2009	2010
Highest	12	11	2	37	52	3
Lowest	1	0	0	2	0	0
Average ±SD	1.8±3.6 a	3.3±3.4 b	0.5±0.7 b	14.4±10.0 ac	12.6±14.9 d	0.7±1.0 cd

Values followed by the same letters are significantly different at p = 0.05

Table 4. The number of winter eggs of *M. submacula* on shoots of the dog rose and tree rose

Number of eggs/ /10 cm of a shoot	Dog rose			Tree rose
	2008	2009	2010	2008
Highest	183	97	0	284
Lowest	2	7	0	17
Average ±SD	35.8±53.7 a	38.6±27.1 b	0±0.0 ab	92.2±75.5

Values followed by the same letters are significantly different at p = 0.05

Table 5. The number of winter eggs of *M. submacula* on shoots of the grandiflora rose

Number of eggs/ /10 cm of a shoot	2011	2012	2013
Highest	243	235	233
Lowest	156	78	47
Average ±SD	115.8±103.5	111.3±106.9	78.5±88.4

though in autumn that rose species shed leaves earlier than the dog rose (sometimes even 10 days earlier).

As for *M. submacula*, that species was observed on the dog rose (in the years 2008–2010) and on the grandiflora rose (in the years 2011–2013).

While conducting observations on the dog rose in 2008, it was noted that *M. submacula* developed better on the ornamental tree roses growing near the dog roses. On 22 October 2008, oviparous females began to lay eggs. As the tree rose plant grew in the immediate proximity of the dog rose plants, some oviparous females moved onto the dog roses where they also laid eggs. It ought to be noted, that the number of eggs laid on the tree rose was clearly higher (Table 4, Fig. 6). In winter 2008/2009, the tree rose suffered from frost damage. In 2009, the development of large numbers of *M. submacula* was observed on the dog roses, since the fundatrix larvae moved from the dead tree rose plant onto the dog roses. In autumn 2009, egg-laying was noted on the dog rose but in spring 2010 no representatives of *M. submacula* were found on that rose species.

On the other hand, on grandiflora rose plants *M. submacula* preferred to lay eggs on the lower parts of shoots. The eggs formed patches or rings encircling the shoots. In 2011, the eggs of *M. submacula* were found on three out of every four shoots of the grandiflora rose. In 2011, the highest noted number of eggs was 243. In 2012, the highest noted number of eggs was 248 eggs, and in 2013, the highest number was 236 eggs (Table 5).

According to Cichocka and Jaśkiewicz (2003), out of nne aphid species encountered on the dog roses, cultivated cut roses, and greenhouse roses from Warsaw and Lublin, seven aphid species laid eggs. The highest number of eggs was laid by the females of *M. rosae* (2–9/female) and *M. submacula* (2–8), whereas the lowest number of eggs was laid by the females of *Longicaudus trirhodus* (Walker 1849) (2–4). Egg survival depended on the severity of frost in winter. If the temperature dropped to –15°C, then 63.0% of the eggs survived, if it dropped to –20°C, then 37.4% survived, and if the temperature dropped to –30°C, only 2.9% of the eggs survived.

During the period of the study, adult stages of mainly seven-spot and two-spot ladybirds could be observed occurring in comparatively large numbers. The adult stages of ladybirds occurred in autumn from the beginning of the aphid egg-laying period until about mid-October and in spring, before leaves developed.

In autumn, usually until the end of October, the ladybirds showed a strong interest in aphid eggs. It is possible that ladybirds had heightened nutritional demands prior to hibernation. In the autumn, 1–3 adult ladybirds per rose plant were found. In spring, more ladybirds were encountered on shoots of the grandiflora rose: even up to 10 individuals per plant.

In autumn, ladybirds mainly destroyed freshly laid eggs on the dog roses and grandiflora roses. They did not penetrate the rugosa roses willingly. The ladybird's hesitation might be due to the fact that eggs were laid among thorns (Fig. 4). In one year of the study, ladybirds destroyed seven out of 18 observed aphid eggs (38.9%) and in the other year, 23 out of 26 observed eggs (88.5%).

M. submacula laid eggs in three locations on the grandiflora rose plants. Ladybirds destroyed 31% of those eggs in autumn 2011 and 14% in spring 2012. In autumn 2012, they destroyed 42% of the eggs. In total, 173 eggs were destroyed. In spring 2013, just before the buds started bursting, ladybird beetles reappeared among the eggs deposited by *M. submacula* on the grandiflora roses and foraged for several hours per day, either eating out holes in egg patches or placing themselves in the middle of an egg ring encircling a shoot, and eating their way round the shoot. In one deposit (182 eggs in total), they destroyed 36 eggs and in another (201 eggs) they destroyed 28. The ladybirds bit into the tops of eggs and ate out the egg interior. The destroyed eggs often fell off the plants, leaving visible gaps in egg deposits.

Conclusions

It can be concluded that aphids overwintering in the egg stage differ in terms of:

1. Time and period of egg-laying. On the studied roses, aphids laid winter eggs from the end of September until mid-November. On the pedunculate oak, *Lachnus* sp. laid eggs from mid-September until mid-October.
2. Locations where the eggs are laid (thin twigs, thicker twigs or bark on the trunk, thorns on rose plants).
3. Egg size. On the studied rose plants, eggs of aphids representing the subfamily Lachninae (*M. submacula*) were visibly larger than eggs of aphids representing the subfamily Aphidinae.
4. The amount of eggs laid. There was the laying of single eggs (*M. rosae, Ch. tetrarhodum, M. dirhodum*) or multiple eggs (*M. submacula, L. roboris, Phylloxera* sp.).
5. According to the number of eggs noted on the respective rose species, aphids laying eggs on rose plants prefer cultivated roses and rugosa roses, laying fewer eggs on the dog roses, i.e. the native rose species.
6. The development of the oviparous females on leaves. The time of leaf shedding is important in connection with the opportunity for such development. Furthermore when autumn is long and warm (temperature does not fall below –5°C), egg-laying can last even until the last days of November or the first days of December.

Adult stages of ladybirds were observed on the studied roses. They were encountered in autumn and in spring, before buds started to burst. Adult stages of those predators fed on aphid eggs.

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