ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 11(1) 2012, 3-11*

STUDY ON INTENSITY OF INFESTATION, BIOLOGY AND HARMFULNESS OF WOLLY BEECH APHID (*Phyllaphis fagi* L.) ON *Fagus sylvatica* (L.)

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Abstract. Aphids are characterized by a specific morphology and show a high biotic potential. Most species have been described from the temperate regions of the world. The purpose of the present research was to investigate the biology, population dynamics and harmfulness of *Phyllaphis fagi* (L.) (Hemiptera: Aphididae: Phyllaphidinae) on *Fagus sylvatica* (L.) and its two varieties 'Pendula' and 'Atropunicea'. Demographic parameters of this aphid were tested in field conditions. Trees as isolated elements of greenery in the urban environment were taken into the consideration. The highest density of overwintering eggs was observed in the bark crevices of forking shoots. The shortest pre-reproduction and reproduction periods and the highest fertility was exhibited in the second generation of aphids. Pre-reproduction and reproduction periods of successive aphids' generations were extended while females' fertility was reduced. Despite of varied number of aphids on *F. sylvatica* and its two varieties, no significant differences were stated. Feeding aphids caused leaves' curling downwards on both sides of the mid-rib. Clear damage was visible even during the presence of few individuals on the leaf. Decorative values of trees were reduced as early as in June.

Key words: *P. fagi*, aphids, beeches, demographic parameters, population dynamics, occurrence

INTRODUCTION

European beech (*Fagus sylvatica* L.) occurs in the wild throughout Europe, with the exception of its south-eastern and northern parts. In Poland north-eastern border of its range runs by. Beech and its varieties have multiple applications as landscape plantings, parks and other [Seneta and Dolatowski 2006].

Phyllaphis fagi (L. 1767) (Hemiptera: Aphididae: Phyllaphidinae), monecious, holocyclic aphid, belongs to the typical beech phytophag. Wingless individuals have

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a yellow-green oval body, with the length of 2.0–3.2 mm [Kudirkaitė-Akuliene and Rakauskas 2009; Szelegiewicz 1968]. The body of aphids, especially the abdomen, is covered with white woolly wax. It limits the contact with excreted honeydew and other aphids in the colony. In addition, it forms a protective insulation of aphids against fungus, parasitoids and predators, excessive evaporation of water and frost [Smith 1999]. During the summer, dwarf aestivatig forms are present, with body length of 1.1 mm. They produce sexual generation consisting of apterous ovipare females and alate males [Blackman and Eastop 1994].

Individuals specialized in aestivation are characteristic for the monoecious, tree-dwelling species. Their well-known instances are found in *Periphyllus*. The factors that cause the formation of aestivating forms are different for each species and require individual determination [Miyazaki 1987]. The number of *P. fagi* generations in a year is not clearly defined, due to the presence of dwarf apterae forms in its development. The occurrence of 5 [Tworek 1996], 7 [Prabucki 1972] or 9 [Iversen and Harding 2007b] generations is stated.

P. fagi is a serious pest in European beech forest nurseries [Gora et al. 1994; Nef and Duhoux 1993]. It feeds in large colonies on the underside of leaves, resulting in their curl downwards along the mid-rib, and often premature falling down. As a result, the growth of young trees in nurseries is inhibited and the trees may even die. In addition, high honeydew output is proved by this aphid [Blackman and Eastop 1994; Gora et al. 1994; Iversen and Harding 2007a].

The purpose of the present research was to investigate the biology, population dynamics and harmfulness of *P. fagi* on *F. sylvatica* and its two varieties ‘Atropunicea’ and ‘Pendula’.

MATERIAL AND METHODS

The research was carried out in 2006–2008, on *F. sylvatica* trees and its two varieties ‘Atropunicea’ and ‘Pendula’ in Lublin, Poland (51.24°N, 22.57°S). Trees as isolated elements of greenery in the urban environment were taken into the consideration.

Sixty shoots with a length of about 1 m with a number of lateral shoots were analyzed. The samples were collected from trees in late autumn (November/December). The number of eggs deposited by *oviparae* females and their location on the shoot were determined in the laboratory. The data obtained were tested by calculating the Pearson correlation coefficient with CI 0.95.

Demographic parameters (fertility, the length of pre-reproductive and reproductive periods) were tested in field conditions. In this aim, 20 shoots of *F. sylvatica*, with large numbers of *P. fagi* eggs were marked in the second decade of April. Lustrations of shoots were carried out every second day in order to capture the moment of *fundatrix* nymphs hatching. After the leaves were fully unfolded, 20 *fundatrices* were closed separately (1 female/1 leaf) in clip cages (transparent plexiglass ring, with 50 mm in diameter, covered with polyester flour mesh). The first progeny of females transferred to a new cage (1 larva/1 cage × 20). Other nymphs from each individual female were removed after being counted. The females were left until they gave birth to all nymphs.

This procedure was continued for four spring generations of *P. fagi* due to the occurrence of dwarf summer forms. Clip cages were checked 3 times a week.

The length of pre-reproduction periods and female fertility of succeeding generations were compared using one-way analysis of variance (ANOVA test). The significance of differences was tested with Tuckey test at statistical significance of 0.05. The length of reproduction periods were tested with non-parametric Kruskal-Wallis test.

The observations on the population dynamics of *P. fagi* on *F. sylvatica* and its varieties 'Pendula' and 'Atropunicea' were conducted over three successive growing seasons (from late April to late autumn). Four trees from each common beech and its two varieties (total twelve trees), were selected in different parts of the city. Every ten days 25 leaves from each tree were collected. The leaves were transferred to the laboratory where wingless (including nymphs) and winged aphids were counted. In order to compare the number of *P. fagi* on *F. sylvatica* and its two varieties the non-parametric Kruskal-Wallis test was used.

RESULTS

Phyllaphis fagi oviparae deposited eggs on the underside of branches and forks of 2–3 year old shoots. The females preferred places with bark crevices. More eggs were recorded up to about 20 cm from the shoots fork (fig. 1) (r = -0.3462). Newly laid eggs were bright, slightly covered with wax, and with time they became black. In early spring, greenish tint appeared, and the body of nymph was visible through the chorion. Fundatrix nymphs were hatched in April, when the buds on the trees were still undeveloped. They showed high mobility. Until the budburst, they moved on the shoots searching for food. It took about 10 days. At the time of leaves' appearance, the fundatrix nymphs began feeding; their bodies increased seize with abundant wax secretion. Pre-reproduction period of this generation lasted 14 days on average (fig. 2a). Just after reaching maturity, females were characterized by high reproductive potency. Reproduction period lasted 18 days on average, at that time fundatrix gave birth to 45 nymphs (on average) (fig. 2b, c). The first generation of virgines had the shortest pre-reproduction and reproduction periods, among all examined aphids' generations. Adult females of this generation were observed as early as mid-May. Their fertility was very high, amounting to the average of almost 60 nymphs per female (fig. 2c). High reproductive effort of aphids reared in the clip cages was confirmed by a high abundance of *P. fagi* on beeches situated in different sites of the city (fig. 3a). Pre-reproduction and reproduction periods of successive aphids' generations were extended while females' fertility was reduced. In summer, only single, dwarf individuals were observed on the leaves. The rearing in the cages in field conditions proved their high mortality as far as in the nymphal stage. Apterous oviparae and alate males were noted on leaves in late September and October. From mid-October, aphids went through the branches and stems, where females deposited numerous, fertilized eggs. Wingless individuals were predominant in aphids' population. Winged forms were observed in May and June and in late September and October (fig. 3b).

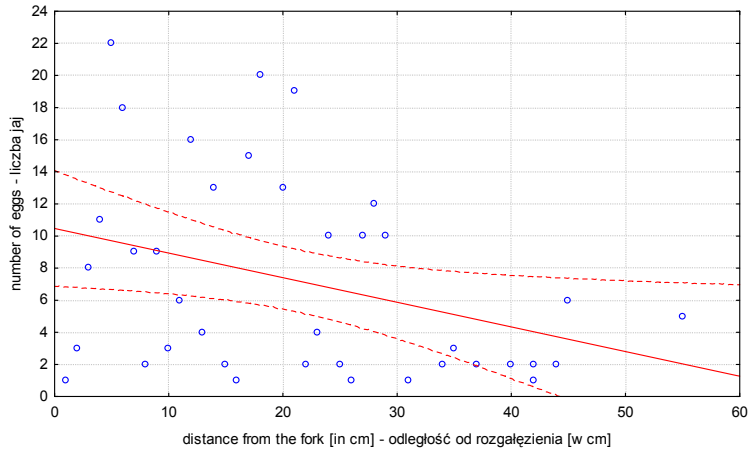

Fig. 1. Egg distribution of *Phyllaphis fagi* L. on the branches of *Fagus* spp.
Rys. 1. Rozmieszczenie jaj *Phyllaphis fagi* L. na pędach *Fagus* spp.

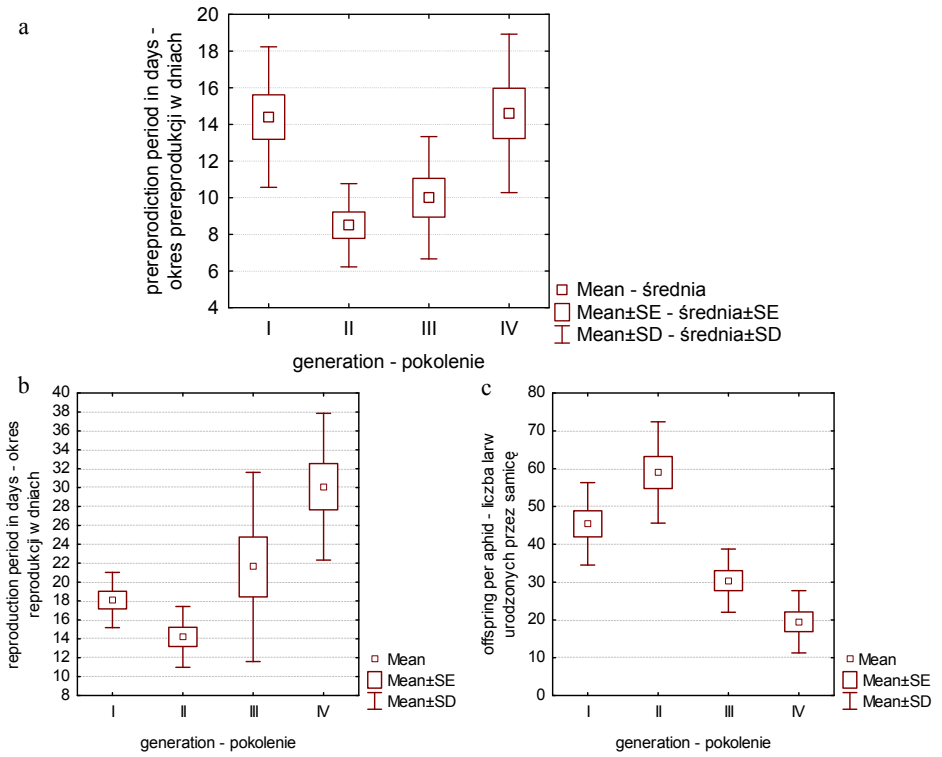

Fig. 2. Life table parameters of *Phyllaphis fagi*: (a) the length of pre-reproduction period, (b) length of reproduction period, (c) females' fecundity
Rys. 2. Parametry życiowe *Phyllaphis fagi*: (a) długość okresu prereprodukcji, (b) długość okresu reprodukcji, (c) płodność samic

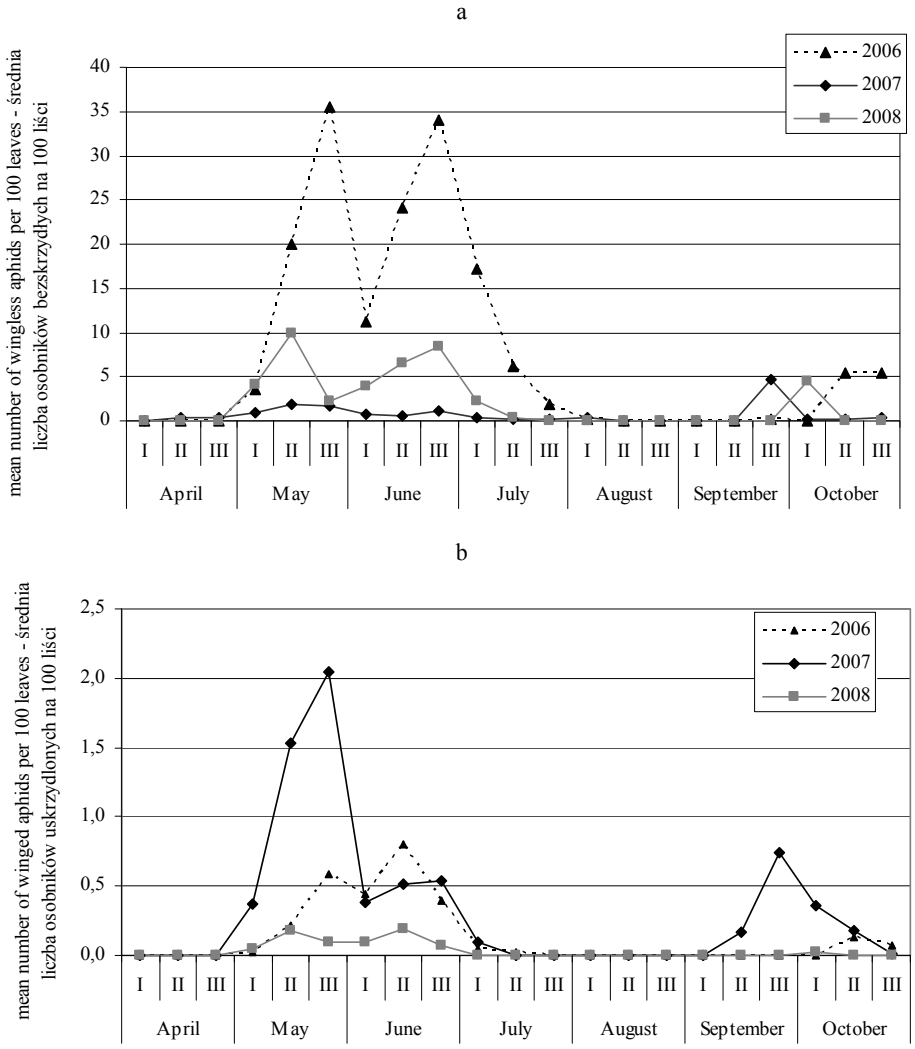

Fig. 3. The population dynamics of *Phyllaphis fagi* L. on beech leaves in 2006–2008: (a) apterous aphids; (b) alate aphids; I, II, III – successive ten days period of the month

Rys. 3. Dynamika populacji *Phyllaphis fagi* L. na liściach buków w latach 2006–2008: (a) mszyce bezskrzydłe; (b) mszyce uskrzydlone; I, II, III – kolejne dekady miesiąca

The number of aphids differed on common beech and its two varieties. The highest number of feeding individuals (representing 50% of all observed aphids) were noted on *F. sylvatica*. The number of insects on 'Atropunicea' and 'Pendula' varieties was similar and amounted to respectively, 24% and 26% (fig. 4). Despite of varied number of aphids on *F. sylvatica* and its two varieties, no significant differences were stated ($p = 0.53$).

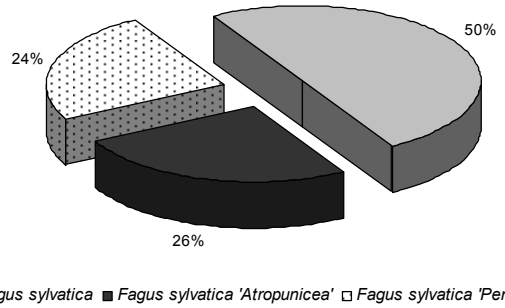

Fig. 4. The infestation of *Phyllaphis fagi* L. on beech leaves in 2006–2008
Rys. 4. Stopień zasiedlenia buka zwyczajnego i jego dwóch odmian przez *Phyllaphis fagi* L. w latach 2006–2008

Phyllaphis fagi formed colonies on both, lower and upper side of leaves. In early spring, they also inhabited petioles. Nymphs and females of this species were characterized by high mobility, actively changing the place of feeding and reproduction, which intensified their harmfulness. Feeding aphids caused leaves' curling downwards on both sides of the mid-rib. Clear damage was visible even during the presence of few individuals on the leaf. This species is characterized by extensive execration of honeydew, which covered not only leaves inhabited by aphids, but also those below. Sooty molds were developed on honeydew and all sorts of dust were stuck. Decorative values of trees were significantly reduced as early as in June.

DISCUSSION

A few studies on *P. fagi* occurrence concerned forests and nurseries. The common beech and its varieties are more and more frequently planted in gardens and green areas in Polish cities and gardens. The degree of infestation and the demographic parameters of aphids is radically different on trees growing in dense forest stands [Prabucki 1972] or nurseries [Iversen and Harding 2007b] compared to trees growing separately or in small groups. They are significant decorative elements of the landscape which should be maintained in the good condition. Hence, the present investigation provides an important contribution to the knowledge extension of *P. fagi* biology and infestation in environments with the pressure of different biotic and abiotic factors. Lack of possibilities to use plant protection management in the urban conditions requires to a better understanding of phytophagy biology to search alternative methods to reduce their numbers.

Own study showed that the highest density of overwintering eggs is observed in the bark crevices of forking shoots. With increasing distance from the forks the number of

eggs decreased. Similarly, *Pterocallis alni* De Geer deposits eggs on alder trees [Gange and Llewellyn 1988].

Burschel and Vite [1951] and Schmutterer [1952] considered that *P. fagi* fundatrices are characterized by the highest fertility due to large size of the body. In Iversen and Harding [2007b] laboratory experiment the rate of growth and reproductive effort of successive generations of this species at different constant temperatures were observed. They pointed out that the reproductive capacity is more dependent on temperature than on aphid generation. In own research (field conditions) it has been assumed that fecundity depends rather on generation. The highest fertility was exhibited in the second generation of aphids. This is in accordance with results obtained by Prabucki [1972] on ten-year beech planting.

Examination of beech leaves revealed that the highest *P. fagi* infestation was observed from May to mid July. During the summer (August/September), at high temperatures, the leaves of trees were free from aphids of this species. It was due to the occurrence of aestivating morphs which decrease or even cease reproduction. Similar information was found by Burschel and Vite [1951]. Summer collapse of aphids population is observed in various species, especially these colonizing trees and shrubs [Jaśkiewicz and Kmieć 2007, Jaśkiewicz and Kot 2007, Karczmarz 2010]. However, on the basis of laboratory experiment, Iversen and Harding [2007b] argued that there were no decreases in reproduction effort of *P. fagi* during summer. This may result from the fact that there are no differences in development between generations, when the temperature is constant [Gange and Pryse 1990]. The statements of the above authors and own research suggest that the fecundity of aphids may be more dependent on daily temperature fluctuations than that of its height.

Winged individuals were observed in numerous aphid colonies on the collected leaves. Their presence was noted from May to mid-July; the highest number was recorded mostly in mid-June. Iversen and Harding [2007b] and Ruszkowska and Wilkaniec [2002] obtained similar results by catching *P. fagi* into yellow water traps.

Feeding effects of *P. fagi* revealed as curling, discoloring, withering and premature dying were observed as early as in June. The leaves were covered with colonies of aphids and honeydew. Thus, this species is dangerous, not only in forest nurseries [Iversen and Harding 2007a], but also in urban green areas.

CONCLUSIONS

Due to the characteristic appearance of *P. fagi* colonies (abundant of white wooly wax) lustration of plants can be easily carried out. It should be performed in mid May, during the feeding of generation which proves the highest fertility.

There was no significant difference in *P. fagi* infestation of *F. sylvatica* and its varieties ‘Pendula’ and ‘Atropunicea’.

Clear damage of leaves was visible even during the feeding of few *P. fagi* individuals. After the intensive spring aphids’ feeding large trees usually regenerate damaged, attention should be paid to young plants. If necessary, the procedures to reduce the number of these pests should be taken.

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BADANIA NAD DYNAMIKĄ LICZEBNOŚCI, BIOLOGIĄ I SZKODLIWOŚCIĄ ZDOBNICZKI BUKOWEJ (*Phyllaphis fagi* L.) NA BUKU ZWYCZAJNYM (*Fagus sylvatica* L.)

Streszczenie. Mszyce charakteryzują się specyficzną budową morfologiczną oraz wykazują wysoki potencjał biotyczny. Opanowały przede wszystkim strefę umiarkowaną półkuli północnej. Celem niniejszych badań było prześledzenie biologii rozwoju, dynamiki populacji i szkodliwości *Phyllaphis fagi* (L.) (Hemiptera: Aphididae: Phyllaphidinae) zasiedlającej *Fagus sylvatica* (L.) i jego dwie odmiany 'Pendula' i 'Atropunicea'. Parametry demograficzne tej mszycy były określane w warunkach polowych, na drzewach rosnących na terenach zieleni miejskiej Lublina. Najwyższe zagęszczenie zimujących jaj obserwowano w spękaniach kory w rozwidleniach pędów. Najkrótszym okresem prereprodukcji i reprodukcji oraz najwyższą płodnością charakteryzowało się drugie pokolenie mszyc. Okresy prereprodukcji i reprodukcji kolejnych pokoleń *P. fagi* wydłużały się przy jednoczesnym zmniejszaniu płodności samic. Notowano znaczne różnice w liczebność mszyc na drzewach buka zwyczajnego i jego odmianach 'Pendula' i 'Atropunicea', jednak nie były one istotne statystycznie. Żerowanie mszyc powodowało zwijanie się blaszek liściowych wzdłuż nerwu głównego. Wyraźne uszkodzenia były widoczne nawet w czasie obecności pojedynczych osobników na liściu. Obniżenie wartości dekoracyjnych drzew obserwowano już w czerwcu.

Słowa kluczowe: *P. fagi*, mszyce, buki, parametry demograficzne, dynamika populacji, występowanie

Accepted for print – Zaakceptowano do druku: 13.10.2011