Appendix 2b

SUMMARY
OF SCIENTIFIC ACCOMPLISHMENTS
AND SCIENTIFIC ACHIEVEMENTS

Autoreferat w języku angielskim

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Lublin 2019

1. NAME AND SURNAME: **Katarzyna Kmieć**

2. DIPLOMAS AND SCIENTIFIC DEGREES:

1999 – **Master of Science in Horticulture**,
Faculty of Horticulture, Academy of Agriculture in Lublin
Thesis title: "Species composition and dynamics of aphid occurrence on selected ornamental shrubs in the Academic Park in Lublin"
Thesis supervisor: Assistant professor Bożenna Jaśkiewicz

2000 – 2004 –doctoral studies at the Faculty of Horticulture, Academy of Agriculture in Lublin;

2005 – **Doctor of Agricultural Sciences** in the field of Horticulture, specialization: plant protection, entomology,
Faculty of Horticulture, Academy of Agriculture in Lublin,
Title of the doctoral dissertation: "Aphids (Homoptera, Aphidodea) inhabitini roses in urban conditions of Lublin",
Supervisor: Professor Bożenna Jaśkiewicz,
Reviewers: Professor Elżbieta Cichocka, Assistant professor Maria Buchowska-Ruszkowska.
The dissertation has been distinguished by Reviewers.

2009 – Certificate telc English B2 Frankfurt/Main, issued by Telc Examination Center UMCS Lublin.

3. EMPLOYMENT IN SCIENTIFIC INSTITUTIONS:

- **Assistant** (since 1 March 2006 till 28 February 2007) – Department of Entomology, Faculty of Horticulture (currently Faculty of Horticulture and Landscape Architecture), Academy of Agriculture in Lublin (currently University of Life Sciences in Lublin).
- **Assistant professor** (since 1 March 2007 till now) – Subdepartment of Entomology, Department of Plant Protection, Faculty of Horticulture and Landscape Architecture, University of Life Sciences in Lublin.

4. INDICATION OF THE SCIENTIFIC ACHIEVEMENTS ACCORDING TO 16 PARAGRAPH SECTION 2 OF THE ACT OF LAW FROM 14 MARCH 2003 ON ACADEMIC DEGREES AND TITLES IN THE ARTS (OFFICIAL JOURNAL OF LAWS OF 2017, ITEM 1789) ACCORDING TO THE REGULATION OF THE MINISTER OF LEARNING AND HIGHER EDUCATION FROM 19 JANUARY 2018 ON THE DETAILED PROCEDURE FOR CONDUCTING ACTIVITIES IN DOCTORAL DISSERTATION, IN HABILITATION PROCEDURE, AND IN THE PROCEEDING OF A PROFESSOR TITLE JOURNAL OF LAWS OF 2018, ITEM 261), ACCORDING TO PARAGRAPH 179 SECTION 2 OF THE ACT OF LAW FROM 3 JULY 2018 REGULATIONS INTRODUCING – THE LAW OF HIGHER EDUCATION AND SCIENCE (JOURNAL OF LAWS OF 2019 ITEM1669)

a) Title of scientific achievement

The scientific achievement constituted cycle of six scientific publications, related in theme, under a single title:

„Analysis of the interactions of gall-forming aphids with the primary host plant, with particular emphasis on the *Tetraneura ulmi* L. - *Ulmus* sp. relationship"

b) Author/authors, title of publication, issue date, name of publishing house

Publications included in the scientific achievement in chronological order:

H1. Kmieć K., Kot I., 2007. *Tetraneura ulmi* (L.) (Hemiptera, Eriosomatinae) on elm as its primary host. Aphids and Other Hemipterous Insects, Lublin, vol. 13, 145-149. [**6** points]

H2. Kmieć K., Kot I., 2010. Występowanie mszyc z podrodziny Eriosomatinae na wiązach w parkach Lublina. Ann. Univ. Mariae Curie-Skłodowska, EEE, XX (1): 7-13. (**2** points]

H3. Kmieć K., Rubinowska K., Golan K., 2018. *Tetraneura ulmi* (Hemiptera: Eriosomatinae) induces oxidative stress and alters antioxidant enzyme activities in elm leaves. Environmental Entomology, 47(4), 840–847. [IF_{2017} **1.661**; **30** points**, times cited WoS **-2**

H4. Kmieć K., Rubinowska K., Michałek W., Sytykiewicz H., 2018. The effect of galling aphids feeding on photosynthesis photochemistry of elm trees (*Ulmus* sp.). Photosynthetica 56 (4): 989-997. [IF_{2017} **1.740**; **25** points**, times cited WoS - **3**]

H5. Kmieć K., Sempruch C., Chrzanowski G., Czerniewicz P., 2018. The effect of *Tetraneura ulmi* L. galling process on the activity of amino acid decarboxylases and the content of biogenic amines in Siberian elm tissues. Bulletin of Entomological Research, 108(1): 69–76. [IF_{2017} **1.721**; **35** points**, times cited WoS - **2**]

H6. Kmieć K., Złotek U., Jakubczyk A., Karaś M., 2018. Biochemical alterations in *Ulmus pumila* L. leaves induced by galling aphid *Tetraneura ulmi* L. Acta Sci. Pol., Hortorum Cultus 17(6), 175–183. [IF_{2017} **0.448**; **20** points**]

I am the first author of all papers constituting the scientific achievement, with own participation from 60% to 80%. Declarations by co-authors of the papers evaluating their individual contribution in the publication are included in Appendix No. 6. None of the above papers were a part of a monothematic cycle of papers in another habilitation procedure.

<u>Summary for scientific achievement:</u>

Total MNiSW points – **118***,**

Impact Factor (IF) – **5,57**

Times cited WoS - **7**

* according to MNiSW score in publication year;

**according to statement issued on 12 December 2016 by MNiSW to the regulation on the awarding of a scientific category to scientific entities and universities (Journal of laws of 2016 item 2154);

Impact Factor (IF) – according to publication year (in the case of papers of 2018 the last available IF is given)

c) Description of scientific aim of the above papers and results achieved along with a description of their possible application

Introduction

Gall-forming aphids account for only about 10% of the world fauna of Aphidoidea. In Poland, in addition to Adelgidae that cause the galls on coniferous trees, most of the gall-forming species belong to the subfamily Eriosomatinae, the representatives of which are nutritionally associated with various species of elm *Ulmus* sp. and poplar *Populus* sp. (Wojciechowski et al. 2015, Blackman and Eastop 2018). In principle, the galls are initiated by the fundatrix first instar (Wool 2004). As a result of larvae feeding, the normal growth of plant tissues is subject to changes, and new complex structures that do not function in classical organogenesis are formed (Oliveira et al. 2016). The key stages in galls development are the initiation of the gall, its growth and formation, as well as maturation and senescing (Raman 2012). It is commonly believed that gall-former has the ability to manipulate the growth and development of plant tissues and modifies the nutritional quality of the host plant by stimulating the expression of relevant genes (Stone and Schönrogge 2003, Tokuda et al. 2013). However, the molecular basis of gall formation has not been explained so far. New plant structures are used by the gallers as a shelter and a source of food, and insect-host plant relationships for this group of phytophagous are among the most complex ones (Larson and Whitham 1991, Shorthouse et al. 2005, Giron et al. 2016, Oliveira et al. 2016).

In response to a herbivore attack, the plant reacts with metabolic changes, which activate defensive reactions (Oliveira et al. 2010, Isaias et al. 2015). Aphids during the penetration of plant tissues damage the walls of individual cells. During feeding watery saliva is secreted into the phloem and disturbs intracellular homeostasis. Many of the proteins contained in aphid saliva are elicitors of plant's defensive reactions (Giordanengo et al. 2010, Rodriguez and Bos 2013, Will et al. 2013, Elzinga et al. 2014). However, no specific chemical elicitor responsible for the induction of galls has been detected so far.

The earliest event in the process of gall formation is probably the irreversible disturbance of the normal course of differentiation of one or more plant cells caused by insect activity. However, the type of "interfering factor" has not been discovered so far (Raman 2011). Due to stress factors, one of the first consequences observed in plant tissues is the generation of reactive oxygen species (ROS) (Choudhury et al. 2017). High concentration of ROS causes oxidative modification of proteins, membranes lipid peroxidation and damage in nucleic acid molecules, it can also trigger the programmed cell death (PCD) process (Gill and Tuteja 2010, Choudhury et al. 2017). A complex antioxidant system consisting of enzymes such as peroxidases, dismutases, catalases and non-enzymatic low molecular weight compounds is responsible for neutralization of cytotoxicity and maintenance of adequate ROS levels in plant tissues (War et al. 2012). Peroxidases play an important role in the regulation of growth and development processes and are also the first line of defense for plants under oxidative stress (Sharma et al. 2012). The action of peroxidases is indirectly related to polyamines, considered to be a new class of growth regulators, which physiological effect spectrum is very broad. (Kubiś 2006). They can be combined with such biomolecules as nucleic acids, phospholipids and many kinds of proteins, including enzymatic proteins. Affecting the content of H2O2, they can trigger hypersensitivity (HR) or PCD reactions. Some polyamines may indirectly enhance the activity and biosynthesis of immune proteins (PR), the induction of which is mainly due to the action of molecules activated on the signal pathways of jasmonic acid, salicylic acid and ethylene (Walters 2003, Walters et al. 2005, Kubiś 2006). Activation of PR proteins such as chitinase and β-1,3-glucanase was observed in the defensive reaction of plants to aphid feeding, similarly as in fungal pathogens infections (Krishnaveni et al. 1999, Forslund et al. 2000, Inbar et al. 2003, Singh and Teotia 2014).

Any changes in the course of metabolic and physiological processes taking place in the plant cell affect the course of photosynthesis, which affects the growth and development of plants. The influence of abiotic and biotic stress factors fundamentally reduces the intensity of this process, due to imbalance in signal pathways and inhibition of PSII repair (Murata et al. 2007, Ashraf and Harris 2013, Guo et al. 2016). Disturbances in this process in response to feeding of herbivores are usually multifaceted and depend mainly on the manner of feeding and the type of defense response of the plant (Nabity et al. 2009, Aldea et al. 2011). Aphids feeding can intensify photosynthesis efficiency or inhibit it (Heng-Moss et al. 2003, Franzen et al. 2007, Franzen et al. 2008). Similarly, different effects were demonstrated in the case of gall-inducing arthropods (Retuerto et al. 2004, Gailite et al. 2005, Khattab and Khattab 2005, Patankar et al. 2011, Castro et al. 2012)

Despite the relatively large number of work on galling aphids, the metabolic reaction of the plant to their feeding is poorly understood. There are no wider studies in the world literature documenting physiological and biochemical transformations taking place in the host plant tissues under the gall-formation process. It seems that, in order to maximize their own benefits, gall-forming insects should manipulate and reduce the defensive reactions of plants during whole galling process. In this context, the main objective of the research was to analyze the impact of gall-forming aphids feeding on the physiological and biochemical reaction of host plants in the subsequent stages of gall development.

The aims of the studies included:

- determination of species composition of gall-forming aphids from the subfamily Eriosomatinae colonizing elm trees in the area of Lublin, with indication of the most numerous species and analysis of damage visible on the leaves;
- analysis of the course of *Tetraneura ulmi* L. spring development on *Ulmus minor* L. as primary host;
- evaluation of an effect of *Colopha compressa* (Koch.) and *T. ulmi* feeding in closed galls and E *Eriosoma ulmi* (L.). in pseudo-galls on the course of photosynthesis photochemistry in leaves of primary host plants;
- demonstration of the relationship between the aphids developmental stage and the number of insects feeding in galls and the physiological and biochemical reaction of the host plant.

The concise description of the results published in the cycle of six scientific publications submitted for evaluation as a scientific achievement is presented below.

Bionomic and ecological studies (papers H1, H2)

The observations carried out in the years 2006-2008 in the green areas of Lublin showed an annual occurrence of two species of aphids from the subfamily Eriosomatinae: *Eriosoma* (*Schizoneura*) *ulmi* L. and *Tetraneura ulmi* L. The presence of *E. ulmi* pseudo-galls was recorded on *U. minor* and *Ulmus glabra* Huds. (paper H2). The aphids appeared on the investigated trees when the buds cracked. Fundatrix larvae were feeding on very young, developing elm leaves, and the first pseudo-galls appeared at the end of April or at the turn of April and May (paper H2). Aphids feeding caused characteristic wrinkling, discoloration and curling underneath, along the midrib, usually one half of the leaf blade. The formation of the "rolls" was usually induced by one founding larva, but 2, 3 and even 4 fundatrix were recorded in some pseudo-galls. The rolls quickly turned yellowish or white-greenish in color. The aphids were feeding in the galls for about 3 weeks depending on the course of weather conditions. On field elm leaves, pseudo-galls were small and covered 10-20% of the blade area. On the mountain elm, the majority of galls were of considerable size, so that they covered 30-50% of the leaf surface. On *U. glabra*, 35-41 aphids were feeding in one roll on average, and 16-21 individuals on *U. minor*. Pseudo-galls of this species on field elm were usually few and were found on 10-16% of the analyzed leaves. After the aphids left the rolls, the pseudo-galls gradually dried up. Less damaged leaves remained on trees, while more distorted leaves fell down (paper H2). *Tetraneura ulmi* formed true (closed) galls and its feeding on the leaves started a little later than *E. ulmi*. Initially, the fundatrix larvae fed on the lower side of the leaf blade, which became folded, and the resulting small bulges closed the aphids on the upper side of the leaf. There was only one founding larva in each gall. Initially, the galls were cone-shaped, eventually they took the shape of beans and were set on a thin stalk. Fully developed galls were green and changed their color to yellow over time (papers H1, H2). The fundatrix larvae moulted four times and reached maturity after about three weeks, depending on the year of research, at the end of May or at the beginning of June. Fertility of females varied from 15 to 85 larvae. The number of second generation larvae, born by the founder, was strictly dependent on the size of the gall (papers H1, H2). The highest number of aphids fed in galls over 21 mm high and over 11 mm wide (paper H1). Larvae of migrants after four moults, at the turn of the first and second decade of June, depending on the year of research, left the galls through cracks appearing in their lower part as winged individuals (papers H1, H2).

Field observations continued in the subsequent years showed the presence of *E. ulmi* and *T. ulmi* galls also on *Ulmus pumila* L. and *C. compressa* galls on *Ulmus laevis* Pall., and this information was presented in the following works of the cycle.

The effect of galling aphids feeding on the photosynthesis photochemistry (paper H4)

Disturbances in one of the most important metabolic processes of plants, which is photosynthesis, significantly affect the growth and development of plants. The yield of photosynthesis in plants can be estimated using a non-invasive chlorophyll *a* fluorescence technique. The advantage of this method is the ability to perform tests at the plants growth site *in situ* and to indicate their reaction to stress factors. The most frequently measured parameter is the maximum quantum yield of photosystem II (F_v/F_m) considered to be a reliable measure of photochemical activity of photosynthetic apparatus. This parameter allows to evaluate plant's response to stress, since it indicates direct damage to the structure of PSII and changes in pigment content. The aim of the study was to determine an effect of gall-forming aphids feeding on the photochemical phase of photosynthesis in host plants. *Colopha compressa* and *T. ulmi* causing closed galls and *E. ulmi* forming pseudo-galls were selected for the study.

Closed galls differed in their structure and location on the leaf blade. *C. compressa* galls were laterally flattened, in the form of the so-called rooster combs and located directly at the midrib, usually in the base part of the leaf. The undamaged part of the leaf blade (above the gall) usually occupied about 1/4 - 1/3 of the leaf area. Bean-shaped *T. ulmi* galls were located between the veins and were usually located in the distal part of the blade. The measurements were carried out on the leaves of three elm species depending on the dominant aphid species: *U. pumila* with galls of *T. ulmi*, *U. laevis* with galls of *C. compressa* and *U. glabra* with rolls of *E. ulmi*. Due to the different rate of development of individual aphid species, constant monitoring of galls development was carried out since early spring. The measurements were performed during sunny days, from 9 a.m. to 11 a.m., *in situ* in the phase when the galls of individual aphid species were fully formed, and numerous migrants larvae of 3^{rd} and 4^{th} instar fed inside. The undamaged and damaged parts of leaves with galls were analyzed separately. The control consisted of leaves of a similar age and the same location in the crown of the tree as leaves with galls, but without any visible damage. The analyses were carried out on 60 leaves for each aphid species. The measurements included initial fluorescence after adaptation to darkness (F_0), maximum quantum yield of PSII (F_v/F_m), effective quantum yield of photochemical reaction in PSII (Y), coefficient of photochemical fluorescence quenching (q_P) and coefficient of non-photochemical quenching (q_N) using the PAM-2000 fluorimeter. Then the leaves on which the measurements were made were collected and analyzed for pigment content. The study was carried out in four combinations for *C. compressa* and *T. ulmi*: 1) control leaves, 2) undamaged part of blades with galls, 3) damaged part of blades with galls, 4) galls. The undamaged part of leaves with rolls, pseudo-galls and control leaves were analyzed for *E. ulmi*. The study proved that feeding of all analyzed aphid species caused disturbances in the process of photosynthesis in host plants leaves. The feeding of *E. ulmi* in pseudo-galls significantly decreased the value of all analyzed parameters both in undamaged parts of leaves with galls as well as in the rolls themselves. The exception was an increase in the value of coefficient of non-photochemical quenching. Such a reaction is typical in stress conditions, when an increase in q_N is accompanied by a decrease in q_P value. The analysis of chlorophylls and carotenoids content showed their significantly lower level in pseudo-galls tissues. On the other hand, the influence of aphids causing true galls on the examined parameters of chlorophyll fluorescence was differentiated. In the case of *C. compressa*, a significant decrease of F_0, F_v/F_m and q_P values only in the damaged parts of leaves with galls was observed. No significant differences in quantum yield of photochemical reaction in PSII were found. In turn, the value of non-photochemical quenching increased only in damaged parts of leaves with galls. The analysis of pigments content in both parts of leaves with galls showed their similar level as in the control leaves, despite the visible discoloration of the leaf blade below the gall. On the other hand, feeding of *T. ulmi* significantly affected the analyzed parameters in both parts of the leaves with galls, with the strongest reaction recorded in the damaged parts of the blades. The content of chlorophylls and carotenoids significantly lower than in the control as well as the value of chlorophyll *a* to chlorophyll *b* ratio were also determined in the damaged parts of leaves. A very low content of photosynthetic pigments was found in the tissues of both *C. compressa* and *T. ulmi* galls. Low content of pigments, especially chlorophylls, reduces the ability to absorb light and limits the photosynthesis process in closed galls. It should be emphasized that in the case of *T. ulmi* the changes in the values of individual parameters of chlorophyll fluorescence were significantly correlated with the number of galls present on the leaf blades. An increasing number of galls gradually inhibited the efficiency of the photochemical phase of photosynthesis in the *U. pumila* leaves. Moreover, as the number of galls increased, the area of undamaged leaf fragments, in which the disturbances were smaller than in the damaged parts, decreased on the blades. It is worth mentioning that the value of F_v/F_m in control leaves of all analyzed elms was lower than the optimal value in the range 0.77-0.83, which indicates the existence of stress conditions in the growth environment of the studied trees. On the basis of the obtained results it was shown that the feeding of gall-forming aphids was an additional biotic stress factor affecting the condition of plants.

The effect of *Tetraneura ulmi* galling process on physiological and biochemical alterations in primary host plant (papers H3, H5, H6)

Analysis of the photosynthesis process under the influence of gall-forming aphids feeding allowed to identify *T. ulmi* as the species exerting the strongest pressure. Several years of observations showed that the largest number of galls is noted every year on *U. pumila*, therefore *T. ulmi* and *U. pumila* were chosen as the model system. The samples for the study originated from trees growing in the green areas of Lublin. The leaves were collected three times, depending on the development phase of the gall: 1) at the time of galls formation; 2) at the stage of fully grown galls and 3) at the stage of "mature" galls. In the first (initial) phase, the galls were about 5 mm long, green and there was a larva of the family founder inside. In the second phase, the galls were bean-shaped, fully developed, green in color with fundatrix and a few young migrant larvae inside. In the third stage, the galls were yellowish in color, with visible galls rupture sites on the surface, filled with migrant nymphs and larvae, and no more live fundatrix females were recorded inside. The leaves with galls were collected "at arm's length" from 3-4 trees. The leaves of a similar age collected from the same trees, but from branches without the galls, served as control. In the laboratory, the galls were removed from the leaves, cut and aphids, molts and honeydew drops were removed from their inside with a brush; then fragments with visible deformations and discolorations surrounding the galls were cut off from the leaf blades. The collected material was divided into four categories: 1) control - healthy leaves without signs of pests and diseases, 2) undamaged parts of leaves with galls, 3) damaged parts of blades with galls, 4) galls. In each category, the analyses were performed in 3 biological repetitions (mixed material from 20-50 leaves), at each of the three stages of galls development separately. The following parameters were analyzed: electrolyte leakage (E_L) by conductometric method; the content of hydrogen peroxide (H_2O_2), substances reacting with thiobarbituric acid (TBARS), proteins, reducing sugars and phenolic compounds by spectrophotometric method; activity of the following enzymes: ascorbate peroxidase (APX) and guaiacol peroxidase (GPOD), catalase (CAT), decarboxylase of ornithine (ODC), lysine (LDC) and tyrosine (TyDC), β-1,3-glucanase and chitinase by spectrophotometric method and polyamine content by high-performance liquid chromatography (HPLC). The obtained results clearly indicate that *T. ulmi* feeding caused a differentiated physiological and biochemical reaction of the primary host plant. The type and direction of the observed changes depended on the developmental phase of the gall, and thus on the developmental stage and the number of aphids feeding inside the gall.

During **gall formation phase**, electrolyte leakage and TBARS concentration measurements did no demonstrate cell membrane damage in the analyzed tissues, and an increased H_2O_2 content was only detected in damaged parts of leaves with galls, where fundatrix larvae made numerous punctures before finding the right feeding site. In order to maintain homeostasis in plant tissues, at this stage, it seems important to maintain control over the toxic and signal role of ROS, in this case H_2O_2, which may be proved by a significant increase in APX and CAT activity in young galls tissues and damaged parts of leaves with galls. Catalase activity was also high in undamaged parts of leaves with galls, which indicates the activation of antioxidant mechanisms in the leaves (paper H3). High activity of CAT as an enzyme that significantly prolongs cell viability may be crucial at this stage of gall development. In the initial phase, increased LDC activity in galls, ODC in all parts of leaves with galls and high content of cadaverine, spermidine and histamine in galls were also detected (paper H5). Polyamines, due to the possibility of their involvement in various processes taking place in plants, may probably play an important role in the formation and development of galls.

They can act in stabilizing manner with respect to lipids of cytoplasmic membranes, modify the action of various enzymes, and also act directly as free radical scavengers. At this stage of galls development, a significant increase in protein content in galls and undamaged parts of leaves with galls and a high level of phenolic compounds in galls were also determined. Increased synthesis and accumulation of phenols in young galls may be one of the first plant responses to biotic stress, as they participate in the removal of ROS. At the same time, they can affect the level of auxins responsible for the division, growth and differentiation of cells and plant tissues. The activity of β-1,3-glucanase in leaves under pressure from *T. ulmi* was similar to that in control, while the activity of chitinase was significantly lower compared to healthy leaves (paper H6). The role of β-1,3-glucanase and chitinase in defensive reactions of plants against insects is insufficiently explained. These enzymes can trigger defensive reactions in the plant by releasing signal molecules or cause direct damage to the insects gut. No changes and a decrease in PR proteins activity may indicate that the plant's defensive processes are inhibited by *T. ulmi* fundatrix feeding.

In **the second phase of galls development**, when they were fully grown and the adult fundatrix and several larvae were feeding inside, there was a strong peroxidation of lipids in the tissues of the galls and damaged parts of leaves with galls, and an increase in H_2O_2 level in undamaged parts of leaves with galls. APX activity was increased in the galls and in both parts of the leaves under aphid pressure. On the other hand, the activity of CAT decreased significantly in the analyzed tissues (paper H3). At this stage, no putrescine was detected in the analyzed plant material, while the highest content of all other analyzed amines was determined in galls. The content of individual amines in damaged and undamaged parts of leaves with galls varied and in many cases was lower compared to the control. In the second stage of galls formation, the activity of the examined decarboxylases also decreased significantly, both in galls themselves and in both parts of leaves with galls (paper H5). The content of soluble proteins in galls and healthy parts of leaves with galls was similar to that in the control, while in damaged parts of leaf blades it was lower than in the control leaves. The activity of both analyzed PR proteins in galls was low, while in the other parts of leaves with galls it usually remained at the control level. A significant increase in the content of phenolic compounds was observed in galls tissues, both in relation to control leaves and compared to their content in young galls. Also in damaged parts of leaves the level of these compounds was higher than in the control (paper H6).

In **the third stage of galls development,** "just before opening", when they were filled with migrant nymphs and larvae, H_2O_2 accumulation, strong electrolyte leakage and very high level of membrane lipid peroxidation were detected in the analyzed galls tissues, with very low peroxidase activity and no CAT activity at all. Similar relationships were observed in the hypersensitivity reaction during the attack of pathogens. Increased tissue puncture and plant sap uptake generates ROS causing lipid peroxidation and damage to cytoplasmic membranes (paper H3). At this stage, no amines were detected in galls and the activity of examined decarboxylases was low (paper H5). However, increased activity of chitinase and β-1,3-glucanase as well as very high content of phenolic compounds were observed (paper H6). An increased activity of β-1,3-glucanase in gall tissues may be beneficial for aphids as it exhibits the ability to hydrolysis of callose (β-1,3-glucan polymer) deposited in sieve tubes during mechanical injury. With intensive tube penetration by numerous feeding aphids, this may facilitate continuous nutrient flow in the phloem. On the other hand, chitinase may be harmful to aphids due to the possibility of hydrolysis of chitin present in the foregut. In damaged and undamaged parts of galled leaves, the level of electrolyte leakage and membrane lipid peroxidation was lower than in control leaves, peroxidase activity was also decreased, while catalase activity was increased. High activity of this enzyme may compensate for low effectiveness of peroxidases. An increased level of H_2O_2 was found only in damaged parts of galled leaves (paper H3). High content of amines was found in both parts of leaves with galls, and an increase in LDC activity was also observed in undamaged parts (paper H5). In turn, the content of soluble proteins and phenolic compounds was similar to that in the control leaves, while a significant increase in the activity of both tested PR proteins was observed in the healthy parts of the blades with galls. Increased activity of β-1,3-glucanase may induce defensive reactions in the plant by releasing oligosaccharide molecules from the walls of plant cells, which are signal molecules. In all stages of galls development, the content of reducing sugars in galls and damaged parts of galled leaves was significantly lower compared to the control (paper H6).

Summary of the results documenting the scientific achievement

- The presence of galls of three species of aphids from the subfamily Eriosomatinae: *C. compressa, E. ulmi* and *T. ulmi* was detected in Lublin area on four species of elm. These aphids occurred with varying intensity and their spring development on the primary host lasted about six weeks and included only two morphs - fundatrix and migrants.
- The presence of galls on elm leaves, regardless of their type, significantly reduced photosynthesis efficiency. The strongest reaction was observed in *U. pumila* inhabited by *T. ulmi*. The presence of chlorophylls and carotenoids in galls tissues enabled the

photosynthesis performance, however, their low content indicates that galls act as assimilation products acceptors.

- Innovative research including a comprehensive analysis of a wide range of biomolecules involved in the process of *T. ulmi* galls formation proved that these aphids feeding causes oxidative stress in the host plant and affects the activity of defense mechanisms. The plant reaction depends on the aphid developmental stage and number of insects feeding inside the gall.
- On the basis of the studies, it was shown that the formation of gall in response to *T. ulmi* feeding resembled the reaction of hypersensitivity. The insect is closed in the gall, where it initially finds favorable conditions for development. In the first stage, the response to feeding of a single fundatrix larvae is an increased activity of antioxidant enzymes, polyamines and phenolic compounds, which maintain a low level of H_2O_2, especially at the site of aphids feeding. However, increasing number of feeding insects generates an increase in the level of H_2O_2 and final products of unsaturated fatty acids destruction with a decrease in the activity of antioxidant enzymes and accumulation of phenolic compounds and PR proteins in galls and adjacent tissues. The aphids leave the senescing galls, which eventually dry up along with the adjacent leaf blade fragment. The disadvantageous effect of insects feeding is limited only to the gall and its immediate vicinity - a part of the leaf with clear deformations and discoloration. The cost of aphids developing in closed gall is the limited reproductive capacity and the need for rapid migration to a secondary host.

I consider the following to be the most important achievements

- Demonstration of an involvement of polyamines, APX, CAT and phenolic compounds in the process of *T. ulmi* galls formation.
- Evidence that feeding of fundatrix and its progeny differentiates the physiological and biochemical reaction of the plant. The feeding of individual fundatrix larvae stimulated the activity of APX, CAT, LDC and ODC enzymes in the tissues of the host plant. Food intake by aphids of the second generation induced oxidative stress, increased activity of PR proteins (chitinase and β-1,3-glucanase) and the level of phenolic compounds in both galls and leaf blades.
- Demonstration that the feeding of gall-forming aphids is an important biotic stress factor decreasing the efficiency of photosynthesis in elm leaves.
- Expanding the knowledge about an effect of gall-forming aphids feeding on the metabolism of host plants makes an important contribution to explaining the defense mechanisms

activated in the plant at different stages of galls development. The results obtained allow for a more complete explanation of these processes and are the next step in understanding the phenomenon of gall formation. They also form the basis for planning and conducting further research, and can be used for breeding cultivars resistant to herbivory.

References

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5. DESCRIPTION OF OTHER SCIENTIFIC AND RESEARCH ACHIEVEMENTS

I graduated in 1999. My master's thesis entitled "Species composition and dynamics of aphid occurrence on selected ornamental shrubs in the Academic Park in Lublin" was done in the Department of Entomology under the direction of professor Bożenna Jaśkiewicz. The research carried out as part of my master's thesis enabled me to get acquainted with the methods of aphids collecting, preserving and preparing and their determination.

Since 1 October 2000, I started 3rd stage studies at the Faculty of Horticulture of the University of Agriculture in Lublin. At that time I was included in faunistic and ecological research on aphids conducted by the team of professor Bożenna Jaśkiewicz. In order to improve my research skills, I took part in several scientific consultations with outstanding Polish aphidologists, professor Elżbieta Cichocka, and professor Barbara Wilkaniec. The works concerned the species composition and dynamics of aphid population and the influence of biotic and abiotic factors on their development in specific urban conditions and were part of the multifaceted research on the influence of urbanization pressure on entomofauna formation. The results of the research, conducted with my participation during doctoral studies, were presented during two national scientific conferences (Appendix 3, II.D: 5.1, 5.2, 5.3; Appendix 4, III.B: 2.1, 2.2) and published in the form of 4 original papers (Appendix 3, II.D: 1.1, 1.2, 2.1, 2.2). During this time I also participated in the preparation of 4 scientific articles published in Ochrona Roślin journal (Appendix 3, II.D: 6.1, 6.2, 6.3, 6.4).

In the years 2001-2003, I carried out research on the occurrence of aphids on roses under urban conditions. The observations included shrubs of park rose, rugosa rose, multiflowered rose and floribunda roses. The study was carried out in Lublin in 4 sites with potentially differentiated anthropopressure influence (park, housing estate, by the street, roadside). Ten species of aphids were found on the shrubs: *Macrosiphum rosae* (L.), *Chaetosiphon tetrarhodus* (Walk.), *Metopolophium dirhodum* (Walk.), *Maculolachnus submacula* (Walk.), *Myzaphis rosarum* (Walk.), *Longicaudus trirhodus* (Walk.), *Aphis fabae* Scop., *Eucalipterus tiliae* (L.), *Macrosiphum euphorbiae* (Thom.) and *Aulacorthum* sp. Comprehensive results were used to write a doctoral thesis entitled "Aphids (Homoptera, Aphidodea) ninhabiting roses in urban conditions of Lublin", which was distinguished by the Reviewers and published in the form of 7 original papers and presented during three national conferences (Appendix 3, II.D: 5.4, 5.5, 5.6). Species composition, abundance and dates of occurrence of particular aphid species on the analyzed roses differed significantly. Most species were found in the so-called "noble roses": 9

species on the park rose, 7 species on the floribunda roses of different varieties, while 5 species on the rugosa rose and only 4 species on the multiflowered rose. The species composition of aphids on the analyzed sites was similar, however, significant differences were found in their abundance. The highest number of these insects was found in the street site and the lowest in the park site (Appendix 3, II.D: 1.3, 1.4, 1.5, 3.1; Appendix 4, III. B: 2.3, 2.4, 2.5). The analyzes of dominance and demographic parameters showed that *Ch. tetrarhodus* developed more dynamically on rugosa rose and in a shorter time than *M. rosae* and was a clearly dominant species in the group. *Macrosiphum rosae* was dominant species on other roses (Appendix 3, II.D: 1.6, 2.3). Coccinellidae was the most numerous group of predators observed in aphids colonies, followed by Syrphidae. The number of aphids in the analyzed sites with a potential increase of anthropopression increased, and it was also accompanied (although slightly) by an increase in the number of predators. The lowest number of aphids per predator was noted in the park site, and the largest number in the roadside site. Parasitization of aphids in the years of research was low. The lowest degree of parasitization was observed in the street site and the highest in the roadside site. The lowest aphid parasitization was observed in the case of the park rose, and the highest in the case of the floribunda roses (Appendix 3, II.D. 3.2). Obtained results proved that the number of individual species increases with increasing intensity of urban pressure, however, in areas under the influence of very strong anthropopressure (roadside) the number tends to decrease.

On 7 February 2005, I obtained the degree of Doctor of Agricultural Sciences in horticulture, specialization: plant protection, applied entomology, and since 1 March 2006 I was employed as an assistant in the Department of Entomology (currently Department of Plant Protection) of the Agricultural Academy in Lublin (currently University of Life Sciences in Lublin) for one year. Since 1 March 2007, I have been employed in the above mentioned unit as an assistant professor. In order to increase my professional competences, I completed three scientific internships during this period (Department of Entomology, Warsaw University of Life Sciences; Department of Biochemistry and Molecular Biology, Siedlce University of Science and Technology; Department of Zoology, Vilnius University, Lithuania) and numerous training courses (Appendix 4, III.L: 1-4, III.Q.1).

After commencing professional work, thanks to the cooperation with scientists from the home Department and other scientific entities, i.e., Department of Plant Physiology, Department of Biochemistry and Food Chemistry, Department of Hydrobiology and Ecosystem Protection, at the University of Life Sciences in Lublin; Department of Biochemistry and Molecular Biology at the University of Life Sciences and Humanities in Siedlce, Department of Agricultural and Forestry Sciences and Resources at the University of Córdoba, Spain, **aphidological research has been extended to other groups of arthropods and interdisciplinary studies on the insect - host plant relationship**. My current research interests are focused on:

- bionomy and ecology of phytophagous insects associated with crops and wild growing plants and factors naturally limiting their abundance,
- analysis of physiological and biochemical reactions of plants to herbivorous feeding.

Bionomy and ecological research

Research on bionomy and ecology of species provides valuable information such as: dates of appearance of subsequent developmental stages and generations, number of generations during the year, peak abundance during the season. Data from research on development biology and population dynamics are the basis for the construction of biological and chemical methods of plant protection. Since 2006, within the framework of my own research and statutory activity, I carried out the project concerning **the species composition of gall-forming aphids from the subfamily Eriosomatinae and the influence of their feeding on primary host plants** (Appendix 3, II. I.3, I.4). In addition to the research, the results of which were included in publications documenting the scientific achievement, I conducted research on the quantitative and qualitative structure of galls caused by aphids on *U. glabra*, *U. pumila*, *U. laevis* and *Populus nigra* 'Italica'. The galls of *C. compressa* and *T. ulmi* were demonstrated on elms, while galls formed by *Pemphigus bursarius* (L.), *Pemphigus phenax* Börner&Blunck and *Pemphigus spyrothecae* Pass. were found on poplar. On black poplar, the most numerous were the galls of *P. spyrothecae*, located on the petioles, which were found on more than 60 % of the analyzed leaves. The most numerous species on elms was *T. ulmi*, which most willingly inhabited the Siberian elm (*U. pumila*). At the same time, this aphid feeding caused the most visible damage to plants in the form of drying leaf blade fragments. The results of these studies were presented in the form of a paper at an international scientific conference in Nitra, Slovakia in 2016 (Appendix 4, III.B. 1.5) and published as a scientific paper in conference materials (Appendix 3, II.D. 4.1). I am also a co-author of work concerning gall-forming aphids and wasps of the Lublin region (Appendix 3, II. D. 1.10). The observations showed occurrence of galls of 11 species of Cynipidae and 2 species of aphids from the subfamily Eriosomatinae on different species of oaks and elm trees. Richer species composition of gall-forming insects was recorded at urban sites. A new to the Lublin region Cynipidae species, *Andricus inflator* (Hart.), was shown. The results of the above research were presented in the form of a poster at the international conference "Plant - the source of research material" in 2012 (Appendix 4, III.B. 1.3). **The results of many years of research on gall-forming aphids were widely presented at international and national scientific conferences** (Appendix 3, II D: 5.11, 5.13, 5.16, 5.19, 5.24, 5.27, 5.28, 5.29). The following were presented: two oral presentations at international conferences in 2016 in Nitra (Slovakia) and in 2017 in Valencia (Spain), three papers and two posters at cyclical national Hemipterological Conferences in 2007, 2013, 2015 and 2017 (Appendix 4, III.B: 1.5, 1.6, 2.6, 2.10, 2.11, 2.14). These issues were also presented during scientific meetings of the Lublin Division of the Polish Entomological Society (Appendix 3, II.K. 3, 9). **The topicality and rank of these works** (published in 2018) **on the international arena is evidenced by their citations in journals of JCR database: PLoS ONE, Photosynthetica, Environmental Entomology.**

Another conducted research were the observations on **the biology of development and harmfulness of *Phyllaphis fagi* L.** colonizing various varieties of common beech in Lublin, the results of which were published in Acta Scientiarum Polonorum Hortorum Cultus (Appendix 3, II.A.1). ***Phyllaphis fagi*** inhabits beeches growing in natural sites, in urban greenery and grown in nurseries. The obtained results showed that the oviparous females laid fertilized eggs mainly on the bottom side of branches and in forks of 2-3 year old shoots, preferring places with rough bark. Hatching of fundatrix larvae was observed in April, when buds on the investigated trees were not yet developed. Very mobile larvae were wandering along the shoots heading towards cracked leaf buds. When the leaves appeared (April/May) they started feeding and their body was covered with abundant wax secretion. The pre-reproduction period of the fundatrix generation lasted 14 days on average, and the reproduction period 18 days on average. One female gave birth to an average of 45 larvae. The first generation of virgines was characterized by the shortest periods of pre-reproduction and reproduction, and the female fertility was very high, averaging almost 60 larvae/female. Periods of pre-reproduction and reproduction of subsequent generations were prolonged with simultaneous decrease in females fertility. In summer, single, dwarf individuals were observed on the leaves. Their rearing in isolators under field conditions showed high mortality even in the larval stage. Oviparous females and winged males on leaves were recorded at the turn of September and October. *Phyllaphis fagi* formed colonies on both the lower and upper side of the leaves. In early spring it also settled petioles. **Aphids feeding caused wrinkling of the leaf blades along the midrib. Significant damage was visible even if several individuals were present on the leaf.** This species excreted honeydew, which covered not only the leaves colonized by aphids, but also those below. **Due to the intensive development, aphids of this species may be particularly dangerous for young beech plants and specimens grown in containers.**

In cooperation with entomologists from my home department I conducted research on the phenology of the **invasive *Pulvinaria floccifera* (Westwood) species**. This cosmopolitan polyphagous coccid is widely distributed especially in the Holarctic region. It is a dangerous pest of fruit trees and ornamental plants mainly in tropical and subtropical regions. In northern and central Europe, the occurrence of this insect was limited to crops under cover. In recent years, an expansion of the range of host plants and the range of occurrence under field conditions has been observed. In Poland, this species is included in the group of invasive alien species. Studies carried out in the Warsaw area on evergreen holly shrubs showed the **ability to overwinter and year-round development of *P. floccifera* under field conditions in Poland**. This species overwintered in the form of second and third instar and developed one generation per year. The only stage actively moving along the host plant in search of a suitable feeding site were first instar larvae. Subsequent developmental stages did not change the place of feeding anymore. Every year the highest population size was observed in July and August. The obtained results proved that **temperature is an important factor reducing the number of this species**. High mortality of wintering larvae was recorded in subsequent years of observation, which was reflected in a significantly lower number of insects in subsequent growing seasons. However, increasingly warmer winters in Poland may be conducive to mass appearance of this species. In the field conditions of Poland, *P. floccifera* currently inhabits only holly shrubs, however, **there is a high probability of this insect development on other evergreen plants** such as holly-leaves barberry, Euonymus and rhododendron commonly cultivated in our country. The results of the above research were presented during the 24th National Scientific Conference "Aphids and Other Hemiptrous Insects" (Appendix 3, II.D. 5.20; Appendix 4, III.B. 2.11) and published as an original paper (Appendix 3, II.A. 13).

In the era of compulsory use of integrated methods of plant protection, research aimed at detection and monitoring of harmful species and analysis of a set of factors limiting their abundance under field conditions are of particular importance. I participated in research on the occurrence of *Synanthedon tipuliformis* (Cl.) and *Anarsia lineatella* (Zeller) in the vicinity of Lublin. *Synanthedon tipuliformis* is one of the pests commonly found in currants of various species. Due to the steadily decreasing profitability of soft fruit production, outlays on plantation protection decrease, and some of them are left as so-called orchard wastelands. Catches of butterflies for pheromone traps carried out in Lublin and its surroundings on blackcurrant plantations devoid of chemical plant protection showed that the **thresholds of harmfulness to *S. tipuliformis* were exceeded in each year of the study**. The high intensity of butterflies' flight most often lasted from the end of May to July. Definitely more butterflies were caught on a plantation located near farmlands and orchards as compared to a plantation located on the outskirts of the city. The analysis of shoots taken from plantations showed that the harmfulness threshold was also exceeded, but the degree of damage in subsequent seasons was lower than predicted on the basis of catches to traps (Appendix 3, II.D. 1.8). *Anarsia lineatella* is considered to be the most dangerous peach pest. It is a species attacking fruits and shoots of stone fruit trees, i.e., peaches, apricots and plums. In Poland it was a quarantine species until 2004. **The catches for pheromone traps showed the occurrence of *A. lineatella* in the Lublin area**. This species developed two generations in our climatic conditions, with the number of males of the first generation being significantly higher in comparison to the number of specimens of the second generation. Prolonged growing season and repeated mild winters in Poland, as well as the prevalence of potential host plants of this pest such as plums, sloes, wild cherry, cherry and pear can have a beneficial effect on both the abundance and the number of *A. lineatella* generations. There is also a danger of this species foraging in apple orchards (Appendix 3, II.D. 1.9). The results of *S. tipuliformis* and *A. lineatella* monitoring of were presented during the 49th and 50th Scientific Session of IOR-PIB (Appendix 3, II.D: 5.7, 5.8; Appendix 4, III.B. 2.8, 2.9).

I also participated in studies on **parasitoids associated with *Swammerdamia pyrella* (Villers) wintering larvae and *Phyllonorycter coryli* (Nic.) as well as *Phyllonorycter nicellii* (Stt.) larvae mining hazel leaves**. *Swammerdamia pyrella* is currently a non-threatening species in intensive orchards, but can be a problem in orchards with limited chemical protection, in organic orchards and in newly established crops. The research was carried out near Lublin in orchards diversified in terms of age and exploitation, where chemical pest control and fertilization had not been carried out for a long time. The rearing of 303 pupae of *S. pyrella* resulted in obtaining 112 parasitic wasps belonging to 7 species within 4 subfamilies: Ichneumonidae, Eulophidae, Pteromalidae and Eupelmidae. It should be emphasized that as many as **4 species were identified from this host for the first time**. Thus, the study increased the list of *S. pyrella* parasitoids described in Poland from 21 to 25 species. Parasitizing of moth pupae in particular years of the study was differentiated and varied from 12.7 to 47.4%. In the first year of the study, the most numerous group of parasites were hyperparasitoids with a clear dominance of *Gelis agilis* F. In the following years, however, the group of primary parasitoids prevailed (Appendix 3, II.A. 3).

Two species of moths of the genus Phyllonorycter are nutritionally associated with both the common hazel (*Corylus avellana*) and the ornamental red-leaved hazel (*Corylus maxima* 'Purpurea'). *Ph. coryli* larvae form mines on the upper side of the leaves, while *Ph. nicelli* feeds in mines on the lower side of the blades. A total of 14 parasitic hymenopteran species were obtained from larvae and pupae of bothleaf-mining species. From this group, **4 species have not yet been listed as parasitoids of the genus Phyllonorycter**. The group of *Ph. coryli* parasitoids consisted of 11 species belonging mainly to the family Eulophidae, with the highest contribution of *Pediobius saulius* (Walk.). Out of this group, 7 species were shown for the first time from *Ph. coryli*. In the group of *Ph. nicellii* parasitoids, 13 species were found, 8 of which were demonstrated for the first time with this host. The highest percentage contribution in the parasitoid complex of *Ph. nicelli* was demonstrated for *Chrysocharis pentheus* Walk. (Appendix 3, II.A. 12).

In the year 2014, I was the main contractor of the research task entitled **"Analysis of species composition of entomofauna inhabiting downy willow (*Salix lapponum*) and blueberry willow (*S. myrtilloides*) in natural sites in the Łęczyńsko-Włodawskie Lakeland"** within the framework of the Ministry of Science and Higher Education grant: "Ecology of population and active protection of boreal relics from the family Salicaceae (*Salix lapponum* and *Salix myrtilloides*) in Lublin Polesie", governed by Magdalena Pogorzelec, PhD, from the Department of Hydrobiology and Ecosystem Protection University of Life Sciences in Lublin. Both in natural communities and in agroecosystems, insects feeding significantly affects the growth, competitive ability and population dynamics of host plants. **So far, no research has been carried out on the occurrence of phytophagous insects on downy willow**. The observations covered the largest population of downy willow in eastern Poland growing in the peat bog near Bikcze Lake in the Łęczyńsko-Włodawskie Lake District. *Salix lapponum* is a relict species exposed to extinction in Poland. The main aim of the research was to answer the question whether insects colonizing downy willow in natural conditions pose a real threat to plants. The research included: identification of species composition of herbivorous colonizing shrubs in a selected site, determination of whether and which species may have a significant impact on the condition of plants, determination of plant reactions to feeding of the most numerous phytophagous on the basis of measurement of chlorophyll *a* fluorescence and determination of hydrogen peroxide level in leaves of selected plants. The **presence of 8 phytophagous insect species representing 4 orders (Hemiptera, Coleoptera, Lepidoptera and Diptera) was showed on willow shrubs**. The beetles included 3 species, lepidopterans and hemipterans included 2 species each, and flies included 1 insect species. Most of the herbivores noted on *S. lapponum* are nutritionally related to the Salicaceae family, the representatives of which have a significant share in the studied phytocenosis. Most of the downy willow shoots were inhabited by *Lochmea caprea* (L.) larvae (65.2%), *Aphorophora salicina* (Goeze) larvae (43.2%) and *Aphis farinosa* (Gmel.) larvae and imagines (16%). Other species inhabited single shoots. The greatest damage in the form of scraped leaves (more than 47% of the analyzed blades) was observed as a result of *L. caprea* feeding. On the other hand, feeding of both hemipterous species did not cause visible damage to plants. Regardless of the feeding method or the degree of plant damage, the life activity of phytophagous induces the physiological-biochemical response of the plant. Histochemical detection of H_2O_2 in *S. lapponum* leaf tissues showed its accumulation only near wound sites caused by insect feeding. Measurements of chlorophyll fluorescence in leaves of plants inhabited by 3 most numerous species: *A. farinosa, A. salicina* and *L. caprea* did not show any significant disturbances in the photosynthesis process. It was proved that the **observed phytophagous had a slight influence on the course of physiological processes of S. *lapponum***. The obtained results were presented during the international conference "Horticulture in shaping life quality" (Appendix 3, II.D. 5.17; Appendix 4, III.B. 1.3) and published as an original paper (Appendix 3, II.A. 14). **The research on entomofauna of downy willow will be continued and will be extended** with the analysis of plants obtained in tissue cultures and introduced in 2018 to habitats during reintroduction of native populations under the project **"Active protection of particularly endangered relict plant species from the Salicaceae family in peat bog habitats"** **POIS.02.04.00-00-0008/17** co-financed under the Operational Programme Infrastructure and Environment 2014-2020, headed by Magdalena Pogorzelec, PhD. In this project **I am the author of the methodology of research and the main researcher** of the task entitled "Entomological monitoring of newly created populations of *Salix lapponum* and *S. myrtilloides*".

Phytophagous arthropods– host plants interactions

Research on the natural resistance of plants and the complex relationships between phytophagous and host plants are important in modern plant protection. Orchids, especially those of the genus Phalaenopsis, thanks to the development of efficient methods of their propagation and the introduction of new, less demanding varieties, are currently among the most popular ornamental potted plants. Scale insects (Hemiptera, Coccomorpha), especially from the Pseudococcidae family, are particularly eager to feed on these plants. Due to the lack of studies on the influence of mealybugs feeding on orchid health in the available scientific literature, an interdisciplinary project was undertaken within the framework of a multi-centre cooperation to **investigate the physiological and biochemical reaction of *Phalaenopsis* x hybridum 'Innocence' to the feeding of *Pseudocococcus longispinus* and *Pseudococcus maritimus***. The study was carried out under controlled laboratory conditions. The results were published in the form of five original papers (Appendix 3, II.A: 4, 5, 7, 9, 11) and widely presented at international (Appendix 3, II.D: 5.9, 5.14, 5.15, 5.18, 5.25) and national conferences (Appendix 3, II.D. 5.21). The listed species of scale insects feed on the leaves, inflorescence shoots and air roots of orchids. They are particularly difficult to notice in the initial stage of plant settlement, when they are mainly located in the corners of the leaves. Visible damage to plants is the yellowing and drying up of leaves, flower buds and flowers. Additionally, the plants are covered with honeydew excreted by the insects. In the study, orchids without inflorescence shoots with seven developed leaves were colonized with third instar larvae and young females of *P. longispinus* or *P. maritimus*. In the first experiment, 5 individuals were transferred to orchids and the transferred insects remained on the plants for 24 hours, 7 and 14 days respectively. It was shown that **feeding only 5 individuals on the plant induced oxidative stress in its tissues and triggered a defensive reaction** in the form of a significant increase in the activity of antioxidant enzymes, i.e., peroxidase and catalase, already after 24 hours of scale insects feeding. In this period, a significant increase in tyrosine decarboxylase activity was also observed. Analyses carried out in subsequent time intervals showed that the prolonged period of mealybugs feeding did not intensify stress nor the plant's defensive reaction. On the contrary, a gradual decrease in membrane lipid peroxidation and antioxidant enzymes activity was observed. On the other hand, **the prolonged period of scale insects feeding stimulated the activity of the analyzed decarboxylases**, which proves that the tested plants excited the mechanisms of natural resistance, since, as it was shown, decarboxylation of amino acids is a part of the plant's response to feeding insects with piercing-sucking mouthparts. It should be emphasized that on the basis of the analysis of all investigated compounds, the reaction of orchids to *P. longispinus* feeding was stronger compared to *P. maritimus* (Appendix 3, II.A. 4, 5, 9). **The activity of both species of scale insects also caused disturbances in the course of photosynthesis process**. Measurements of chlorophyll *a* fluorescence showed a significant decrease in maximum quantum yield of PS II (F_v/F_m), which is an indicator of stress tolerance, after 24 hours of mealybugs feeding. After 7 and 14 days of P. *maritimus* feeding, the F_v/F_m value gradually increased and was similar to that in control plants. On the other hand, in plants inhabited by *P. longispinus*, the quantum yield of PS II showed a downward trend (Appendix 3, II.A. 9). Studies on the effect of different density of feeding individuals of *P. longispinus* on stress level and antioxidative activity in the tissues of the host plant were also carried out. Test plants were inhabited with 5, 20 and 50 individuals and the measurements were made after 10 days of scale insects feeding. The results of the experiment confirmed that even single insect feeding is a stress factor (intensification of lipid peroxidation and electrolytes leakage from cell membranes) stimulating the activity of antioxidant enzymes (peroxidase and catalase) and proline synthesis in plants. At the same time it should be emphasized that the **feeding of more numerous insects did not strengthen the changes in the analyzed parameters, except for electrolytes leakage and catalase activity (**Appendix 3, II.A. 7). In another experiment the effect of *P. maritimus* feeding on the content of phenolic compounds and free amino acids as well as the activity of enzymes involved in metabolic changes causing the increase in the content of some secondary metabolites, i.e., L-Phenylalanine ammonia-lyase (PAL) and L-tyrosine ammonia-lyase (TAL) was investigated. The content of the above substances and enzyme activity were determined after 1, 5 and 24 hours, and 7 and 14 days of feeding of five individuals of *P. maritimus*, respectively. Significant increase in the content of free amino acids in orchid leaf tissues during the experiment was proved. In the case of phenolic compounds, a decrease in their content was observed during the first five hours of feeding, their rapid increase was noted after 24 hours of insects activity and then a second reduction was found. The feeding of *P. maritimus* significantly inhibited the activity of TAL at each stage of the study. In turn, PAL activity was significantly higher during the first five hours of insects feeding. This enzyme is involved in the biosynthesis of phytoalexins, transformation of phenolic compounds to lignin-like substances and induction of salicylic acid synthesis (Appendix 3, II.A. 11).

In the context of herbivores - host plants interactions, studies on the influence of *Coccus hesperidum* scale insect feeding **on the course of photosynthesis in host plants** were also carried out. The experiment used lemon *Citrus limon* 'Ponderosa' and fern *Nephrolepis biserrata* plants, which were colonized with 10, 30, 50, 100 and 200 first instar larvae, and then cultivated under controlled conditions for 6 months. After calculating the number of insects present on the plants, 5 classes of pest density were determined depending on the average number of individuals on the leaf. Next, fluorescence of chlorophyll and the content of chlorophylls and carotenoids in leaves were measured in each class. The visual analysis of plants showed visible symptoms of insects feeding in the form of chlorosis and necrosis of leaves and their falling. *C. hesperidm* feeding had a negative influence on the photosynthesis intensity in the tested plants. A significant decrease in the level of photosynthetic pigments in the analyzed leaves, as well as in the maximum photochemical yield of PSII, quantum yield of photochemical reaction in PSII and photochemical quenching was proved. The value of non-photochemical quenching increased. It should be emphasized that the degree of pigment reduction was basically correlated with the number of pests feeding on leaves, although a stronger reaction was detected in fern plants compared to lemon. A similar relationship was also found in the measured parameters of chlorophyll fluorescence. The results obtained were published as an original scientific paper (Appendix 3, II.A. 6).

I also participated in a study on **the effect of *Acrobasis advenella* (Zinck.) caterpillars feeding on the content of selected secondary metabolites in inflorescences of *Sorbus aucuparia* and *Aronia melanocarpa*** (Appendix 3, II.A. 2). *Acrobasis advenalla* is a moth spread all over Poland and is associated with plants of the genera Crataegus, Sorbus and Prunus. The caterpillars feed on flower buds, damaging on average about 20% of the buds in the inflorescence. This species was shown in 2004 on black chokeberry plantations. The choice of the host plant by insects depends, among others, on its biochemistry. Plant secondary metabolites are compounds that have a deterrent effect on insects. These substances can directly or indirectly influence the feeding intensity and growth of phytophagous, body size at different stages of development and fertility of imagines. The obtained results proved that the content of flavonoids and phenolic acids in inflorescences of *S. aucuparia* and *A. melanocarpa* was similar, while the differences in the level of tannins, which significantly higher content was found in chokeberry inflorescences, were found. Tannins as compounds that can form complexes with proteins and have the ability to inactivate digestive enzymes are perceived as one of the main barriers protecting against phytophagous feeding. However, the high content of these compounds in chokeberry inflorescences was not a barrier for *A. advenella*. The feeding of caterpillars in rowanberry inflorescences in all the years of the study caused a significant decrease in the content of phenolic acids with simultaneous growth or lack of differences in the content of tannins. On the other hand, the level of all studied secondary metabolites in chokeberry inflorescences decreased significantly in each year of the study. **The obtained results indicate that *A. melanocarpa* does not show resistance to *A. advenella* feeding.**

As part of the multicentre scientific cooperation with employees of the University of Life Sciences and Humanities in Siedlce, the University of Zielona Góra and the University of Life Sciences in Poznań, I participated in research aimed at establishing the **influence of wingless females feeding on the expression level of clh2 gene encoding chlorophyllase (CLH), activity of the CLH enzyme and chlorophyll *a* content in *Zea mays* seedlings' leaves**. Six maize genotypes (Ambrosia, Eleganza, Tasty Sweet, Touran, Vasa, Złota Karłowa) differing in the degree of resistance to the tested aphid species were used in the experiment. The conducted biotests proved that *R. padi* feeding stimulated the accumulation of clh2 transcript and chlorophyllase activity and caused the decrease in chlorophyll *a* level in seedlings of the tested cultivars. The tissues of susceptible cultivars Tasty Sweet and Złota Karłowa were characterized by the strongest reaction. The lowest modifications in the level of analyzed parameters were observed in seedlings of resistant cultivars Ambrozja and Waza. **It was proved that CLH enzyme activity in maize seedlings colonized by aphids was regulated both at the transcriptional and post-transcriptional levels** (Appendix 3, II.A. 10).

Another research problem was **the analysis of the effect of the use of Juglone (JU; 5-hydroxy-1,4-naphthoquinone) on the expression level of *Cat1, Cat2* and *Cat3* genes encoding appropriate catalase isoenzymes in seeds of maize and wheat**. The germination efficiency, catalase activity and H_2O_2 content in cereal seeds exposed to juglone were also evaluated. The application of JU significantly stimulated the abundance of three target catalase transcripts, as well as induced CAT activity and production of H_2O_2 in both maize and wheat grains. The application of juglone also inhibited the germination process of grains of both investigated cereals (Appendix 3, II.A. 15).

Recently I have also worked with **Inmaculada Garrido Jurado, PhD, from the Department of Agricultural and Forestry Sciences and Resources, University of Córdoba**. The result of the joint research is the preparation of a paper accepted for publication in the Journal of Economic Entomology (Appendix 3, II.A. 16). The experiment analyzed the susceptibility of three cultivars of basil *Ocimum basilicum* L.: 'Sweet basil', 'Purpurascens' and 'Fino Verde' to *Tetranychus urticae* Koch feeding. The feeding preferences of *Tetranychus urticae* were determined using a "selection test". The reaction of host plants to pest feeding was analyzed on the basis of H_2O_2 and malondialdehyde (MDA) content and the activity of guaiacol peroxidase and catalase in inhabited leaves. It was shown that 'Purpurascens' cultivar was the most resistant to *T. urticae* feeding, which was reluctantly chosen by the pest and in which a strong defensive reaction was recorded already after 24 hours of insect feeding.

6. Summary

The main object of my scientific interest are aphids and other hemipterans inhabiting cultivated and ornamental plants and interactions between phytophagous and host plants. Conducting research in this area constitutes a good basis for teaching classes in the form of lectures and exercises for students of the faculties: Horticulture and Landscape Architecture, Agrobioengineering, and Biology, Animal Sciences and Bioeconomy of the University of Life Sciences in Lublin. I am the author and co-author of 10 educational modules. Under my direction, 13 master's theses and 10 engineering theses have been prepared. I made 14 reviews of diploma theses. Three times I was a member of the examination board for student internships. I am a member of the Programme Council of *Herbal Science and Plant Therapy*.

I was a researcher in project financed by the Ministry of Science and Higher Education "Ecology of population and active protection of boreal relics from the Salicaceae family (*Salix lapponum* and *Salix myrtilloides*) in Lublin Polesie" (NN304385239). I also carried out 1 expert opinion commissioned by the District Court in Poznań concerning the settlement of the production line by pests.

I took part in 7 international and 14 national scientific conferences, where I gave 5 oral presentation and presented 25 posters. I co-organized an international scientific conference "Horticulture in shaping life quality".

For eleven years I have been a member of the Hemipterological Section of the Polish Entomological Society, and for ten years I have been a member of the Polish Entomological Society. I served as a member of the Audit Committee (2010-2013) and Deputy Chairman (2013-2016) in the structures of the Lublin Division of the Polish Entomological Society.

I have reviewed 2 publications for journals of the JCR database distinguished with the IF coefficient: Pest Management Science and Journal of Agricultural Science and Technology and 4 manuscripts for national journals listed in the list of the Ministry of Science and Higher Education: Electronic Journal of Polish Agricultural Universities, Agronomy Science, Folia Pomeranae Universitatis Technologiae Stetinensis Agricultura, Alimentaria, Piscaria et Zootechnica, Herba Polonica, as well as 1 chapter in the monograph "Vegetation of roadside strips in Lublin. Potential and threats".

I had one month's foreign scientific internships concerning morphological, taxonomic and phylogenetic analysis of the scale and aphid species. I also participated in two national internships, perfecting the ability to analyze biochemical and molecular connections of aphids

with host plants and broadening knowledge in the field of systematics, biology and ecology of mites and their interactions with host plants.

I was a member of the Team for Parametric Evaluation of the Faculty of Horticulture and Landscape Architecture and an elector entitled to elect the Dean and Vice-Deans of the Faculty of Horticulture and Landscape Architecture. Currently, I am a member of the Programme Council of *Herbal Science and Plant Therapy* and the Guardian of the year for full-time students of the first degree in *Plant Protection and Phytosanitary Control*. I am also a supervisor of the entomological section of the Student Scientific Club of Plant Protection SKOR. Every year I take an active part in the preparation and implementation of popular science projects within the framework of subsequent editions of the Lublin Science Festival. I was also involved in the promotion of the Faculty of Horticulture and Landscape Architecture at the University of Life Sciences in Lublin during "University Open Doors".

My scientific achievements, together with papers documenting scientific accomplishment, comprise 77 papers. In this number there are 30 original works, 4 chapters in English monographs, 2 chapters in Polish monographs, 1 scientific paper in conference materials, 30 published abstracts, 5 scientific and popular science articles, 4 collective studies and 1 expert opinion. Out of 30 original papers, 19 were published in journals from Journal Citation Reports database.

A summary of the scientific achievements is presented in Table 1 and 2.

Table 1. Summary of scientific papers published in journals with MNiSW scores

No.	Journal	Numer of publications (year)	IF (in publication year)	Points according MNiSW	Item number in Appendix 3
A. Before PhD degree					
Papers in scientific journals from the list B according MNiSW					
1.	Zeszyty Naukowe Akademii Rolniczej im. H. Kołłątaja w Krakowie	1 (2002)	-	3	II.D.1.1
Chapters in scientific monographs					
2.	Aphids and Other Homopterous Insects	2 (2001)	-	2 x 6	II.D.2.1; D.2.2
3.	Fauna miast Europy Środkowej 21. wieku	1 (2004)	-	3	II.D.3.1
Papers in other journals					
4.	Scientific works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture	1 (2003)	-	2	II.D.1.2
5.	Ochrona Roślin	2 (2001) 1 (2002) 1 (2004)	- - -	2 x 0,5 0,5 0,5	II.D.6.1; D.6.2 II.D.6.3 II.D.6.4
B. After PhD degree					
Papers in scientific journals from Journal Citation Reports (JCR) database					
6.	Acta Scientiarum Pololonorum, Hortorum Cultus	1 (2012) 1 (2014) 1 (2013) 1 (2018)* 1 (2007) 1 (2006)	0,691 0,552 0,522 0,448 - -	20 20 20 20 9 4	II.A.1 II.A.4 II.A.2 I.B.6 II.D.1.7 II.D.1.4
7.	Acta Biologica Hungarica	1 (2018)	0,439	15	II.A.15
8.	Arthropod-Plant Interactions	1 (2017) 1 (2015)	1,591 1,448	30 30	II.A.11 II.A.6
9.	Biochemical Systematics and Ecology	1 (2016)	0,929	15	II.A.10
10.	Bulletin of Entomological Research	1 (2015) 1 (2018)*	1,761 1,721	35 35	II.A.7 I.B.3
11.	Bulletin of Insectology	1 (2015)	1,075	20	II.A.8
12.	Dendrobiology	1 (2018)	0,761	20	II.A.14
13.	Environmental Entomology	1 (2018)*	1,661	30	I.B.5
14.	Journal of Economic Entomology	1 (2016)	1,824	35	II.A.9
15.	Journal of Insect Science	1 (2014)	1,025	30	II.A.3
16.	Journal of Plant Interactions	1 (2014)	0,837	20	II.A.5
17.	Photosynthetica	1 (2018)*	1,740	25	I.B.4
18.	Turkish Journal of Zoology	2 (2017)	0,558	2 x 20	II.A.12; A13
Papers in scientific journals from the list B according MNiSW					
19.	Annales UMCS, EEE	1 (2007) 1 (2010)*	- -	2 2	II.D.1.5 I.B.2
20.	Electronic Journal of Polish Agricultural Universities, Topic Forestry	1 (2013)	-	7	II.D.1.10
21.	Electronic Journal of Polish Agricultural Universities, Topic Horticulture	1 (2007)	-	4	II.D.1.6
22.	Progress in Plant Protection/Postępy w Ochronie Roślin	1 (2010)	-	2 x 6	II.D.1.8;.D1.9
Chapters in scientific monographs					
23.	Aphids and Other Hemipterous Insects	1 (2005) 1 (2007)*	- -	6 6	II.D.2.3 I.B.1
Papers in other journals not listed by MNiSW					
24.	The Journal of Agrobiology and Ecology	1 (2005)		2	II.D.1.3
	total A+B (for scientific achievement)	**39 (6)**	**20,141 (5,57)**	**536 (118)**	

*papers constituting scientific achievement

Table 2. Detailed bibliometric data

L.p.	specification	before PhD degree	after PhD degree	total
1.	Number of papers in journals from JCR database	0	19	**19**
2.	Number of other scientific papers	5	13	**18**
3.	Number of scientific articles	4	0	**4**
4.	Number of abstracts	5	25	**30**
5.	Expert opinion	0	1	**1**
6.	Number of popular science articles	0	1	**1**
7.	Collective studies	0	4	**4**
8.	Total number of publications	14	63	**77**
9.	Total MNiSW score acc. to publication year	22	514	**536**
10.	Summary IF in publication year	0	20,141	**20,141**
11.	Number of citations (without self-citations) according to Web of Science*	0	39 (22)	**39 (22)**
12.	Hirsch index according to Web of Science*	0	3	**3**

* data on 18 January 2019

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