

Aesculus hippocastanum L. State Changes in Lithuania

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Abstract

Common horse-chestnut (*Aesculus hippocastanum*) is an introduced plant and has been successfully used for planting for a long time in Lithuania. The state of the *A. hippocastanum* growing in larger cities was assessed in 1992-2009. Moreover, the assessment was carried out throughout the entire country during 2006-09. The results of the research described the changing situation of *A. hippocastanum* during the investigative period: the state was sufficiently good for separate periods, but it began to deteriorate in 1995-97, when a *A. hippocastanum* was infected with fungi diseases (agents – *Guignardia aesculi*, *Erysiphe flexuosa*, and *Schizophyllum commune*). Unfavourable environmental conditions had also made an influence, whereas horse-chestnut leafminer (*Cameraria ohridella*) was the most harmful pest over all territory of Lithuania since 2005-06. This invasive pest is common in most European countries. Noteworthy of fallen leaves elimination is the most effective mean restraining abundance of *C. ohridella* and the spread of fungi diseases.

Keywords: *Aesculus hippocastanum*, diseases, pest, environment

Introduction

Aesculus hippocastanum L. is referable to the Sapindaceae family and Hippocastanoideae subfamily. This species originated from the southern Balkan peninsula, in northern Greece, and in southern Bulgaria. *A. hippocastanum* was brought from Constantinople to Western Europe in the late 16th-early 17th centuries [1]. There are no exact records about the beginning of the introduction of *A. hippocastanum* in Lithuania. Initially they were grown in parks of manor houses, and later this species spread because of favourable climatic conditions. Currently *A. hippocastanum* is a common ornamental plant in green areas of Lithuanian cities. These ornamental trees are grown in parks, squares, on roadsides, and near country-houses. *A. hippocastanum* is not the main ornamental species in city greeneries, as together with *Acer negundo* L. and *A. pla-*

tanoides L. it reaches about 20% of all tree species used for city greening [2]. Thus *A. hippocastanum* is used quite rarely.

A. hippocastanum has been in a sufficiently good state for a long time because of tolerable climatic conditions and the absence of disease agents and harmful pests. However, the situation has changed during recent years and the state of *A. hippocastanum* is deteriorating. The phytopathological state of *A. hippocastanum* worsened a few years earlier in countries situated to the west and south of Lithuania. The causes of the impairment are both biotic (new disease agents and pests appeared over a short time) and abiotic (climate change). However, despite the economic importance of pests and pathogens that represent a key component of the chestnut environment, species variation for disease resistance remains poorly understood.

The aim of our study was to assess the factors determining changes of state to the common *A. hippocastanum* growing in Lithuania during 1992-2009.

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Table 1. Scale of tree damage assessment.

Damage degree	Characteristics	Point
Relatively healthy	Leaf or trunk defoliation up to 10%, crown characteristic of the species, trees without signs of weakening	1
Weakened	Trees with slightly open crown reduced increment leaves, trunks or root defoliation up to 11-25%	2
Weak	Open crown highly reduced increment or its absence 26-50% of leaves, branches or trunks are damaged or dead	3
Dying	Crown is extremely open 51-80% of leaves, branches or trunk are damaged	4
Dead leaves, fresh deadwood	81-100% of leaves, branches or trunk is damaged. Recently dead trees. Leaves and branches could be with fungi <i>mycothallus</i>	5

Materials and Methods

The state of *A. hippocastanum* was investigated and assessed every July during 1992-2009 in the larger cities of Lithuania (Vilnius, Kaunas, Panevėžys, Šiauliai, Klaipėda, Marijampolė, etc.). Due to the wide dispersal of *C. ohridella*, the state of *A. hippocastanum* was begun to be assessed over the entire territory of Lithuania in 55 cities and settlements in total. For more precise investigation *A. hippocastanum* from three streets, two squares, and one park of Kaunas – the Middle Lithuania city – were chosen. The state of approximately 1,000 trees was assessed. These *A. hippocastanum* were observed from leaf emergence in spring until their fall, and the state of tree trunk was assessed during the period when trees were leafless.

The degree of tree damage was estimated according to the method proposed by A. Ziogas et al. [3] and adapted to our work. The categories of tree state were evaluated within a 5-grade scale (Table 1).

After tree state assessment, the average damage grade was estimated, employing a modified procedure applied in agriculture and forestry [4] according to the formula:

$$V = \frac{\sum_{i=1}^5 (n_i \cdot b_i)}{N}$$

...where:

V – average grade of damage

n_i – number of plants damaged to the same grade and the sum of products of the i -th grade

b_i – the numeric value of the i -th grade

N – number of checked plants

Pathogens were identified according to the symptoms of diseases and fungi morphological features defined by descriptors [5-8]. The pests were described according to G. Deschka and N. Dimic [9].

Statistical calculations were made using MicroSoft Exel 2003.

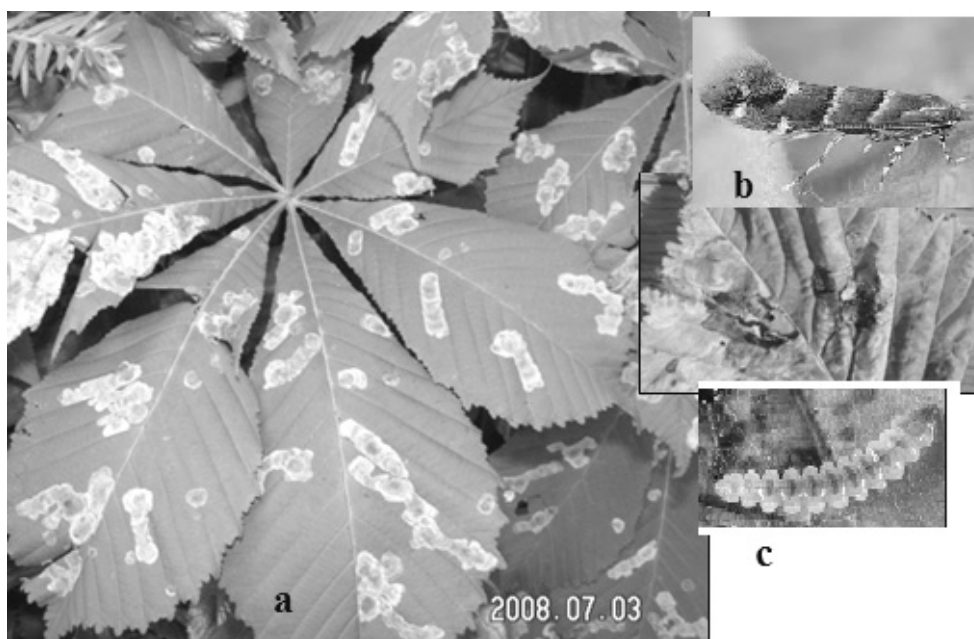


Fig. 1. *Cameraria ohridella* on *Aesculus hippocastanum* (a – damaged leaves of *Aesculus hippocastanum*, b – butterfly, and c – larvae of *Cameraria ohridella*).



Fig. 2. Spread of *Cameraria ohridella* on *Aesculus hippocastanum* in Lithuania in 2009 (1-5 damage point).

Results

In Lithuania *A. hippocastanum* state was quite good and stable until 1997. Later it began to change, with causes varying from year to year. In Lithuania, like in all Europe, new pathogenic fungi and pests appeared every few years, damaging these trees (Figs. 1 and 2).

A. hippocastanum leaves injured by leaf blotch disease, whose agent is *Guignardia aesculi*, (Peck) Stew. (anamorpha *Phyllosticta sphaeropsoides* Ellis & Everk. (syn. *Phyllostictina sphaeropsoides* (Ellis & Everk.) Petr., *Asteromella aesculicola* (Sacc.) Petr.) were first noticed in 1998 (Fig. 4). The spread of this disease is caused by climatic conditions. In springtime, when the leaves of the *A. hippocastanum* are unfolding, the ascospores that manage to place themselves on the leaves, germinate if leaves are dewy for a few hours at least. And later, when fungi spread repeatedly in conidia, the most favourable condition is wet and warm weather [5]. Therefore, it appeared firmly in warm and wet summers of 1998, 2001, and 2003: average temperature of summer months was 19.1-20.9°C and precipitation was 118-144 mm. The disease symptoms include big brown irregularly-shaped spots surrounded by a yellow or brownish edge appear on leaves around the middle of the summer; later they quickly expand and the edge of the leaf starts curling up inward near the spots. Black fruit-bodies are clearly seen in the middle of the spots. The conidia infect leaves repeatedly all summer. Injured leaves fall pre-

maturely. Stromata forms at the end of the summer and over winter inside them. In spring fruit-bodies with spores infecting *A. hippocastanum* emerge in stromata [10]. The occurrence of spotting is subdued according to recent spread of *C. ohridella*.

A new *A. hippocastanum* disease – powdery mildew (causative agent *Erysiphe flexuosa* (Peck) U. Braun & S. Takam) was detected in Kaunas, Lithuania; in 2004. It was also registered in Vilnius and Šiauliai in the same year [11]. Cleistothecia (120-160 mm in diameter) of this fungus consists of 3-5 ascos, each containing 6-8 unicelled ascospores [12]. This fungus originated from North America [7], where it is called *Uncinula flexuosa*, but after genetic research this

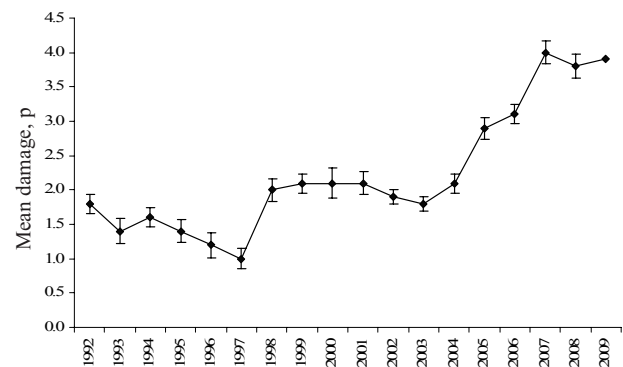


Fig. 3. Dynamics of the horse chestnut damage state in Lithuania during 1992-2009 (mean±SE, p<0.05).

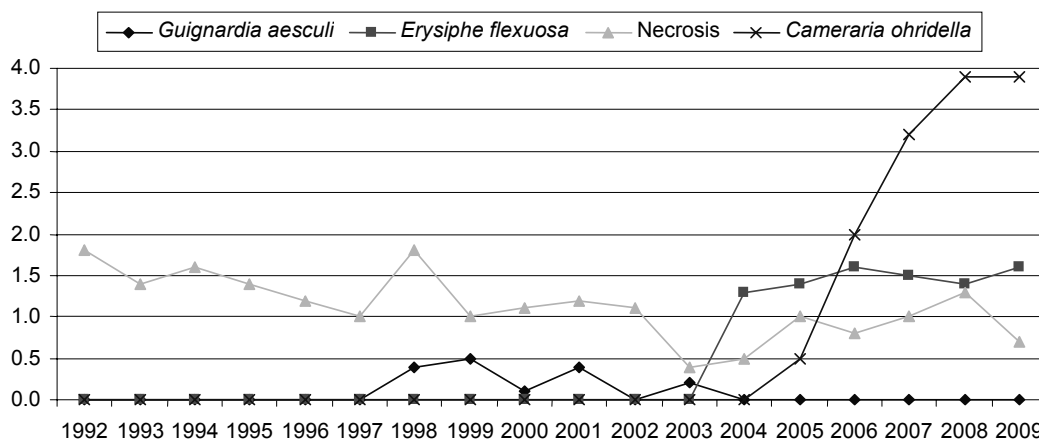


Fig. 4. Dynamics of horse chestnut pests, diseases agents, and necrosis damage in Lithuania during 1992-2009 ($p < 0.05$).

fungus was classified to belonging to *Erysiphe* genus [8]. In Europe it primarily appeared in Germany around 1999 [13] and quickly spread to other countries: Switzerland [14], England [14], Slovakia [13], Slovenia [16], and Hungary [17].

It was ascertained that mildew makes heavier damage for more luxuriant *A. hippocastanum* growing under more favourable conditions and also pruned trees that grow large sprouts. *A. hippocastanum*, growing nearby under the same conditions is not equally resistant to *Erysiphe flexuosa*. Fungus – the causative agent of the mildew affects *A. hippocastanum* in the same way as other powdery mildews do, namely by decreasing leaves' assimilation surfaces and volatilizing water. This impedes photosynthesis and transpiration; in addition, plant decorativeness decreases. Noticeably, a recently spread pest (*Cameraria ohridella* Deschka and Dimic) and not the diseases has been the most harmful factor on horse-chestnut during the last four years in Lithuania (Fig. 3).

C. ohridella was detected for the first time on *A. hippocastanum* near Ochrid Lake, Macedonia, in 1980. In 1984 it was described as a new species [9]. The *C. ohridella* have quickly spread north from Macedonia and after a few years appeared in Croatia, Hungary, and Romania [18]. Later (1989) the *C. ohridella* emerged in Austria [19]. The injuries done by *C. ohridella* were noticed later in other European countries: the Czech Republic and Germany, 1994 [20, 21]; Italy, 1997 [22]; Silesia, Poland, 1998 [23]; Turkey, 1999; France and Bulgaria, 2000 [19, 21]; northern Sweden, Denmark [24], England [21], and Ukraine, 2002 [25]; southern Sweden, 2006 [26].

C. ohridella is an invasive species. *C. ohridella* has originated from the temperate climatic zone, thus it is resistant to frost [26]. The speed of the expansion and the abundance of this insect are features of the invasive species. Both of these features are common for *C. ohridella*. Since its detection in southern Europe (1980), *C. ohridella* had spread into northern European countries (e.g. Finland) during the last three decades.

In Lithuania the first mines on leaves of the *A. hippocastanum* were observed in autumn 2002 in the suburb of

the seaside town Klaipėda. During 2003-04 neither *C. ohridella* nor mines were found there. However, the presence of mines was observed in 14 cities and towns in 2005; this number growing to 27 in 2006 and 40 in 2007 [27]. Even though J. Buszko [26] reported *C. ohridella* as an invasive species in Europe, it had spread throughout Lithuania in 2006 as accidental species without formation of the reproducing population. In 2006-07 *C. ohridella* were found in separate districts of the Latvian-Lithuanian border.

The adult *C. ohridella* moth spread anemochory by air masses. Wind can bring them miles away. In that case, as they get onto *A. hippocastanum* leaves and lay eggs on them a new pest generation develops. When the number of moths is large and trees are thickset in green, the spread is extremely quick.

Different vehicles (long-distance lorries, trains, ferries, etc.) can serve as significant means of distribution. Adult moths and *C. ohridella* pupae sheltered in fallen leaves may 'travel' in this way. The greatest accumulation of this pest was observed in greeneries of larger cities and on roadsides of the main highways [17, 23]. Spreading speed of 50 km per generation was recorded for the *C. ohridella* near the main roads planted with *A. hippocastanum* in Ukraine [25].

Spread of the most important pest of recent years – *C. ohridella* – was observed in 55 cities, towns, and settlements of Lithuania (Fig. 1). The pest spread unevenly over all territory of Lithuania; some regions can be marked as being less influenced by the pest. The healthiest, *A. hippocastanum* grow in western and northeastern Lithuania (mean damage is 1-2 points), most injured trees grow in the middle and southwestern Lithuania (mean damage is 4-5 points) (Fig. 1). *C. ohridella* has spread throughout the country within 7-8 years (since it was first noticed in 2002). Countries situated close to Lithuania were colonized by *C. ohridella* even faster: Poland within 5 years (speed of expansion is 100 km per year) [26].

It is a common practice that the damage grade differs in the same city or town. This depends on the growing conditions and the place. The heaviest damage to *A. hippocastanum* was noticed in parks and streets, where the fallen leaves were left on the ground (near parks, squares, green

fences, or similar places). Nonetheless, trees growing on roadsides under the worst edaphic conditions (covered under-tree) where fallen leaves were removed regularly, had the least number of leaf mines.

Stem damage to young, recently planted *A. hippocastanum* trees are usually caused by growth and climatic conditions. Stems of trees planted in open areas (parking places near shopping malls, streets) are stressed by large temperature fluctuations typical for Lithuania at the end of winter and the beginning of spring. As a consequence, stems fissured. The appeared wounds are colonized by saprotrophic fungus – *Schizophyllum commune* Fr. The fungus starts to parasitize under favourable conditions and cause white surface rot [28]. The dead bark areas enlarge and form necrosis on stems; the bark detaches and leaves naked areas on the stem. Cultivar ‘Baumannii’ trees of the *A. hippocastanum* species brought from Poland to Lithuania were damaged in the same way. Nonetheless, these injuries were not detected on pruned *A. hippocastanum*. Even pruned *A. hippocastanum* trees are more resistant to *S. commune* than the other tree species [29]. The fruit-bodies of *S. commune* were only found on *A. hippocastanum* growing together with trees of other genus (*Tilia*, *Acer*). If streets are planted solely with *A. hippocastanum*, *S. commune* are not detected there, neither on mechanically damaged nor on pruned trees [30].

In Lithuania the intensive pruning of trees growing along roadsides has been exercised since 1995. Various tree species tolerate differently the extremely hard pruning that was done in Lithuanian cities. Large wounds are left after cutting branches of *A. hippocastanum*; they heal poorly, especially those larger than 15-20 cm in diameter; moreover, about 80% of them are affected by wood and pith rot after 2-4 years. A few wounds left will inevitably shorten the tree’s life time.

Part of *A. hippocastanum* trees (up to 30%), especially those located in the narrow streets of old towns and city centres, were starved, and peculiarly had leaf necrosis. The mentioned situation was observed in Kaunas, Panevėžys, and Šiauliai during the investigation.

Discussion

State-wide assessment of all trees growing in Lithuanian urban areas has continued for 15 years. Data of long-time observations of *A. hippocastanum* are therefore available [2, 31-33]. It can be affirmed that the state of these trees got worse during 2004-09 (Fig. 2, 4). The most significant causes could be the following: human activity (i.e. tree pruning, intense transport activity with other countries) as well as climatic change, which possibly stimulated the emergence of new pests and pathogens.

During 1992-97 the *A. hippocastanum* state was rather good and stable (mean damage was around 1 point), whereas the state used to worsen only during the dryer summers, when the leaves of trees growing near streets got stronger necrosis. The *Guignardia aesculi* started to spread in 1998. The state of *A. hippocastanum* got worse independently on

the growing place. Around 2002 and 2003 the intensiveness of *G. aesculi* spread decreased. However, due to the spread of *C. ohridella*, conditions have worsened from 2005 (Fig. 4). In Lithuania *C. ohridella* moths fly from the end of April to September-October. Leaves damaged by *C. ohridella* become brown and fall in July-August. Certain parts of these trees tend to additionally grow new leaves in August-September. Therefore, trees cannot prepare themselves for winter in time and can be injured by frost [34]. *A. hippocastanum* is grown in Lithuania as a decorative plant, but for the affect of the *C. ohridella* it loses decorativeness and hence its suitability for planting is questioned.

Because of its double flower, decorativeness, and sterility, the *A. hippocastanum* species ‘Baumannii’ could be suitable for cities and roadside greeneries. But its non-resistance for climatic influence (wide temperature ranges occurring in winter and spring) together with infection by *S. commune* was noticed. Raising seedlings of this variety in Lithuania could possibly make them more resistant to climatic influence if compared with imported young trees.

The Means for *A. hippocastanum* State Improvement

In 2000 the EU project CONTROCAM (Control of C.) was prepared. The aim of the project was to frame the biological control strategy of this new pest. Science institutions from Austria, Switzerland, France, Germany, Italy, and Greece have participated in this project [35, 36]. Nonetheless, effective means for reducing harmfulness of the horse chestnut leafminer and diminishing its spread have not yet been discovered.

The Mechanical Means Coherent with Pathogen Development Peculiarities

The pathogen fruit-bodies, as well as *C. ohridella* larvae and pupae overwinter in fallen leaves and infect young leaves in spring. Hence, the following method for reducing infection could be offered fallen leaves elimination and extermination during the whole period of vegetation. It is essential to eliminate leaves until the beginning of April, when moths come out of the pupae. Leaves must be burned or composted for a longer time covered with a sheet or ground layer. The pupae of the pest die if the temperature in a heap of piled leaves reaches at least 40°C [37]. Pupae vitality under laboratory conditions was investigated in Austria. Their tolerance for cold and high temperatures was proved. The death-rate of pupae kept during the winter under 39°C and 30% relative humidity reached 100%, whereas the death rate of pupae, kept under –21°C and 30% relative humidity was 33% [34].

Leaf elimination and composting is safe for humans and the environment, therefore it is widely used in many European countries. Fallen leaves of horse-chestnut must be gathered and eliminated carefully. Even if a small proportion of the infected leaves are left on the ground, the large potential of reproduction and the three generations per year will quickly restore the pest abundance.

A. hippocastanum badly tolerates hard pruning. In order to maintain vitality and prolong their life, only small branches can be pruned. As a consequence, the most preferable is tree planting at places where pruning is completely unnecessary.

The activity of helpful organisms reducing the number of pests is not significant. In Switzerland and Germany, 28 species of organisms able to kill *C. ohridella* were found. Lacewings (*Chrysopidae*) and spiders were the most effective among them. Spiders defeat grown-up adult moths [38].

Parasite insects were expected to be successfully used against this dangerous pest. Research in Bern revealed that under natural conditions the infection of *C. ohridella* caterpillars do not exceed 3% [37]. The larger ratio of caterpillars with parasites are detected in places where pest evidences for a longer time (10 and more years), consequently the possibility of balance between pest and its parasitoids can be considered after a longer period.

Tits are powerful destroyers of *C. ohridella*. Tits of various species eat significant parts of the parasitoids as well as the moth. Nonetheless, they are able to kill no more than 3% of these pests [37]. Increasing the number of tits and keeping them under protection in urban territories can possibly mitigate pest harmfulness. It is worthy to project experiences of neighbouring countries onto Lithuania, e.g. Germany spread information about *C. ohridella* to encourage raking leaves and protecting tits [39].

Experiments on using pheromone traps were accomplished in the Czech Republic and Poland, but they did not give any expected results to decrease the population of *C. ohridella* [40, 41].

The practice of chemical means is based on direct use of insecticides, namely spraying it on plants. Alsistin and Dimilin are used in Poland. This method is rarely used concerning hygiene and ecological motives. The method of tree intoxication with insecticide microinjections was developed and tested in 2000 in Poland [42, 43]. Initially thought to be effective, this method later appeared as noxious for trees [41].

During recent years, *A. hippocastanum* has been recovering and the number of mines on their leaves has been gradually decreasing in countries where *C. ohridella* has been observed for over 10 years [41]. As a result of ecological hoemostasis, pest content should stabilize in the long term [34].

Conclusions

During 1999-2004 some new invader pest species (*C. ohridella* and *Erysiphe flexuosa*) were intensively spreading and damaging *A. hippocastanum* in Lithuania. Since 2005-06 *C. ohridella* (invasive pest mining leaves) has been the main factor reducing the decorativeness and resistance to diseases of *A. hippocastanum* in Lithuania. As a consequence of leaf mining, powdery mildew has been mostly appearing as fungi disease instigated by its causative agent *Erysiphe flexuosa*. Moreover, the most negative influence for introduced *A. hippocastanum* cultivars is being

done by unfavourable climate and environmental conditions, as well as the surface wood corroder *Schizophyllum commune*. Fallen leaf removal is the most effective means of restraining the abundance of *C. ohridella*, *Guignardia aesculi*, *Erysiphe flexuosa*, and *Schizophyllum commune* due to the elimination of a significant number of ready-to-hibernate pupae and fungal spores.

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