

ANALYSIS OF THE SPECIES COMPOSITION OF PREVAILING PESTS OF *Araliaceae* JUSS. IN KYIV, UKRAINE

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Abstract

For the first time in Kyiv, Ukraine, the insect pest complex is studied of six open-ground woody plants of *Araliaceae* Juss. (*Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim., *Eleutherococcus sessiliflorus* (Rupr. & Maxim.) S. Y. Hu., *Hedera helix* L., *Aralia cordata* Thunb., *Aralia elata* (Miq.) Seem., *Kalopanax septemlobus* (Thunb.) Koizd.). We monitored collections of the three botanical gardens in the city, and qualitatively and quantitatively analyzed the diversity of pests. Five insect species were found that damaged the vegetative and generative organs of plants over the vegetative season: *Sciaphobus squalidus* Gyll., *Cteniopis flavus* Scop., *Aphis fabae* Scop., *Cetonia aurata* L., *Pulvinaria* Targ. Four different trophic groups of insects damaged the aboveground plant parts, causing injuries to the assimilation apparatus, young shoots, buds, and generative organs, respectively. The phytophages and their impact on the plants varied depending on the species, aggressive behavior, and the plants' reactions to injury.

Key words: *Araliaceae* Juss., species, insect fauna, insect influence, harmful activity, phytophage.

INTRODUCTION

Analysis of modern literature shows that introduction significantly widens and enriches the diversity of decorative plants through testing and establishing new and promising ones to use in landscape design (Kotsun and Pylypchuk, 1999). Highly decorative introduced plants play a lot of significant roles in the diverse plantations in metropolises and other settlements in Ukraine, for they contribute the largest share of the marketed species (Pototska, 2012). Introduction can be successful or not depending on the biological make-up and ecological adaptations studied as the organism grows, develops and adapts to the specific conditions it finds itself in.

An introduced plant faces unfavorable environmental factors both biotic and abiotic. Thus, it employs the adaptation mechanisms which are an important aspect of its biology. Special attention should be paid to selecting species least damaged by pests, and evaluating their viability under the burden of phytophages that lower the defensive capabilities and vitality of plants, which is immediately reflected on their ornamental value.

The plant tolerance to damage by insects is linked to the activation of defensive mechanisms of putting up physical and chemical barriers. Thus, plants avoid damage because of the specific features of their morphology, physiology, biochemistry of secondary metabolites, and variability of ontogenesis, supporting some ability to grow, re-grow, and reproduce after injury.

The biological tolerance of plants in urbanized environment varies widely and depends on a number of coincident factors: the habitat, the agricultural techniques to establish and maintain the plantation, the prophylactic measures to prevent the infection by pathogenic microorganisms, etc. The inhibited metabolism of plants in metropolises lowers their resilience and facilitates the spread of pests which can severely injure their vegetative and generative organs. The negative impact of pest insects interferes with plants' growth and development. It renders them susceptible to the effects of abiotic factors, mainly cold and frost. The insect influence is not limited to the direct consumption of biomass. The insects are also vectors of pathogenic microorganisms and can, through disrupting the integrity of tissues,

transfer phytopathogens from the infected to the healthy plants (Symochko, 2002).

Overall, this makes the species composition and negative effects of the insect complex of phytophages affecting introduced plants from the Araliaceae family in Kyiv an urgent scientific problem.

According to Shinohara and Ibuki (2011), significant damages were noted to the leaves of *A. elata* and *A. cordata* by larvae of two sawflies, *Conaspidia singularis* Mal. and *C. hyaline* Sato, respectively, at the plantations of the central area of the Honshu Island in 2009-2010.

Among the species of *Araliaceae* whose natural range includes temperate and subtropic regions of Europe and Asia, *H. helix* proves tolerant to the illumination, humidity, and temperature regime. The ivy's resistance is partially explained by the glycosides in its cells that can induce spasms and excitation, and disrupt respiration in insects (Rose, 1996). According to Ivy Removal Project, retrieved from <https://www.portland.gov/parks/nas/noivy>, the toxicity of glycosides of *H. helix* glycosides to insects does not preclude feeding of the larvae of four moth species (Rose, 1996), the scale insect *Lichtensia viburni* Sign. (Van-Rossem et al., 1979) of the superfamily Coccoidae F., and the mite *Phytoptus hedericola* Keifer (Knihinicki and Boczek, 2002) in the Netherlands and Australia, respectively on its leaves. Metcalfe (2005) reports 70 insect species feeding on ivy in England: 16 beetles, 27 hemipterans, and 27 lepidopterans and thrips. Analysis of available publications (Borchsenius, 1950) showed that five 5 Coccoidae species, namely *Icerya purchasi* Mask., *Ferrisia virgata* Ckll., *Asterolecanium arabidis* (Sign.), *Aspidiotus hederae* (Vall.), *Dynaspidiotus britannicus* (Newst.), and *Hemiberlesia rapax* (Comst.) were found on the leaves, shoots or fruit of ivy. According to Evans (1954) and Martinez et al. (1985), sheep and goats can eat ivy in winter when they do not have enough food, and the red deer *Cervus elaphus* L. and roe deer *Capreolus capreolus* L. rely on it as a staple. Eating *H. helix* fruit was recorded for nine species of invasive and common birds such as the common blackbird *Turdus merula* L. and the American robin *T. migratorius* L., the

common starling *Sturnus vulgaris* L., the house sparrow *Passer domesticus* L., Steller's jay *Cyanocitta stelleri* Gm. and cedar waxwing *Bombycilla cedrorum* Vieillot, according to Ivy Removal Project, retrieved from <https://www.portland.gov/parks/nas/noivy>.

Among the nine bird species feeding on the ivy fruit in England, only the common wood pigeon, *Columba palumbus* L. eats the seeds (Snow and Snow, 1988). It was found that ivy is the main food plant for a dusky lady beetle *Clitostethus arcuatus* Rossi (Majerus, 1994).

Despite ivy containing a number of toxic secondary metabolites (triterpenoid saponins), the British researchers found a host of arthropods feeding on it. The list includes 86 species of insects and mites of 13 families, most of which belong to Anthocoridae (minute pirate bugs) and Coccidae (soft scales), 13 and 12 taxa, respectively (Majerus, 1994). There are six insect pests of *H. helix* in Ukraine: *Zygina flammigera* Geoffr., *Eupoecilia ambiguella* Hb., *Abraxas grossulariata* L., *Lasiocampa quercus* L., *Lobesia botrana* Den. et Schiff., *Tetranychus urticae* Koch. (Lytvynov and Yevtushenko, 2005).

The local literature does not sufficiently cover the *Araliaceae* resistance to insect pests.

Our aim was to study the diversity and structure of the pest insect complex affecting the woody species of *Araliaceae* in Kyiv and to evaluate the level of infection and the resistance of plants.

MATERIALS AND METHODS

We conducted research on *Araliaceae* in open-ground collections of the three botanical gardens of Kyiv: the botanical garden of the National University of Life and Environmental Sciences of Ukraine (BG NULES), the M.M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine (BG Hryshko), and the O.V. Fomin Botanical Garden of the Taras Shevchenko National University of Kyiv (BG Fomin) in 2018-2020. In the course of the field study, we identified and counted the pests taking into account the phenology of plant growth and development. During monitoring we examined every plant and on seeing the insects or injuries to the

plant, collected the pests to identify in the laboratory. In the field we found, analyzed and classified the damage to the plants, evaluated the level of damage to each plant, counted insects. The analysis and identification of insect species were done in the lab (Stankevych and Zabrodina, 2016).

To find the aphid colonies we examined young juicy shoots, noting the visible signs of leaf laminae damage (curving, deformation, honeydew) (Dovidnyk, 1999). The level aphid infection was graded using a four-point scale: 0 points - buds, leaves, and shoots are aphid-free; 1 point - single aphids present; 2 points - small colonies covering less than half the area of buds, leaves and shoots; 3 points - colonies occupy more than half area of the above (Dovidnyk, 1999).

The weevils we counted before the buds opened by gently shaking them off the branches down onto a white sheet, on four sides of a bush. Thus, we could calculate the average density of pests per plant.

The coccids were counted during the vegetation period: before and during the budding, the unfolding, growth and development of leaves. On every plant, we examined four branches on four sides of the crown.

RESULTS AND DISCUSSIONS

On the six woody species of *Araliaceae* we found four species of pests and signs of damage they caused to the vegetative and generative organs of plants.

In the first decade of April 2018, we recorded many weevils *Sciaphobus squalidus* Gyll. (*Curculionidae*) on the buds of *Eleutherococcus senticosus* in the collection of BG NULES.

Large populations of the insects are found in Polissya and Forest-Steppe, while in the Steppe zone the species occurs in areas with increased humidity.

It damages fruit, berry, forest and decorative plants (Lytvynov and Yevtushenko, 2005).

The beetles are active in daytime, at night they descend to the ground and seek shelter (Lytvynov, 2005).

The females oviposit under the edges of unfurled leaves. The eggs can be infected by parasites, such as *Poropoea stollerckii* Forst., *P. difilippii* Selv., and the larvae can be injured by the braconids *Triaspis caudatus* Nees. and *Bracon variator* Nees.

As the larvae go deeper into the soil, many are consumed by earwigs, spiders, carabids and other predatory arthropods (Lytvynov and Yevtushenko, 2005). The embryo develops for about a fortnight. The larvae fall down and bury into the ground where they eat fine roots of trees and shrubs. After wintering in the soil, the larvae keep feeding and at the end of summer pupate at the depth of 40-50 cm. Thus, a generation of weevils develops in two years.

The beetles appear at the start of the vegetation period, before the buds open (Figure 1).

For 28-34 days they feed, gnawing out large, irregularly shaped indentations, damaging leaves, emptying buds on the inside (Figure 1).

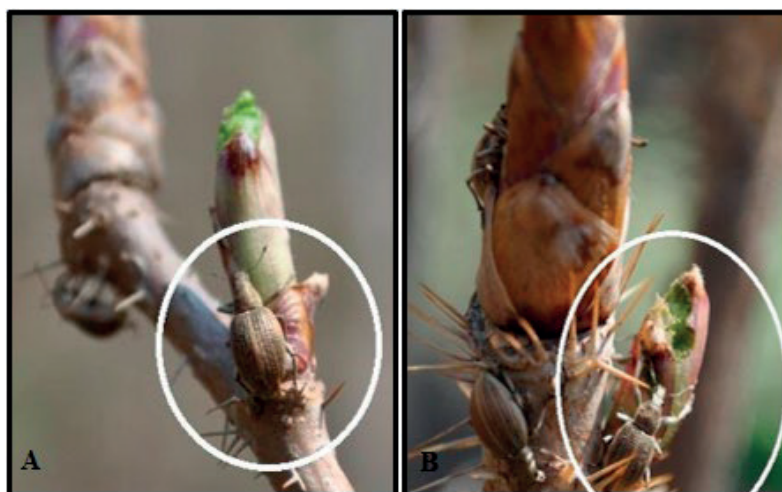


Figure 1. *Sciaphobus squalidus* on *Eleutherococcus senticosus*; A - imago; B - imago and typical damage to buds (plant collection of the M.M. Hryshko National Botanical Garden of the NAS of Ukraine, April 2018)

As we counted the pests on one bush of *E. senticosus* (BG Hryshko), we found 32 *S. squalidus* predominantly on the upper part of a plant (mostly, buds). As for the generative organs of *E. senticosus*, we found the following: 12 buds (13% of all monitored) were damaged and did not grow or develop, 22 buds (23%) were severely damaged yet proceeded to develop and open.

We found no more pests on *Eleutherococcus* at the time of intense budding; the leaves bore the signs of injuries they had received (Figure 2).

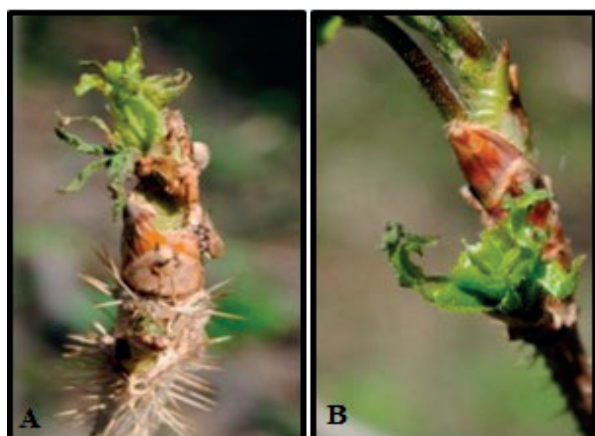


Figure 2. Damage to *Eleutherococcus senticosus*:
A - a bud injured by *Sciaphobus squalidus*;
B - development of leaves after damage (plant collection of the M. M. Hryshko National Botanical Garden of the NAS of Ukraine, April, 2018)

In the summer of 2018, we found colonies of *Aphis fabae* on the lower side of leaves of *E. sessiliflorus* (Figure 3). Small noticeable colonies of pests covered 10-15% of the laminae (2 points). The colonies gravitated to the central veins of the pinnately compound leaves of *E. sessiliflorus*. We saw no further manifestations and indications of their harmful action on the species.



Figure 3. *Aphis fabae* colonies on the leaves of *Eleutherococcus sessiliflorus* (plant collection of the Botanical garden of the NULES, July 2018)

The migrating species *A. fabae* is common in different habitats, on shrubbery and herbaceous plants. It is polyphagous and feeds on beets, fruit, berry, agricultural and decorative plants (Dychenko et al., 2015). The eggs overwinter at the bases of shoots of the European spindle, *Viburnum*, and mock-orange. In April at 7-9°C the surviving eggs release larvae that after 12-14 days of feeding become wingless females spawning five to eight larvae daily (Dychenko et al., 2015).

Besides *E. sessiliflorus*, aphids appeared in 2018 and 2019 on the leaves and generative organs of a perennial herbaceous plant *A. cordata*; the colony was less numerous than on other species, and the infection rate did not exceed 2 points. There was no visible damage to vegetative and generative organs (Figure 4).



Figure 4. *Aphis fabae* colonies on *Aralia cordata*:
A - generative organs; B - leaves (collection of plants of the O. V. Fomin Botanical garden of the National Taras Shevchenko University of Kyiv, June 2019)

We recorded numerous cases of aphids colonizing woody lianas *H. helix* in the three botanical gardens of Kyiv. The rate and nature of the damage varied: in May 2018 we found small aphid colonies on young shoots of *H. helix*, together with several ants in the BG Hryshko. The ivy's rate of infection was within 2 points, there were no typical injuries (Figure 5 A).

Yet in BG Fomin in May 2020, on *H. helix* branches, aphid infection reached 3 points. The insect fed intensely causing visible twisting and deformation of leaf laminae (Figure 5 B).

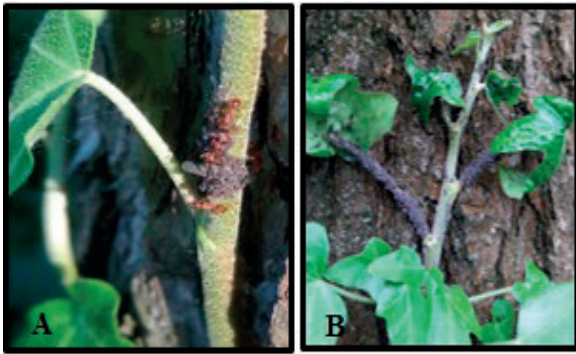


Figure 5. Aphid infection on shoots and leaves of *H. helix*, May 2020; A - damage to plants of the M. M. Hryshko National Botanical Garden of the NAS of Ukraine; B - damage to plants of the O. V. Fomin Botanical Garden

Aphids colonize the underside of young and succulent shoots and leaves and suck the juice (Figure 6 A, B).



Figure 6. *Hedera helix* infected by aphids; A, B - deformations of leaf laminae; C - leaves shape unaffected by harmful effect of aphids (O.V. Fomin Botanic Garden, May 2020)

The damaged leaves become misshapen, wrinkled or twisted, lose turgor and desiccate. As the aphids feed, the leaf is punctured and the saliva enzymes enter the plant tissue inducing cell plasmolysis and breaking up starch into sugars (Dychenko et al., 2015). Thus, the plant's surface becomes covered in liquid sugary secretions; respiration, photosynthesis, and nutrition are inhibited; conditions favour the development of the ustilaginaceous fungi (Puzrina, 2020).

Besides the direct harm they cause, aphids transmit over a hundred viral infections (Puzrina, 2020). The toxic saliva enzymes make the affected plants sickly even after the pest colonies are fully destroyed.

In ivy stands we found young shoots significantly colonized by aphids, which caused leaf deformations later because of intense feeding. Aphids are the most numerous phytophages feeding on *Araliaceae*, they are more fecund and reproduce faster than other pests which makes them so harmful. Their populations can rapidly recover even after intense agricultural measures. Some species can have 20 generations in a single season, raising the probability of becoming resistant to insecticides and becoming more harmful as a result.

In early July 2020 we found three sulfur beetles (Figure 7) on the inflorescences of *A. elata* (*Cteniopus flavus*, syn. *Cteniopus sulphureus* L.). Given the plants' height and architecture we examined only the accessible inflorescences.

The beetles feed on pollen, preferring the umbelliferous plants (*Araliales*: *Apiaceae*). They are found mostly in the Steppe and Forest-Steppe regions of Europe, usually near flooded meadows (Ohloblyn and Znoiko, 1950).

The larvae live in dead wood, tree trunks and hollows, rotting stumps, more rarely in soil where they eat roots (Kazenas et al., 2014).



Figure 7. Adult sulfur beetle *Cteniopus flavus* on flowers of *Aralia elata* (O.V. Fomin Botanical Garden, July 2020)

We found another pest, *Pulvinaria* sp. (Coccidae), in large numbers. This insect was

found on young shoots and petioles of *E. senticosus*, *A. elata* and *K. septemlobus* (Figures 8, 9). Females secrete white egg sacs during oviposition (Figure 9).

The insects reproduce and recover rapidly. They frequently cover bark of trees and shrubs. The females attach themselves to the trunks and branches and become motionless (Borchsenius, 1950). Feeding on juice, they cause premature defoliation and deformation of older sprouts.

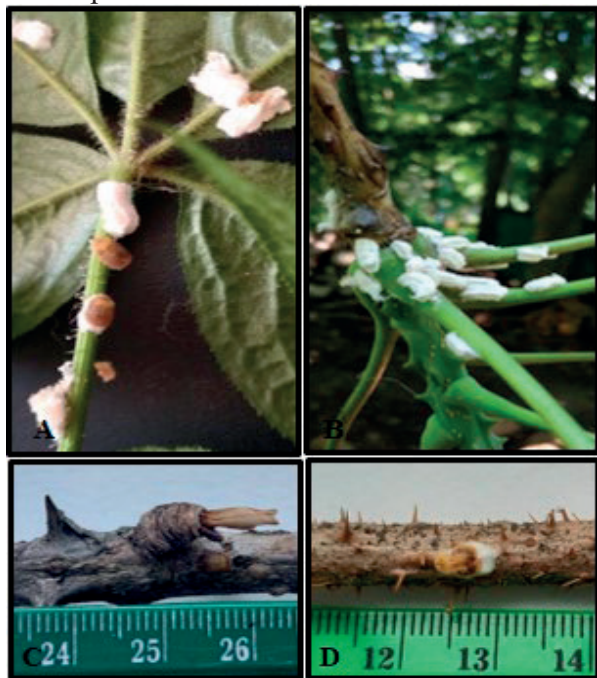


Figure 8. *Pulvinaria* sp. on shoots and petioles; A - on *Eleutherococcus senticosus*; B, C - on *Kalopanax septemlobus*; D - on *Aralia elata*

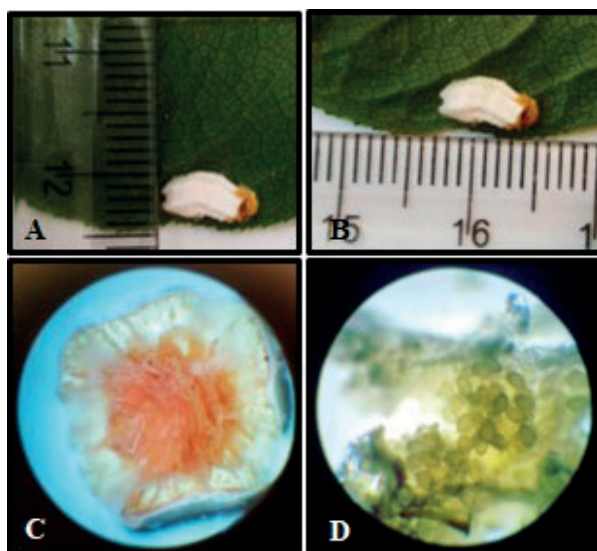


Figure 9. *Pulvinaria* Targ. sp.; A, B - the egg sac secreted by the female; C - the female (x 20); D - eggs inside the egg sac (magnification 50)

The pests are spread together with the seedlings and cuttings. The mobile larvae crawl from one tree to another on touching branches, occasionally carried on people's clothing.

In July, when *A. elata* blooms, its inflorescences attract Coleoptera, in particular *C. aurata*. The beetles actively feed from the third decade of May into June. They consume flowers, overripe fruit beginning to ferment, juice from injuries of young bark, etc. (Ryndevych et al., 2014).

CONCLUSIONS

We found that the pest insect complex of woody plants of the *Araliaceae* family in Kyiv numbers five species. The injuries they inflict are various. The phytophages belong to four trophic groups: coccids and aphids damage the assimilation apparatus and young shoots, *Sciaphobus squalidus* specializes in buds, and the sulfur beetle in generative organs. *S. squalidus* gnawed out large pits in *E. senticosus* buds, leading to partial loss of leaves and death of buds. Numerous aphid colonies on the abaxial surface of leaves of *E. sessiliflorus* and on young shoots of *H. helix* and *A. cordata* spoiled the ornamental value of plants. We recorded significant deformations of leaf lamina of *H. helix* caused by aphid saliva enzymes entering leaf tissues. On the inflorescences of *A. elata* we found *C. flavus* beetles feeding on pollen. A few species of *Pulvinaria* sp. (Coccidae) were observed on the shoots and petioles of *E. senticosus*, *A. elata* and *K. septemlobus*.

The most abundant phytophages of *Araliaceae* are aphids. The reasons are two-fold: their fecundity, and the fact that they spawn every 12-14 days. Outer manifestations of the injuries were the most visible on *H. helix*: deformed leaf laminae which soon die.

Early in the vegetation season, *S. squalidus* fed on the buds of *E. senticosus* for a month, leaving large pits causing the death of buds. In these cases, the phytophages both decrease the ornamental value of plants and negatively affect the plants' vitality in general.

The changes in pest numbers and thus the rates of damage to plants depend largely on the weather. Likely, it is the temperature regime in spring that determines the appearance of *S.*

squalidus on *E. senticosus* buds in particular. Also, the numbers of pests significantly depend on the agricultural techniques in use.

The plants' resistance to unfavorable factors is a complicated and interconnected complex of adaptive and protective functions gained in the evolutionary process.

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