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THE PAGODA TREE (*SOPHORA JAPONICA* L.) SEED DAMAGE BY PEST *BRUCHOPHAGUS SOPHORAE* CR. ET CR. IN NITRA CITY (SLOVAKIA)

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Abstract

In the city of Nitra research on *Sophora japonica* L. seeds in five localities (Výstavná street, Andrej Hlinka avenue, Nábrežie mládeže street – University area, City park, Čajkovsky street) was carried out. The field research was realized in 2010. The seeds were evaluated according to the percentage of damaged seeds, the percentage of healthy and germinating seeds, and the percentage of affected but unhatched individuals. The occurrence of parasitoids was monitored as well. The average sample was weighed in a dried state before and after the hatching to measure the weight difference. Data were evaluated by one-way analysis of variance at 95% significance level. Also the impact of location on the number of damaged and healthy seeds was surveyed. An important part of the research was to characterize the external morphological differences between healthy and damaged seeds before the adult hatching. Potentially healthy seeds, not damaged by the pest, were given into Petri dishes, where the ability of undamaged seed germination was studied. *Bruchophagus sophorae* Cr. et Cr occurred to a large extent in all selected localities. The total average number of damaged seeds in selected localities was 490. It was found that each locality had germinable seeds able to create a healthy plant. During the research no species of natural pest enemies could be identified.

KEY WORDS: *Sophora japonica*, *Bruchophagus sophorae*, Nitra city, seed damage

Introduction

Sophora japonica L. is a deciduous tree 15 to 25 m high with a globular crown. Seed propagation is rarely used. In the early spring, cultivars are grafted on the original species in the garden nurseries (HORÁČEK, 2007). *Sophora japonica* is an introduced woody plant. Its area of origin is in East Asia - Central China, Korea, but it is widely cultivated in warmer regions around the world. The first declared occurrence in Europe was in 1747 (GREGOROVÁ *et al*., 2006). MACHOVEC *et al*. (2000) mentioned the first planting of *Sophora*

japonica L. in Slovakia in 1840. *Sophora japonica* L. requires a protected position in the sun. It tolerates soft shading; the thin canopy creates an umbrella-type crown. The tree is adapted to a drier habitat, deep, light, loamy and nutritious soil, containing calcium. It is relatively frost hardy, but in the moist habitats, especially in young growing stages, it often freezes. The predominant type of mycorrhiza is arbuscular mycorrhiza. The *Sophora* tree tolerates emissions very well (GREGOROVÁ *et al*., 2006). According to the results of measurements of chlorophyll fluorescence, *Sophora japonica* L. tolerates changed environmental conditions very well (JASENKA & SUPUKA, 2010). It was argued that *Sophora japonica* L. was permanently at a low level in terms of fertility. However, its seeds matured under our conditions in late autumn and winter (dry pods remain on the trees until the late spring), the seeds are developed, and after the stratification they are germinable (MACHOVEC *et al*., 2000). Animal pests (GREGOROVÁ *et al*., 2006) indicate the occurrence of *Croesus septentrionalis*. GILMAN & WATSON (1994) also indicate damage by the potato leafhopper, which kills young stems and thus causes profuse branching or witches broom on small branches. Usually, it is not dangerous for older trees. The *Sophora* species is generally pest- and disease free. Occasionally, it might get a fungus cancer. Its inflictor is powdery mildew, which forms a fungus mat looking like a white coating on the leaves. The disease is usually not serious (GILMAN & WATSON, 1994). GREGOROVÁ *et al*. (2006) indicates the occurrence of the following fungal pathogens: *Ganoderma resinaceum*, *Inonotus hispidus*, *Inonotus nidus - pici*, *Nectria cinnabarina*, *Phytophthora cinnamomi*, *Verticillium alboatrum*, *Rigidoporus obducens*. JUHÁSOVÁ *et al*. (2004, 2009) reference damage of *Sophora japonica* by fungus *Fusarium lateritium* Nees., *Fusarium javanicum* desm. PÚPAVOVÁ *et al*. (2010) indicate the occurrence of fungi *Phyllosticta* spp. Pers. In former Czechoslovakia there are 60 known species from the Eurytomidae family (POPESCU & FUSU, 2003). One of them occurs also on the pagoda tree. In 1988, the pest *Bruchophagus sophorae* Cr. et Cr. was observed on pagoda trees at ten localities of south-western Slovakia (HRUBÍK & VOOKOVÁ, 1993). Pest larvae eat the seeds of *Sophora japonica* L. It's a kind of a palearctic species (SE part of Asia, Transcaucasian region, Europe: Ukraine, Hungary, Romania (POPESCU, 2003, 2006), whose origin is in the SE part of Asia (ZEROVÁ, 1995). The larvae of the pest are white, with an indistinctly developed head, but with a strongly chitinized upper jaw. On the last segment of the larvae body there are chitinized labels. They live inside the seeds, and after the feeding they remain in the seeds, where they pupate. The pupa is open, at first it is pale yellow, then the back, head and prothorax change to black, and the abdomen remains light gray. The pupa's length is 2.9 mm; the adult's length is from 3.0 to 3.1 mm. The adult has two pairs of membranous wings, whose venation is thin; the caudal wings are slightly shorter and smaller than the front wings (Fig. 1). Eyes are cinnamon red; legs and antennae are dark gray, almost black (HRUBÍK & VOOKOVÁ, 1993).

Bruchophagus sophorae Cr. et Cr. has become a major harmful factor to the fruits of *Sophora japonica* L. in Slovakia. It damages almost all seeds and some sources therefore often wrongly conclude that seeds cannot mature in our conditions. For this reason, *Sophora* is reproduced mainly through vegetative propagation in our country. In some countries, this pest is reportedly a positive factor for the oil increase in the seeds, which are used in the cosmetics industry. The main focus of research is on examining the extent of seed damage and germination of *Sophora japonica* L. seeds. Furthermore the possible effects of relevant location on the number of damaged seeds were monitored as well.

Material and Methods

The research of *Sophora japonica* L. seeds was carried out in five selected localities in Nitra city (Tab. I). Samples were collected near the roads and elsewhere. Nitra's altitude ranges from 138 to 587 m above sea level (www.nitra.sk). Nitra is situated at 48°18'46.34" N and 18°05'09.74" E. Its center is the transverse plain, which lies 140 m above sea level and stretches throughout the city. The climate of Nitra region ranges from

semi-arid to humid. The average precipitation per year is about 600mm. The average annual temperature of this area is close to 10 ºC (AMBRUŠ & FOJTÍK, 1977).

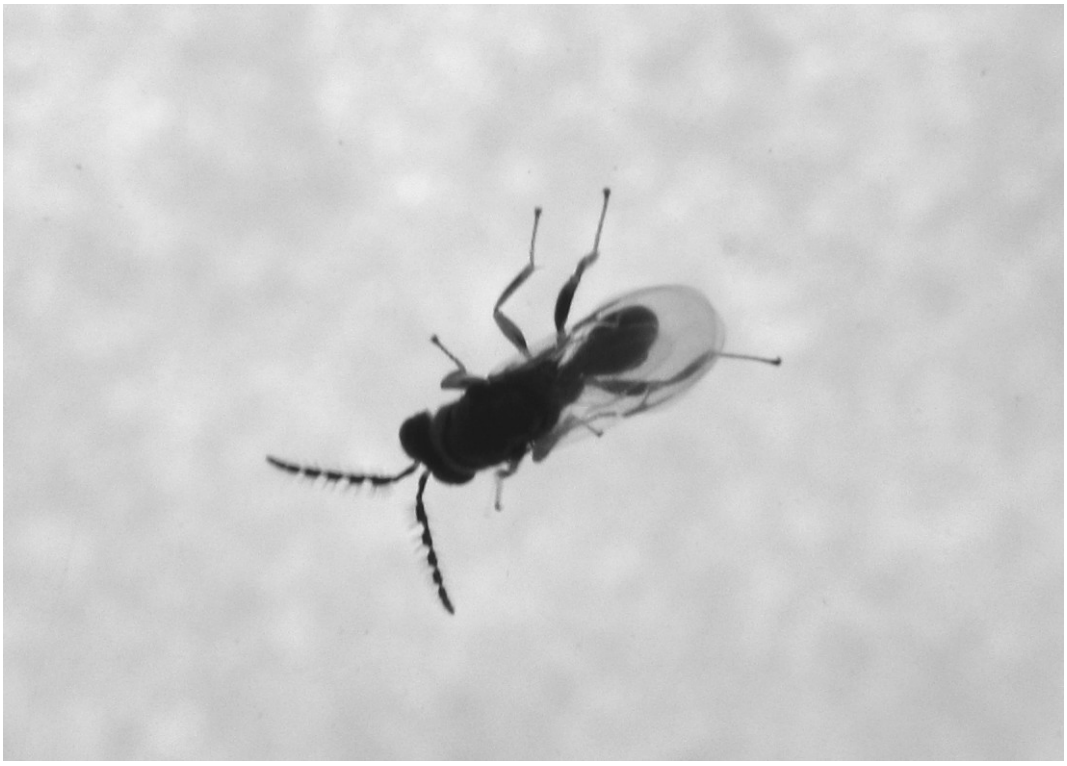

Figure 1. Male of *Bruchophagus sophorae* Cr. et Cr.

Table I. Brief description of the monitored localities of *Sophora japonica* L.

Locality No.	Locality name	Altitude (m)	Geographic position	Type of habitat
1	Výstavná street	138	48°18´40.69´´ N 18°06´19.68´´ E	Alley planting along the pedestrian path, near housing area
2	Andrej Hlinka avenue	136	48°18´50.21´´ N 18°06´18.58´´ E	Alley planting along the road and parking area
3	Nábrežie mládeže street – SPU area	139	48°18´25.99´´ N 18°05´25.67´´ E	Group planting of park type on the boundary of main and secondary road
4	City park	142	48°19´02.11´´ N 18°04´52.05´´ E	Park planting, enclosed with pedestrian paths, near water areas
5	Čajkovsky street	184	48°18´04.44´´ N 18°03´34.31´´ E	Planting of alley type along the access road and parking area, close to the main road

We have monitored the volume of the occurrence of the pest *Bruchophagus sophorae* Cr. et Cr. and the damage to *Sophora japonica* L. seeds caused by this pest. The field research was realized in 2010. Fruits were harvested in late May. From each locality we have collected 100 pcs of seeds from five individual different trees. The seeds were shelled and stored in air bags which remained open to let the adults freely fly out. The seeds were kept like this until August, so that all adults could fly out. The seeds were evaluated according to the percentage of damaged seeds, the percentage of healthy and germinating seeds, and the percentage of affected but unhatched individuals. Unhatched individuals in seeds were identified via cross section. The occurrence of parasitoids was monitored as well. Data were evaluated by one-way analysis of variance at 95% significance level using Statgraphics centurion software. Also the impact of location on the number of damaged and healthy seeds was surveyed. An important part of the research was to characterize the external morphological differences between healthy and damaged seeds before the adult hatching. Potentially healthy seeds, not damaged by the pest, were given into Petri dishes, where the ability of undamaged seed germination was studied.

Results

Bruchophagus sophorae Cr. et Cr occurred to a large extent in all selected localities. No significant difference has been proven between the number of healthy seeds and the locality. The lowest average number of healthy seeds per tree (0.8 %) was at locality number 4 (City Park). The highest average value was recorded at locality number 2 (A. Hlinka avenue), where the average number of healthy seeds was 3.2 % per tree (see Tab. II). The difference between the location and the number of hatched adults was also demonstrated. The highest average number of unhatched adults (17 %) was at localities number 3 and 5, and the lowest average number (11.8 %) was at locality number 4 (see Tab. III). The total average number of damaged seeds in selected localities was 98 seeds per tree. The highest average number of damaged seeds was at locality number 4 (99.2 %) and the lowest average number at locality number 2 (96.8 %) (Tab. IV). However, the differences between the localities were very small. A significant difference between the number of hatched adults and the locality was proven (P-Value = 0.0067). The average number of hatched adults was 83.44 %. The highest average number of hatched adults was at locality number 4 (87.4 %) and the lowest average number was at locality number 5 (80 %) (Tab. V).

Table II. Summary Statistics for number of healthy seeds.

Locality No.	Number of counts	Average number	Standard deviation	Coeff. of variation	Minimum	Maximum
1	5	1.4 %	0.547723	39.123%	1.0 %	2.0 %
2	5	3.2 %	2.38747	74.6084%	1.0 %	7.0 %
3	5	1.6 %	1.14018	71.261%	0.0 %	3.0 %
4	5	0.8 %	0.83666	104.583%	0.0 %	2.0 %
5	5	3.0 %	2.54951	84.9837%	0.0 %	7.0 %
Total	25	2.0 %	1.82574	91.2871%	0.0 %	7.0 %

Table III. Summary Statistics for number of unhatched seeds.

Locality No.	Number of counts	Average number	Standard deviation	Coeff. of variation	Minimum	Maximum
1	5	12.4 %	3.64692	29.4106%	6.0 %	15.0 %
2	5	14.6 %	2.70185	18.5058%	10.0 %	17.0 %
3	5	17.0 %	3.74166	22.0097%	12.0 %	22.0 %
4	5	11.8 %	3.03315	25.7047%	9.0 %	15.0 %
5	5	17.0 %	4.89898	28.8175%	11.0 %	24.0 %
Total	25	14.56 %	4.04228	27.7629%	6.0 %	24.0 %

Table IV. Summary Statistics for number of damaged seeds.

Locality No.	Number of counts	Average number	Standard deviation	Coeff. of variation	Minimum	Maximum
1	5	98.6 %	0.547723	0.5555%	98.0 %	99.0 %
2	5	96.8 %	2.38747	2.46639%	93.0 %	99.0 %
3	5	98.4 %	1.14018	1.15871%	97.0 %	100.0 %
4	5	99.2 %	0.83666	0.843407%	98.0 %	100.0 %
5	5	97.0 %	2.54951	2.62836%	93.0 %	100.0 %
Total	25	98.0 %	1.82574	1.863%	93.0 %	100.0 %

Table V. Summary Statistics for number of hatched seeds

Locality No.	Number of counts	Average number	Standard deviation	Coeff. of variation	Minimum	Maximum
1	5	86.2 %	3.34664	3.88241%	84.0 %	92.0 %
2	5	82.2 %	1.78885	2.17622%	79.0 %	83.0 %
3	5	81.4 %	3.20936	3.9427%	78.0 %	86.0 %
4	5	87.4 %	2.88097	3.29631%	84.0 %	91.0 %
5	5	80.0 %	4.41588	5.51985%	74.0 %	86.0 %
Total	25	83.44 %	4.15411	4.97856%	74.0 %	92.0 %

It was found that each locality had germinable seeds able to create a healthy plant. Germinated seeds are presented in Fig. 2. The germination of seeds was mostly affected by fungal pathogens that completely prevent seeds from germination. However, most of healthy seeds were able to swell up. Approximately half of the seeds were able to germinate and create cotyledons. Tab. VI shows the number of germinated seeds and the number of healthy seeds.

Figure 2. Germinated seeds of *Sophora japonica*.

Table VI. The number of germinated seeds at selected localities

Locality No.	Number of healthy seeds	Number of germinated seeds
1	7	4
2	16	10
3	8	4
4	4	2
5	15	8

During the research no species of natural pest enemies could be identified. The presence of parasitoids in the damaged seeds or their adults could not be detected. In one seed one larva was always developing: more larvae or emergence holes were not recorded.

Morphological indicators of healthy generative material (Fig. 3):

- seeds are smooth, bean-shaped without any distortions,
- the color of seeds varies from dark brown to black, their size is around 1 cm,
- during the husking the seeds can be easily separated from the seed coat,
- seeds are without visible holes or other deformations.

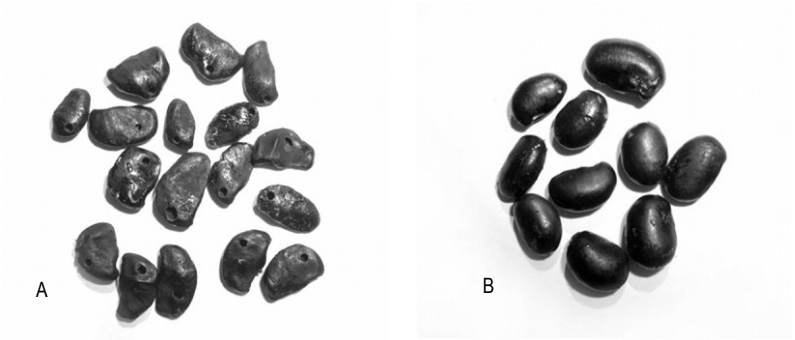

Figure 3. Damaged (A) and healthy (B) seeds of *Sophora japonica.*

Conclusion

The monitored pest damages almost 100% of *Sophora japonica* L. seeds. To produce healthy and vital material, research into seed protection against this pest is still needed. It is therefore wrongly presumed that the seeds of *Sophora japonica* L. are not able to mature and germinate in Slovakia. However, germination research has confirmed that *Sophora japonica* L. is able to produce high quality plants also through generative propagation. Such grown individuals are more vital than vegetatively propagated plants. At present, the number of intact and healthy seeds is very low because the protection against this pest is not performed. However, the pest adults are not able to hatch from all seeds, as confirmed by the research of damaged seeds without hatching holes. This is caused by the fact that adults are not able to get through the seed coat and also by the presence of various species of fungi that kill the pest larvae or unhatched adults. Since the pest lays eggs in very young fruits, which are very soft, it would be appropriate to do the protection during this period.

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ОШТЕЋЕЊА СЕМЕНА *SOPHORA JAPONICA* L. АКТИВНОШЋУ ШТЕТНЕ ВРСТЕ ОСА *BRUCHOPHAGUS SOPHORAE* CR. ET CR. У ГРАДУ НИТРА (СЛОВАЧКА)

ЈАН КОЛАР

Извод

Истраживања семена *Sophora japonica* L. вршена су током 2010. на пет локалитета у граду Нитра у Словачкој. Семена су груписана према проценту оштећености, затим према процентуалном броју здравих и исклијалих примерака и броја оштећених и неисклијалих. Истраживањима су праћени и паризитоиди. Оса *Bruchophagus sophorae* Cr. et Cr. налажена је у семенима софоре на свим истраживаним локалитетима. Праћена је бројност *B. sophorae* и степен оштећења семена софоре која проузрокује ова оса. У току истраживања нису утврђени природни непријатељи *B. sophorae*. У једном семену увек се развија једна ларва. *B. sophorae* полаже јаја у врло младим – меканим плодовима, па је препорука да се третирање уради током овог периода.

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