THE RESULTS OF MONITORING OF CONOBIONTS OF SELECTED SPRUCE SPECIES (PICEA SPP.)

Peter KELBEL
Botanical Garden of P. J. Šafárik University, Mánesova 23, SK - 043 52 Košice
e–mail:<pkelbel@kosice.upjs.sk>


In the years 1992 to 1994 we checked spruce seeds and cones for pests in forest stands in Slovakia. In the cones the three most important pests were found: Cydia strobilella L., Kaltenbachiola strobi WINN. and Dioryctria abietella DEN. et SCHIFF. Cydia strobilella was the most important species with overall average range of infestation 53.2% in the period of main collection, Kaltenbachiola strobi (14.9%) was the second one and then Dioryctria abietella (6.0%). X–ray testing of the seeds showed the presence of two pest species – Megastigmus strobilobius RATZ. and Plemeliella abietina SEITN., the range of seed infestation by Megastigmus strobilobius reached 5.1%, by Plemeliella abietina 4.1% in average. During the research in the Botanical Garden of P. J. Šafárik University in Košice in the course of years 1995 – 2000 the cones of the following species were analysed: Picea abies [L.] KARST., Picea pungens"Argentea", Picea omorica (PANČ.) PURK., Picea sitchensis (BONG.) CARR., Picea glauca (MOENCH) VOSS. Analyses revealed the presence of four pest species in the cones of Picea abies: Dioryctria abietella, Cydia strobilella, Assara terebrella ZINCK. and Kaltenbachiola strobi. Cydia strobilella reached the average range of infestation 28.0% during the studied period, Dioryctria abietella 18.0%, Assara terebrella 16.0% and Kaltenbachiola strobi 8.0%. In Picea pungens"Argentea", Dioryctria abietella was the dominant pest (31.4%), the occurrence of Cydia strobilella was only sporadic. In Picea omorica (PANČ.) PURK. cones only Dioryctria abietella (14.8%) was found. In Picea sitchensis (BONG.) CARR., Cydia strobilella infested 58.4% of cones, Dioryctria abietella 4.0% and both pests shared 2.8% of cones. In Picea glauca (MOENCH) VOSS. only Cydia strobilella occurred (34.4%).

Key words: Picea spp., cone and seed pests, Dioryctria abietella, Cydia strobilella, Assara terebrella, Kaltenbachiola strobi, Megastigmus strobilobius, Plemeliella abietina

1. Introduction

Norway spruce (Picea abies [L.] KARST.) is one of the most widespread and economically important woody species in Slovakia. It forms large natural homogenous stands, and also stand mixtures with fir, further with pine (Pinus sylvestris L.), sycamore maple (Acer pseudoplatanus L.), rowan (Sorbus aucuparia L.), stone pine (Pinus cembra L.) and dwarf pine (Pinus mugo TURRA) (PAGAN, 1997).

These facts imply annual need of big amount of high–quality seed so that both natural and artificial regeneration is ensured. Among the factors decreasing seed yield of spruce cones and impairing a part of the seed insect pests play an important role. Only few data on insect pests of spruce cones and seeds are found in Slovak literature.

Basic and source literature is represented by the work of ČERMÁK (1952), who summarised, besides his own research, also the knowledge of foreign authors. In Slovakia, the study of spruce cone damage was carried by KRAĽ (1960 a, b). His papers are aimed at two, the most important pests – Cydia strobilella and L. Dioryctria abietella DEN. et SCHIFF. SKUHRAVÁ a SKUHRAVÝ (1960) give in the survey of Gall Midges (Cecidomyiidae) on spruce also the species living in its cones and seeds, the species presence was precised later.
In 1968 the samples of spruce cones coming from 106 localities in Bohemia and Moravia were checked (Kříštěk et al., 1992). Insect pests of cones and seeds of introduced spruce species in Slovakia were studied by Hrubík (1978).


At our work, we aimed at the following goals:
1. to contribute to the knowledge on actual species composition of conobionts of selected spruce species (*Picea spp.*) and to evaluate their economic importance,
2. to verify, or, as the case may be, to complete knowledge from bionomy or ecology of spruce conobionts,
3. to define recommendations for forest seed management as far as prevention and pest control possibilities are concerned.

### 2. Material and methods

In the years 1992 – 1994 we checked the pests of cones and seeds of spruce *Picea abies* (L.) Karst. in forest stands in Slovakia. When selecting the localities for the collection of the material we tried to cover all the territory of Slovakia with different nature conditions. Within each region dealing with spruce seed one or two forest enterprises were chosen (within the original structure of State forests in Slovakia), at which sampling was carried in selected forest district. This sampling was made at the time of main cone collection, in December and January. Minimum range of the selection was set down in such way that total number of cones reached according to the methods of Gusev and Rimskij – Korsakov (1961) 400 pieces of fruit as a minimum. Besides this random collections were carried in the region of Košice and Zvolen during vegetation period. They were aimed at checking of both precociously casted fruit and diapausing pests. In the main collection period of the year 1992 the samples came from 14 forest enterprises, in 1993, also with regards to poor seed crop, we managed to cover 10 forest enterprises. Total amount of the analysed spruce cones was 2 075 pcs, 1 318 pcs came from the main collection and 757 cones form random collections. Detailed data on the origin of the samples are given in separate paper (Kelbel, 1997). The check of the cones had two phases. In the first one tangential section was done – they were examined for the presence of pests visually and the range of the inside damage of cones was recorded. Subsequently, in the second phase, after the seed extraction from the cones from particular samples, the sample of 4 × 100 seeds was taken according to standard methods. These seeds were analysed by X–ray at the Institute of Forest Ecology of Slovak Academy of Sciences – Arboretum Mlyňany by the X–ray equipment of Softex IMB (Japan). Evaluation of X–ray pictures allowed to determine the infestation of seeds by particular insect pests as well as the ratio of full and empty seeds. Determination of total percentage of damage followed.

The research continued in the Botanical Garden of P. J. Šafárik University in the years 1995–2000 in the period of main collection, in December and January, within the project "Integrated study of factors contributing to degrading of woody plants in changed conditions of environment", supported by grant no. 2/1039/21 of grant agency VEGA (Slovakia). Brief
characteristics of the territory: Botanical Garden of P. J. Šafárik University is situated in northwestern part of Košická kotlina Basin, on the foothils of eastern extremity of Slovenské Rudohorie Ore Mts., in the locality Bankov, local part Červený breh (square no. DFS 7293a). The terrain is slopy with NE exposition, altitude 218 to 370 m above sea level. Soils are shallow and geological foundation is formed by phylits. Mean yearly temperature is 8,4 °C, mean annual precipitations reach 643 mm.

In the Botanical Garden total number of the cones analysed was as follows: 428 cones of *Picea abies* [L.] KARST. from the group planting about 30 trees, 242 pcs of cones from three individuals of *Picea pungens* "Argentea", 207 pcs of cones from two individuals of *Picea omorica* /PANČ./ PURK., 125 pcs of cones from one individual of *Picea sitchensis* /BONG./ CARR. and 105 pcs of cones from two individuals of *Picea glauca* (MOENCH) VOSS..

Tangential section of the cones was made by knife, this was followed by visual evaluation of inside damage by insects. X–ray analysis of seeds was not carried in the Botanical Garden. The larvae found were fixed in 75% ethanol.

3. Results and discussion

*Picea abies* [L.] KARST.: Detailed results of analyses from the years 1992 –1994 with tables, and graphs were published in separate paper (KELBEL, 1997), therefore we will summarize the most important results. The cones were infested by three most important pests: *Cydia strobilella* L., *Kaltenbachiola strobi* WINN. and *Dioryctria abietella* DEN. et SCHIFF. At the same time, various combinations of the occurrence of the above pests were found. Literature data on number of insect species in cones and seeds of *Picea abies* [L.] KARST. are very variable. STADNICKIJ (1969) studied entomofauna of cones and found 135 species, which are included, from the point of view of systematics, in six orders of insect. POKROVSKAJA (1972) found 10 species of spruce seed pests, the most important was *Cydia strobilella*. DOLGIN a NESIN (1981), when checking spruce cones and seeds, determined totally 12 pests. In 1968 the check of the samples of spruce cones, coming from 106 localities in Bohemia and Moravia, was carried (KRÁSTEK et al., 1992). The analyses revealed the presence of the following pests: *Cydia strobilella, Dioryctria abietella, Kaltenbachiola strobi, Ernobius abietis, Megastigmus strobilobius* and *Plemeliella abietina*.

In Slovakia the investigation of spruce cones was carried by KRÁL (1960 a, b), who concentrated in his papers on two species – *Cydia strobilella* and *Dioryctria abietella*. The species presence of pests in our results corresponds well with the results of analyses of prof. KRÁSTEK in Moravia.

*Cydia strobilella* was the most important species, with total average range of infestation 53,2% in the period of main collection. Separate occurrence of the pest dominated (80,5% of cases of infestation), in combined occurrence the interaction with *Kaltenbachiola strobi* (14,4%) prevailed, further it occurred with *Dioryctria abietella* (4,7%) and both of the pests at a time (0,4%). The number of feeding caterpillars in one cone was from one to five, the most frequent was the occurrence of one or two caterpillars. The range of inside damage of the cones reached from 3,8 to 100% of destroyed seeds, and this was dependent not only on the number of feeding caterpillars, but on the size of cones as well. The data on economic harmfullness of this species vary much in literature, e.g. ZAȘEȘ (1959) gives even 97% infested cones in Bulgaria in 1955. JAKOVLEV (1962) found 90% infested cones in France in 1961, STADNICKIJ (1967) gives the infestation from 80 to 100%, in 1966 in Leningrad region. According to STADNICKIJ et al. (1978), 50 – 75% of cones are invaded when the seed crop is good and even 100% in the years with poor seed crop. KRÁSTEK et al. (1992) found the range of cone infestation 30,8% in 1968. As far as the damage of seeds in cones is concerned
ČERMÁK (1952) states, that the presence of one caterpillar of *Cydia strobilella* reduces germinating capacity of the seeds to 26%, 6 caterpillars destroy all seeds. KRAĽ (1960 a) found, that during the feeding of one caterpillar the seed yield of cones was reduced by 0,07 – 1,36%, in the case of the occurrence of up to five caterpillars the reduction of seed yield was by 0,8 – 6,22%. VARIŃSKY et al. (2000) stated that in 1999 spruce cones were damaged by the above given pest in central Slovakia, the area of damaged stands was estimated to 3 500 ha, from this area 1 500 ha was with high degree of damage, the rest with low degree. Outside Slovakia e.g. STADNICKIJ (1967) gives the losses from 12 to 20% of seeds, during the poor seed yield in 1966 up to 50%. SKRZYPECZYNSKA (1980) gives the losses up to 20%, when the cones are infested by 1 or 2 caterpillars, in extreme cases, when the number of caterpillars reached 9 – 14, the losses were 90 to 96% of seeds. Our analyses showed the losses of seeds in one cone from 3.8 do 100% and this was dependent not only on the number of caterpillars, but on the cone size as well. The number of caterpillars in one cone was from 1 to 5, the most often one or two caterpillars. SKRZYPECZYNSKA (1980) gives the occurrence of 1 to 14 caterpillars, the most often also one or two. According to STADNICKIJ (1967) in Leningrad region, after the year with good seed crop, at the time of poor seed crop (1966), up to 30 – 40 caterpillars occurred in one cone. With regards to the fact that all the ontogeny of the pest, except for flights and egg–laying, takes place in cone, the pest is, at the same time, protected from the unfavorable environment conditions. The knowledge untill now shows the possibility of mass outbreak even on larger areas.

*Kaltenbachiola strobi* was the second most important pest, with total average infestation range 14,9%. It occurred separately in 47,2% of cases, in the other cases always in combination with another pests *Cydia strobilella* (51,3%) and with both *Cydia strobilella* and *Dioryctria abietella* (1,5%). During the two years direct combination of the species *Kaltenbachiola strobi* and *Dioryctria abietella* occurred in no case. The number of cocoons found in one cone varied from 1 to 8, however, the range of inside cone damage was minimal. As far as *Kaltenbachiola strobi* is concerned, literature data contain again different values of damage – e.g. in former USSR up to 10% of cones (GREBENŠČIKOVA et al., 1968), in Poland the infestation of cones reached 10 – 30% (SZMIDT, 1953). In our samples the average infestation reached 14,9%. When evaluating inside damage of cones, MADZIARA–BORUSIEWICZ (1961) gives destroying of 1% of seeds in Poland, in former USSR it reached 10% (STADNICKIJ et al., 1978), ČANKOV (1974) in Bulgaria gives 15,3 to 41,7%. According to our knowledge the inside damage of cones was minimal, as a rule up to one per cent seeds in cone.

*Dioryctria abietella* occurred totally in 79 cones, average range of infestation reached 6.0%. It occurred the most often separately (54,4%), when the occurrence was combined, the interaction with *Cydia strobilella* (41,8%) dominated. In the cones it was found together with both *Cydia strobilella* and *Kaltenbachiola strobi*. One or two feeding caterpillars occurred in one cone, only in one extreme case (Forest Enterprise Košice, Forest District Jasov) even seven caterpillars of different size were found in one cone (in 1993). This was probably the consequence of food competition. The presence of caterpillars of different size points out the absence of marker feromone and egg–laying to already invaded cone. The caterpillars of *Dioryctria abietella* were generally characterized by wasteful feeding and the infested cone was thus usually completely destroyed. From the point of view of bionomy it is necessary to mention, that a pupa was found right in the cone from the random collection (Forest Enterprise Košice, Forest District Jasov). This phenomenon was recorded again in 1993 in the cone coming from the sample from Forest Enterprise Oravský Podzámok. Simultaneously a cannibalism was noted in this pest in larval stage (in the course of catterpilar keeping) – stronger and more aggressive individuals ate the feabler ones. PAŠEK (1954) gives caterpillar feeding even in galls of various aphis species on spruce at the time of poor yield of cones.
DAROS et al. (1993) gives the infestation of cones in 19 spruce species. Literature data point out the occurrence of *Dioryctria abietella* in the cones of all conifers, e.g. ROQUES (1983) mentions the occurrence in the cones of different species from Pinaceae family, especially in the genera Picea, Abies, Pseudotsuga, Pinus and Larix. *Dioryctria abietella* affects also the cones of introduced woody species, HRUBÍK (1978) stated that *Dioryctria abietella* damaged 20 taxa of conifers and it causes high infestation of cones and seeds every year. KRÍSTEK et al. (1992) gives in results of analyses from the year 1968 55.3% contribution of *Dioryctria abietella* to the damage of the cones of *Picea abies*. In other countries literature data are again much variable. SZMIDT (1953) gives the damage 1 – 5%, in some years even 90% (SZMIDT, LUTEREK, 1974). On the territory of former USSR GREBENŠČIKOVA et al. (1968) found 8.2% damage of cones, SAKSONS (1973) gives the infestation range 0.8 to 10% in Litva. According to STADNICKIJ et al. (1978) this pest infested 0.5 to 25% of spruce cones, two caterpillars destroys in the course of its ontogeny 15 to 25% seeds in cone, two caterpillars up to 50% of seeds. According to our knowledge feeding of two and more caterpillars leads, owing to wasteful feeding, to the complete destroy of the cones. As far as the bionomy of the pest is concerned, we would like to point out the finding of circular cocoons right in cone (in two cases) and to the cannibalism found during the experimental caterpillar keeping.

Total average cone infestation by insects in the two years studied (1993 – 1994) reached 63.4%.

When the dependence on environmental conditions was evaluated a negative correlation of combined occurrence of *Dioryctria abietella* and *Cydia strobilella* with altitude was found. This is conditional on strict negative correlation of the range of cone infestation by *Dioryctria abietella* with altitude, which increases the probability of combined occurrence of *Dioryctria abietella* and *Cydia strobilella* in lower altitudes (KELBEL, 1997).

In literature *Ernobius abietis* FABR. is included among the pests of spruce cones, too. These problems were dealt with in a separate paper (KELBEL, 1993). The analyses revealed the presence of *Ernobius abietis* neither in precociously fallen fruit, nor in ripe cones, collected in the period of main collection. Its presence was recorded only in older, open cones. The range of occurrence in the samples analysed was from 2.5% (Tatra National Park) to 90% (Forest Enterprise Košice, Forest District Jasov). The number of feeding larvae in one cone was much variable, from 1 to 44. The range of inside damage was thus also much variable, from indiscernible to total one. However, with regards to the occurrence after the period of main collection, the destructive activity of larvae can be evaluated from the point of view of forest seed management irrelevant. We recommend to consider *Ernobius abietis* an indifferent, or a useful species. Harmfullness of the species has been the resource of controversies in literature. According to KAPUSCINSKY (1966) the statement that *Ernobius abietis* is harmful to spruce cones is incorrect, since it settles the cones that are already old and dry. Numerous authors, cited in the work of KRÍSTEK et al. (1992), consider it an important insect pest. It is included among cone pests also by ROQUES (1983). Our results give the evidence of the fact, that the influence of *Ernobius abietis* on seed quality is not relevant when the seed is extracted in time. SKRZYPczynska (1982) in detailed evaluation of entomofauna of spruce cones in Poland included it, from the point of view of ecology, in the coenotic group of sapro– and coprophagous, not among conophagous and seminiphagous insects, although in newer paper (1997) she admits that the role of *Ernobius abietis* and *Gastrodes abietum* BERG. in cones is not unequivocal.

When analysing the cones we found numerous occurrence of *Gastrodes abietum* in some samples, however, we did not discover that they damage cones. SKRZYPczynska (1982) included this species into the group of so–called seasonal insects. According to our findings *Gastrodes abietum* used partially open cones in order to hide under the seed scales from
unfavourable weather. When the cones were taken over to warm place Gastrodes abietum were leaving the cones en masse.

X–ray analyses of seeds revealed the presence of two pest species – *Megastigmus strobilobius* Rätz. and *Plemeliella abietina* Seithn.

The infestation of seeds by the pest *Megastigmus strobilobius* reached in average 5.1%.

In this seminiphagous pest the level of the damage is variable, e.g. according to Čankova (1974) it was 14% and Roques (1983) 4 – 5%. Krístek et al. (1992) states that the range of damage was 32.8% in 1968 (from the total number of seeds occupied by the insects and originally full). Our analyses revealed average infestation 5.1%.

In the second pest, *Plemeliella abietina* total average infestation was 4.1%. As far as the pest *Plemeliella abietina* is concerned, literature data are again much variable. For example, Madziara–Borusiewicz (1961) up to 57%, Grebenščikova et al. (1968) from 1.0 to 26%, Annila (1973) 20.5% and Roques (1983) 1 – 2%. Krístek et al. (1992) found the infestation 67.2% (from the total number of seeds occupied by the insects and originally full). Total average infestation reached 9.2%.

During the research in the Botanical Garden of P. J. Šafárik University the presence of four pest species in the cones was found: *Dioryctria abietella*, *Cydia strobiella*, *Assara terebrella* Zinck. and *Kaltenbachiola strobi*. Further insect species, which are, however, regarded indifferent, were found in cones: *Ernobius abietis* and *Gastrodes abietum*.

*Cydia strobiella* reached average range of cone infestation 28.0% in the period studied, the most frequent was the occurrence of one or two caterpillars in one cone. In this pest a diapause in larval stage, lasting one to two years, was confirmed.

*Dioryctria abietella* infested 18.0% cones in average, from this amount in combination with *Cydia strobiella* it infested 11.0% of cones.

*Kaltenbachiola strobi* occurred in average in 8.0% of cones, from this amount in two per cent it occurred in combination with both *Cydia strobiella* and *Assara terebrella*. *Assara terebrella* was discovered already in 1996, this was dealt in detail in separate paper (Kelbel, 1998). Total average of cone infestation reached 16.0% in this pest, in two per cent from this there was a synergic occurrence with *Cydia strobiella* and *Kaltenbachiola strobi*. Literature provides inconsistent information on the occurrence of caterpillars of *Assara terebrella* in living, or, as the case may be, only in fallen spruce cones. According to Holste (in Čermák, 1952) the caterpillar of this species occurs only in fallen spruce cones on the ground. Čermák (1952) summarized the knowledge until then stating, that it is needed to study the biology of the pest in detail with regards to the well–founded suspicion, that the caterpillar destroys seeds in cones already on tree. Pfeffer et al. (1954) included this species among spruce cone pests. Patocka (1956) diagnosed it in the cones of fir *Abies numidica* De Lann. ex Carr. from the Arboretum of Forest Research Institute in Kysihýbel a and one individual of *Abies alba* Mill. near the town of B. Štiavnica, however, he did not succeed to rear the above given species from fallen cones of *Picea abies*, collected in the surroundings of B. Štiavnica. It is clear from his research into fir cones, that caterpillar of *Hyphantidium terebrellum* (= *Assara terebrella*) affects already living cones on trees. If these cones are seriously infested, their development is retarded or they fall precociously. Krístek et al. (1992) gives in his data on bionomy feeding caterpillars in developing cones up to late autumn. The feeding continues in the fallen cone, where the caterpillar winterizes. These data are in accordance with our observations. Patocka (1956) claims, that in nature. The pupation of the caterpillars comes on after winterizing inside the cone, according to Escherich (1931) also in the ground. According to Krístek et al. (1992) the caterpillar continues feeding in the spring of the second year and pupates in the spring of the third year, it means that the ontogeny takes two years. Hrubík (1975) diagnosed this pest in the cones of fir *Abies numidica* De Lann. ex Carr. in the Arboretum Myňany. The caterpillars damaged young cones, caused their
growing brown and gradual getting dry. SKRZYP CZYN SKA (1982) gives this pest in the survey of entomofauna of spruce cones of Picea abies in Poland, in the coenotic group of conophagous insects. KRISTEK et al. (1992) includes among the host woody plants of this species, besides spruce, also pine and Douglas–fir, analyses of spruce cone samples from the localities in Bohemia and Moravia in 1968 did not reveal this pest. This author considers the species Assara terebrella underestimated from the point of view of its harmfulness. DAROS et al. (1993) gives the occurrence of this pest, besides the indigenous spruce species Picea abies, also in the cones of four exotic spruces (Picea smithiana /WALL./ BOISS., P. asperata MASTERS, P. montigena MASTERS and P. morrisonicola HAYATA), which are taxonomically close to the species Picea abies, however, neither any spruce from the section omorica nor north American spruce species were infested.

Picea pungens"Argentea":
Dioryctria abietella was the dominant pest in the cones, with average infestation range 31.4% in the period studied, the occurrence of Cydia strobilella was recorded only in the years 1997 and 1998 and it was only sporadic. On the locality Továrniky Dioryctria abietella was diagnosed in the cones with the infestation range 23.1% (JUHÁSOVÁ, HRUBÍK, 1984).

Picea omorica /PANČ./ PURK.: 
Only Dioryctria abietella was found in the cones, average infestation range was 14.8%. In Arboretum Mlyňany 12.8% of cones of the above spruce was infested by this pest species and on the locality Svodov the infestation range was 24.2% (JUHÁSOVÁ, HRUBÍK, 1984). The infestation of the cones by Dioryctria abietella was pointed out also by ČERMÁK (1952), he referred to the data found in Yugoslavia. DAROS et al. (1993) gives also Cydia strobilella in the cones.

Picea sitchensis (BONG.) CARR.: 
Average range of cone infestation reached 65.2% in the period studied, from this number Cydia strobilella damaged 58.4% of cones, Dioryctria abietella 4.0% and both pests invaded 2.8% of cones together.

Picea glauca (MOENCH) VOSS.: 
Average range of cone infestation in five years reached 34.3%. Only Cydia strobilella caused the cone damage. ČERMÁK (1952) gives Dioryctria abietella as the pest of cones of the spruce Picea alba LINK. [= Picea glauca (MOENCH) VOSS.]. He referred to the data from Germany. The pests of cones and seeds of the genus Strobilomyia on this spruce species were dealt with by FIDGEN et al. (1998). FOGAL and LAROCQUE (1992) found the damage of the cones and seeds caused by the following pests: Choristoneura fumiferana CLEM., Cydia strobilella and Strobilomyia neanthracina MICHElsen. DAROS et al. (1993) discovered also the damage of cones by Cydia strobilella, whilst the most frequently one caterpillar occurred in one cone.

4. Conclusions
The paper sumarizes the data on the infestation of cones of Picea abies both in forest management conditions and the conditions in the Botanical Garden of P. J. Šafárik University in Košice, where during five years also the cones of the following selected introduced species were analysed: Picea pungenscv."Argentea", Picea omorica, Picea sitchensis and Picea glauca.
We can state, that as far as the damage of cones and seeds of *Picea abies* concerned, in the forest management conditions great variability occurred not only between particular distant localities, but within former forest enterprises as well.

The process of protection and struggle against conobionts is very hard, regarding their inward way of life and not always visible outer symptoms of seed and cone damage.

Recommendations for forest seed management can be the following:

1. During the seed collection it is necessary to check the state of health of certified stands for seed collection and to exclude the stands with mass occurrence of the pests from the collection.
2. In establishment of tree seed orchards it is necessary to avoid the proximity of spruce stands, regarding both undesirable pollination from the background and possible migrations of conobionts.
3. In tree seed orchards, with regard to the facility of access to particular trees, relatively small height of the trees, accessibility of crowns and favourable field conditions, it is possible to apply further precautions:
   a) in August and September to remove obviously damaged fruits from the trees,
   b) rake off and burn precociously fallen fruit,
   c) in spring and autumn to destroy winterizing cocoons of *Dioryctria abietella* by regular loosening of soil,
   d) to increase the seed crop by regular and directed fertilization which leads to indirectly proportional decrease in the damage of fruit by conobionts,
   e) from the middle of May to the middle of June preventive spraying of the crowns by approved contact insecticides (insecticidal screen), in the period of possible flights and egg-laying,
   f) in future the gradual use of feromone catchers is considered – for example in Poland, sexual feromones against *Cydia strobilella* were tested (Skrzypczynska et al., 1998).

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References


Summary
In the years 1992 to 1994 we checked spruce seeds and cones for pests in forest stands in Slovakia.
In the cones the presence of the three most important pests was found: *Cydia strobilella* L., *Kaltenbachiola strobi* WINN. and *Dioryctria abietella* DEN. et SCHIFF. *Cydia strobilella* was the most important species with overall average range of infestation 53.2% in the period of main collection, *Kaltenbachiola strobi* (14.9%) was the second one and then *Dioryctria abietella* (6.0%). X-ray testing of the seeds showed the presence of two pest species – *Megastigmus strobilobius* RÄTZ. and *Plemeliella abietina* SEITN., the range of seed infestation by *Megastigmus strobilobius* reached 5.1%, by *Plemeliella abietina* 4.1% in average. During the research in the Botanical Garden of P. J. Šafář University in Košice in the course of years 1995 – 2000 the cones of the following species were analysed: *Picea abies* L., *Picea pungens* “Argentea”, *Picea omorica* (PANČ.) PURK., *Picea sitchensis* (BONG.) CARR., *Picea glauca* (MOENCH) VOSS.. Analyses revealed the presence of four pest species in the cones of *Picea abies*: *Dioryctria abietella*, *Cydia strobilella*, *Assara terebrella* ZINCK and *Kaltenbachiola strobi*. *Cydia strobilella* reached the average range of infestation 28.0% during the studied period, *Dioryctria abietella* 18.0%, *Assara terebrella* 16.0% and *Kaltenbachiola strobi* 8.0%. In *Picea pungens* “Argentea”, *Dioryctria abietella* was the dominant pest (31.4%), the occurrence of *Cydia strobilella* was only sporadic. In *Picea omorica* (PANČ.) PURK. cones only *Dioryctria abietella* (14.8%) was found. In *Picea sitchensis* (BONG.) CARR., *Cydia strobilella* infested 58.4% of cones, *Dioryctria abietella* 4.0% and both pests shared 2.8% of cones. In *Picea glauca* (MOENCH) VOSS.. only *Cydia strobilella* occurred (34.4%).

The process of protection and struggle against conobionts is very hard, regarding their inward way of life and not always visible outer symptoms of seed and cone damage. Recommendations for forest seed management can be the following:

1. During the seed collection it is necessary to check the state of health of certified stands for seed collection and to exclude the stands with mass occurrence of the pests from the collection.
2. In establishment of tree seed orchards it is necessary to avoid the proximity of spruce stands, regarding both undesirable pollination from the background and possible migrations of conobionts.
3. In tree seed orchards, with regard to the facility of access to particular trees, relatively small height of the trees, accessibility of crowns and favourable field conditions, it is possible to apply further precautions:
   a) in august and september to remove obviously damaged fruits from the trees, rake off and burn precociously fallen fruit
   b) in spring and autumn to destroy winterizing cocoons of *Dioryctria abietella* by regular loosening of soil
   c) to increase the seed crop by regular and directed fertilization which leads to indirectly proportional decrease in the damage of fruit by conobionts
   d) from the middle of May to the middle of June, in the period of possible flights and egg-laying to apply insecticides by ground application in a form of low-volume spraying within the framework of advanced defence in order to form so-called insecticidal screen
   e) in future the gradual use of feromone catchers is considered – for example in Poland, sexual feromones against *Cydia strobilella* were tested (Skrzypczynska et al. 1998)