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# CONE AND SEED INSECTS IN NORWAY SPRUCE [*PICEA ABIES* (L) KARST.][*]
# Insekti šišarica i sjemena smrče (*Picea abies* (L) Karst.)

Sakib Kišija[1]

**Izvod**

Učestalost insekata šišarica i sjemena smrče (*Picea abies* (L) Karst.) iz tri regije južne Norveške analizirana je za razdoblje od 1968. do 2006. godine, sa rentgenskih fotografija uzoraka sjemena i kartona kontrole uzoraka šišarica. Više temperature, posebno posljednjih 20 godina, su vjerovatno pridonjele učestalijim godinama uroda sjemena smrče. U radu su konstatovani sljedeći insekti šišarica i sjemena smrče: *Cydia strobilella* (L.), *Plemeliella abietina* (Seitn.), *Megastigmus strobilobius* (Ratz.) *Kaltenbachiola strobi* (Winn.), *Strobilomyia anthraciana* (Czerny.), *Dioryctria abietella* (Den. *et* Schiff.), *Eupithecia abietaria* (Ratz.) i *E. analoga* (Zett.). Zabilježene su i patogene gljive *Pucciniastrum areolatum* ((Fr.) G.H. Otth.) i *Chrysomyxa pirolata* (Wint.).

***Ključne riječi**: Cydia strobilella* (L.), *Plemeliella abietina* (Seitn.), *Megastigmus strobilobius* (Ratz.), klima.

**Abstract**

Frequency of gall and spruce insects (*Picea abies* (L) Karst.) from three Norwegian regions were analyzed during the period from 1968 to 2006, from the x-ray photos of samples of seeds and files of control of gall samples. Higher temperatures, especially during the last 20 years, have most probably contributed to more frequent years of good production of spruce seeds. The paper has indicated the following gall and spruces insects: *Cydia strobilella* (L.), *Plemeliella abietina* (Seitn.), *Megastigmus strobilobius* (Ratz.) *Kaltenbachiola strobi* (Winn.), *Strobilomyia anthraciana*

[*] Master these from Norwegian University of Life Sciences (UMB), May 2008.

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(Czerny.), *Dioryctria abietella* (Den. *et* Schiff.), *Eupithecia abietaria* (Ratz.), and *E. analoga* (Zett.). The pathogen fungi were observed as well: *Pucciniastrum areolatum* ((Fr.) G.H. Otth.) and *Chrysomyxa pirolata* (Wint.).

***Key words****: Cydia strobilella* (L.), *Plemeliella abietina* (Seitn.), *Megastigmus strobilobius* (Ratz.), climate.

## 1. INTRODUCTION - *Uvod*

Norway spruce (*Picea abies* (L.) Karst.) is the most important and most widespread tree species in Norway. Cone and seed insects in Norway spruce have been topic for many publications. Alf Bakke is one of the first in Norway, and probably in Europe, who has undertake one extensive and formative resource of spruce cone and seed insects (BAKKE 1953; 1963; 1969). Many other have had big advantage of his work, both in Norway and international. Other central contribution from Nordic countries are WIERSMA (1979) and ANNILA (1981). Researchers from Europe, apart from that, who have published familiar works, between other, are; ROQUES (1983), SKRZYPCZYŃSKA (1986) and SEIFERT (2000). In Norway, however, it has not been did systematical studies of spruce cone and seed insects since Bakke's work from 1950- and 60-ies. The information we have about importance of different insect damages from year to year and between regions are deficient. Specially knowledge and resources of insect damages in spruce seed orchards in Norway are missing (EDVARDSEN 2005).

The experiences tell us that deference cone insects can destroy a lot of spruce seed production and thereby reduce seed access. An example of insect species which is not easy to clean off is spruce seed midge (*Plemelliella abietina* (Seitn.)). Insect damages do that germinate capability of seeds been lesser and seeds quality been lower. Cone collectors, besides, get reduce their effort because they mast use time to escape damaged cones. For example, results from one resource of spruce cone and seed insects in Finland that the total percents of seeds which are destroyed by insects have vary from 24.4 % in 1978 to 65.3 % in 1975 (ANNILA 1981). After one good seed year in 2002 plans Norwegian Seed Authority to collect 170 tones of spruce cones. Of that scheduled volume was less than 4.5 tones of spruce cones collected. It does to that one big quota of spruce cones was damaged by insects and fungus (EDVARDSEN 2005). In supplement to insect damages will problems with seed access been more additionally strengthen of spruce periodical cone production (*masting*), which does that can go long time between the good seed years. In South Norway good spruce seed years occur with 3-4 years interval, and in Trøndelag counties with up to 8-10 years interval (BØRSET 1985; FYSTRO 1962; 1993).

Days culture forestry which produces plants from collected seed request seed with high genetic quality, reason lowest possible coasts. Researches show that Norwegian forestry owners can calculate with one increment of value of timber

production of circa 10 % by use of spruce seed from seed orchards (SKOGFRØVERKET 2008). Because that reason, use of this refined seed is therefore big and strongly increasing. Today most part of seeds come from seed orchards (in 2007 was quota circa 60 %) and in 2008 it is plan to collect circa 70 – 80 % seed from seed orchards (EDVARDSEN personally informs 2008). In Norway today exist around 20 spruce seed orchards of the first generation whose give seed to several areas of country and different elevation zones. One seed orchard has a limited amount of trees whose we can collect cones from and seed production on areas like those been thereby more vulnerable for the insect damages than under collecting from common forestry stocks.

The wish for better knowledge about seed insects is especially motivated reason that we know little about how will climate in future affects relation between seed damagers and seed production. Several aspects of temperature relations and cone insects have been study also under Norwegian rates. For example BAKKE (1971) has find that quota of spruce seed moth (*Cydia strobilella* (L.)) in prolonged diapause is correlated with elevation zones, likely reason of climate differences.

## 2. APPROACH TO THE PROBLEM AND THE AIM – *Problematika i cilj istraživanja*

The Norwegian Seed Authority (*Skogfrøverket*) sits with a long time serial for spruce cone and seed insects. This is unique because that had one central seed supplying responsibility in long time. Today all country has been supply with seed from Seed Authority.

The main aim with this these is describe occurrence of spruce cone and seed insects in deferent regions of South Norway for period from 1968 to 2006. Data base is Seed Authority's extensive data material about spruce cone and seed insects. This material contains X-rays of spruce seeds and also analysis cards of cone simples. I check whether some of species are more common in some regions and elevation zones during period of 39 years, and also how cone access and factors whose affect cone access was during this period. Further away become results about insect occurrence put to context with climate trends (NORDLI 2008).

## 3. MATERIAL AND METHODS – *Material i metode rada*

The main material for this searching has been X-rays of spruce seeds (hereafter called for X-ray analysis) and analysis of spruce cones (hereafter called for cone analysis). Seed Authority has in its archive about 4200 spruce seed samples, there each sample consist of two X-rays à 100 seeds. All together, I have register spruce cone and seed insects from 739 seed samples from X-rays and 864 cone samples from cone analysis cards. Those are distributed over time serial of 39 years and come from three regions along one North-South axis in South Norway (Figure 1). Thereby we have assortment of spruce seed collected both from coast areas, from de

lowest elevation zones, and forth over law areas and inland areas to higher elevations and spruce mountain forest up to 1000 m a.s.l..

Three spruce seed insects have been registered from X-rays: Spruce seed midge (*Plemeliella abietina* (Seitn.)); Spruce seed moth (*Cydia strobilella* (L.)) and Spruce seed chalcid (*Megastigmus strobilobius* (Ratz.)). Nine cone-, seed insects and fungus have been register during cone analysis of analysis cards: Spruce cone gall midge (*Kaltenbachiola strobi* (Winn.)); Spruce cone pyralid (*Dioryctria abietella* (Den. *et* Schiff.)); Spruce cone fly (*Strobilomyia anthraciana* (Czerny.)); Pugs (*Eupithecia abietaria* (Ratz.)) and (*Eupithecia analoga* (Zett.)); Spruce seed midge (*Plemeliella abietina* (Seitn.)); Spruce seed moth (*Cydia strobilella* (L.)); Cherry-spruce cone rust (*Pucciniastrum areolatum* (Fr.) G.H. Otth.) and Inland spruce cone rust (*Chrysomyxa pirolata* (Wint.).

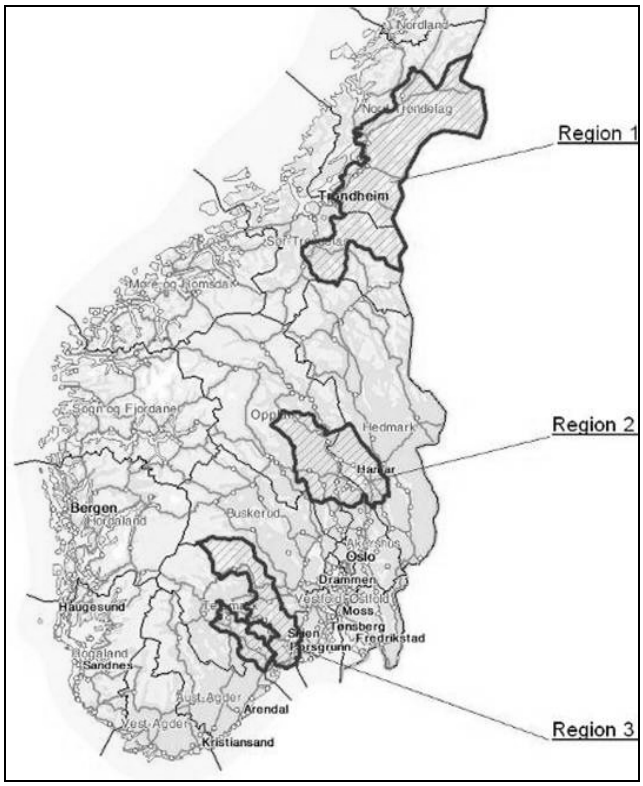



Figure 1 Regions where the analyzed cones have been collected from
*Slika 1. Regije iz kojih su prikupljane analizirane šišarice*

Spruce seed insects have been determined by species with help of the determination key make by SIMAK (1955; 1980). Heidi Røsok Bye from the Seed Authority in Hamar and Olle Rosenberg from the Forestry Research Institute of

Sweden have given me help during the practical determination of insects. No damaged, full developed seeds on X-rays (Figure 2A) appear with well developed endosperm and embryo. Empty seeds are seeds without any content, or with rests of wrong developed endosperm, embryo or seed membrane (Figure 2B). Larvae of spruce seed midge, has often one conjugated shape and it is surrounded by one seed skin without gap (Figure 2C). Seeds with gap in seed skin and whose are filled with excrements, are significant indications that damages are did by larvae of spruce seed moth (Figure 2D). Larvae of spruce seed chalcid have more round shape than larvae of spruce seed midge. There surrounded with one no feed seed membrane to cavity under seed skin and there is not gap in seed skin (Figure 2E) (WIERSMA 1979). Damages of spruce seed midge and spruce seed chalcid can be easy confuse on X-rays.

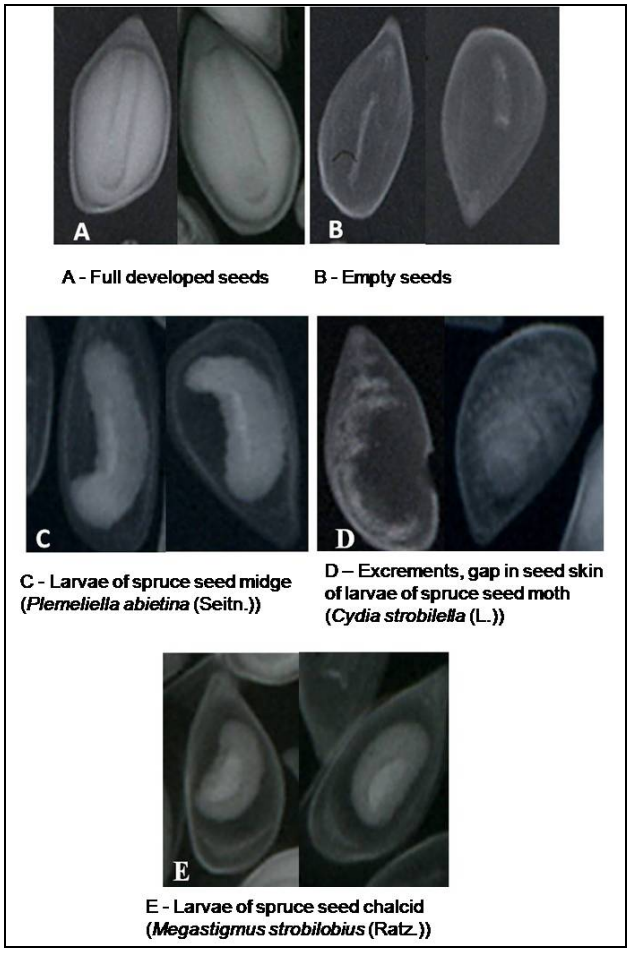
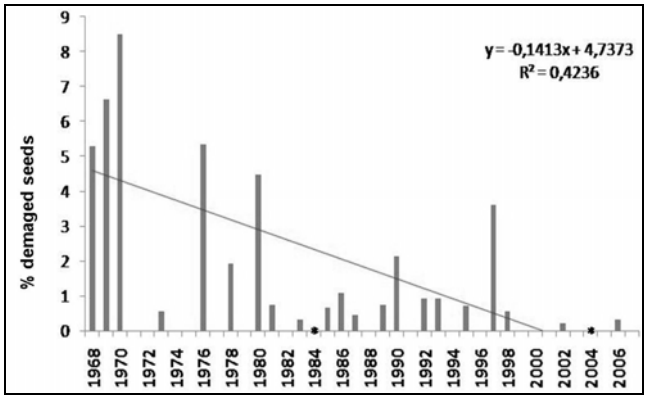



Figure 2 X-rays with examples of the most important conditions of spruce seed
*Slika 2. Rentgenske fotografije sa primjerima najvažnijih stanja sjemenki smrče*

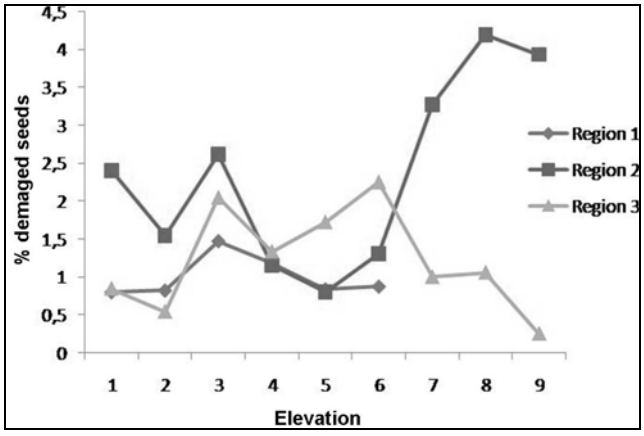
## 4. THE RESULTS – *Rezultati*

In all I have seen at 147700 spruce seeds. Region 1 was best represented with in all 404 seed samples, then region 2 with 226, and region 3 with 109 samples. In the average over whole period of 39 years, in the total material, there were 60 % full seeds, 36 % empty seeds and 4 % (3 % spruce seed gall midge, 1 % spruce seed moth) insect damaged seeds. The average damage percent of seed insects per year for period (1968 – 2006) varied from minimum 0.6 in 1973 to maximum 8.5 in 1970.

**Spruce seed moth (*Cydia strobilella* (L.)**

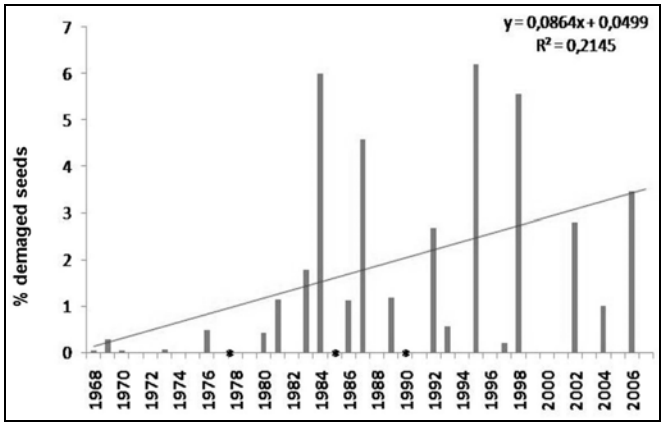



Graph 1 Occurrence of spruce seed moth (*Cydia strobilella* L.) in X-rays over period of 39 years
*Grafik 1. Učestalost insekta Cydia strobilella (L.) na rentgenskim fotografijama za razdoblje od 39 godina.*

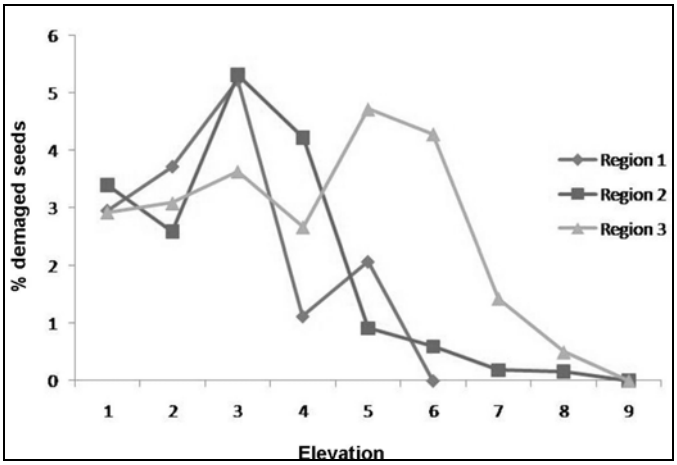



Graph 2 Occurrence of spruce seed moth (*Cydia strobilella* L.) in X-rays in regions and elevation zones over period of 39 years.
*Grafik 2. Učestalost insekta Cydia strobilella (L.) na rentgenskim fotografijama po regijama i po nadmorskim visinskim zonama za razdoblje od 39 godina.*

**Spruce seed gall midge (*Plemeliella abietina* (Seitn.)**




Graph 3 Occurrence of spruce seed gall midge (*Plemeliella abietina* Seitn.) in X-rays over period of 39 years.
*Grafik 3. Učestalost insekta Plemeliella abietina* (Seitn.) *na rentgenskim fotografijama za razdoblje od 39 godina.*

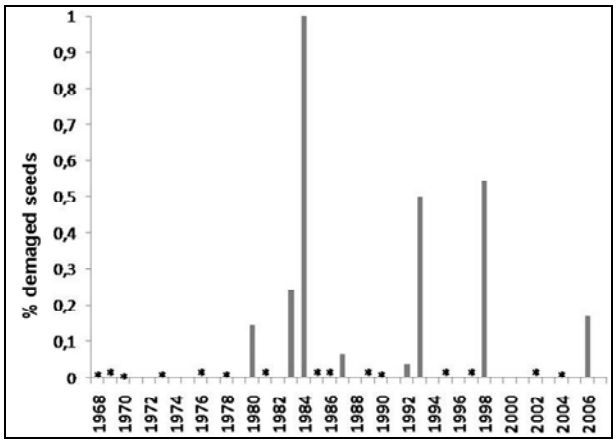



Graph 4 Occurrence of spruce seed gall midge (*Plemeliella abietina* Seitn.) in X-rays in regions and elevation zones over period of 39 years.
*Grafik 4. Učestalost insekta Plemeliella abietina* (Seitn.) *na rentgenskim fotografijama po regijama i po nadmorskim visinskim zonama za razdoblje od 39 godina.*

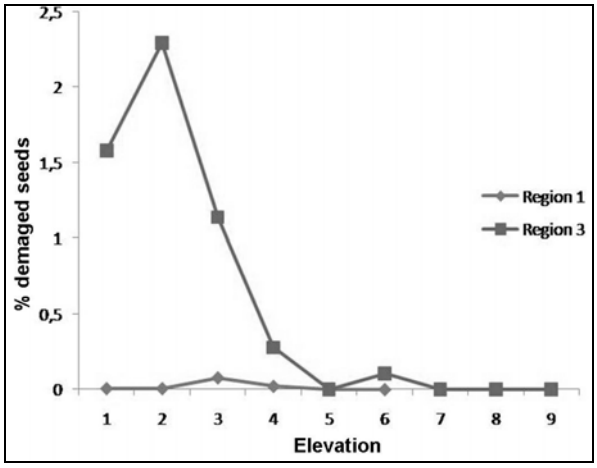
Graph 1, 3 and 5: Occurrence of spruce seed insects in X-rays over period of 39 years. Years where occurrence of insects is near zero are marked with a star (*). Years without pillars or stars are years in whose seed samples were not collected. The trend line is highlighted with the regression line (equation in right corner, except Graph 5). Pillars represented percent quota of seeds with symptoms by seed insect per sample of 200 seeds.

Graph 2, 4 and 6: Occurrence of spruce seed insects in X-rays in regions and elevation zones over period of 39 years. Each point represents average percent seeds whose are damaged by seed insect per average seed sample per elevation zone per region for whole period.

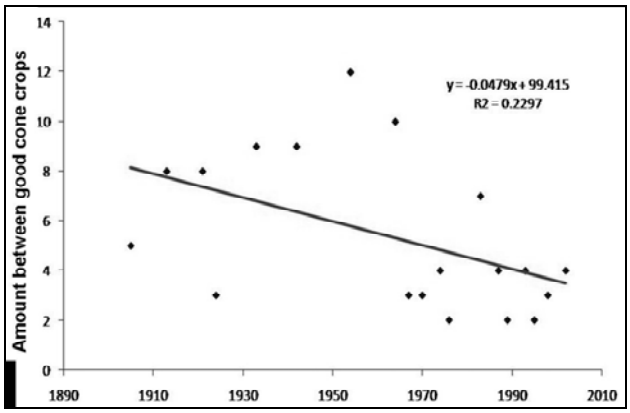
**Spruce seed chalcid (*Megastigmus strobilobius* (*Ratz.*))**




Graph 5 Occurrence of spruce seed chalcid (*Megastigmus strobilobius* Ratz.) in X-rays over period of 39 years.
*Grafik 5. Učestalost insekta Megastigmus strobilobius* (Ratz.) *na rentgenskim fotografijama za razdoblje od 39 godina.*

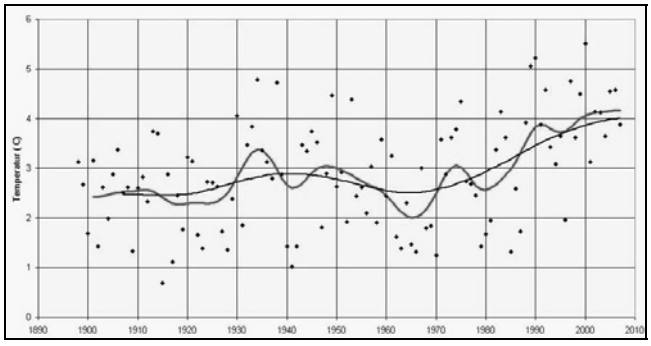



Graph 6 Occurrence of spruce seed chalcid (*Megastigmus strobilobius* Ratz.) in X-rays in regions and elevation zones over period of 39 years.
*Grafik 6. Učestalost insekta Megastigmus strobilobius* (Ratz.) *na rentgenskim fotografijama po regijama i po nadmorskim visinskim zonama za razdoblje od 39 godina*




Graph 7 Occurance of years with good cone crops
*Grafik 7. Učestalost godina sa dobrim urodom sjemena*

Graph 7: Occurrence of years with good spruce cone crops in East and South Norway in lower elevation zones, period of 100 years. Each point represents good spruce cone crops in East and South Norway in lower elevation zones during period of 100 years. The decreased trend is highlighted with the regression line (equation in right corner). Material is collected from Seed Authority's overview over good spruce cone crops (FYSTRO 1993), and it is carved this these.




Graph 8 Temperature[2]
*Grafik 8. Temperatura*

Graph 8: Historic average variation in air temperature in East Norway in period of 110 years (NORDLI 2008). Points represent medium years temperature during period of 110 years, more oscillate line represents medium temperature for one scale

[2] Source: The Norwegian Meteorological Institute

of 10 years during whole period, less oscillate line represents medium temperature for one scale of 30 years during whole period.

In all there were investigated 864 cone samples (from control reports of cone samples) in period of 39 years. The most representative was region 1 with 430 cone samples, then region 2 with 293, and the less representative was region 3 with 141 cone samples.

Results from cone samples analyses show that in average for whole period per average cone sample was 34 % cone simples sizable damaged by spruce seed moth (*Cydia strobilella* (L.)), 15 % by spruce cone midge (*Kaltenbachiola strobi* (Winn.)), 5 % by spruce cone fly (*Strobilomyia anthraciana* (Czerny.)), 3 % by spruce seed midge (*Plemeliella abietina* (Seitn.)), 2.2 % by spruce cone pyralid (*Dioryctria abietella* (Den. *et* Schiff.)), 0.1 % by pugs (*Eupithecia abietaria* (Ratz.) and *E. analoga* (Zett.)), and supplement to these 5.2 % by cherry-spruce cone rust (*Pucciniastrum areolatum* (Fr.) G.H. Otth.) and 0.35 % by inland spruce cone rust (*Chrysomyxa pirolata* (Wint.)).

Cone insects alone or together with seed insects and fungal diseases, can destroy up to 80% of collected spruce seed in some years.

## 5. CONCLUSION - *Zaključak*

This study, of the time series of cone and seed insects, gives some indications whose can be useful. The results show us how condition and development of occurrence related time, regions and elevation zones with weight on spruce seed insect was. It can look like, from the trends, that occurrence of the two most important spruce seed insects in South Norway is substantially affects of the climate development over time.

Spruce seed moth (*Cydia strobilella* (L.)), which is most usual in Trøndelag and in northern and higher elevation zones in South Norway (BAKKE 1994), has occurred in less magnitude in the last years whose are became warmer.

Spruce seed midge (*Plemeliella abietina* (Seitn.)), which is most usual in higher elevation zones in South Norway (BAKKE 1994), has occurred in larger magnitude in the last years.

Spruce seed chalcid (*Megastigmus strobilobius* (*Ratz.*)) is not so widespread in Norway, but after the few registrations presented on Graph 5, I will assume that if this species is not synchronized with temperature development (Graph 8) so it in cause prefers warmer than colder years.

Increasing of medium air temperature, especially in last 20 years, has likely caused more common spruce cone years and unleveled trends for the respective spruce cone and seed damagers.

Warmer climate in newer time is one possible explanation of change in insect occurrence and more common cone years.

Temperature is important both for accession of cones (flowering and cone establishment, insect swarming etc.) and also for spruce cone and seed insect life

circle, and it reflects among other things in that length of the growth season in this period has became longer. That is important with low air humidity under swarming. Temperature increasing has possible cause that time point for start of spring and time point for spring have been earlier. Other affects of warmer climate will potentially, beside of spruce cone resistance which will become weakened, especially in the end of spread area, guide to modification related natural enemies and opponents.

There is one general tendency for that the insects do not cause high level of damages in years with good cone crops (informed by Ingvar Fystro, former director of Seed Authority). It applies especially in years with good cone crops whose come longer time after one good cone crop year. During good cone crop years insects forming up and in years with less cone crops, whose come one/two year after good cone crop year, damages become very high. The good geographical data about true cone and seed crop which spruce forest produce, defined in for example weight unit per area, will give us possibility to find out more about population oscillations, synchronization between species and spreading geography of species. Unfortunately, data like this not exist.

That is important to continue with that conservative analyses method of spruce cones and X-rays of spruce seeds in future so that we have same background bases for forth study in this field. The Seed Authority sits with more X-rays and that I have analyzed are circa 17 % of all X-rays that has been taken of spruce seeds from whole country, which exists in archive so long.

Monitoring and improvement of the knowledge about damages of cone- and seed pests are especially needed to support commitment on refinement of plants in forestry and establishment of more spruce seed orchards, in Norway in recent time, where spruce seed trees grow under other ecologic relations than regular spruce forest.

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## Sažetak

Najveći broj šumskih sadnica smrče (*Picea abies* (L.) Karst.), danas u Norveškoj potječu iz sjemenskih plantaža osnovanih iz selektovanih plus stabala. Iskustva poslijednjih godina su pokazala da štete uzrokovane insektima i gljivicama mogu da ozbiljno ugroze količinu dostupnog sjemena. Primjer tome je 2002. godina u kojoj je većina šišarica smrče bila naprosto uništena insektima i patogenim gljivama. Rezultati ovog rada pokazali su da insekti šišarica samostalno ili zajedno sa insektima sjemena i patogenim gljivama mogu uništiti i do 80 % prikupljenog sjemena u pojedinim godinama.

U ovom radu opisane su štete uzrokovane insektima šišarica i sjemena smrče za period od 1968 do 2006, iz tri regije južne Norveške. Podaci potječu iz arhivskog materijala Centra za šumsko sjemenarstvo Norveške (*Skogfrøverket*) iz Hamara.

*Cydia strobilella* (L.) ima manju učestalost u uzorcima sjemena posljednjih godina.Ovaj insekt je u literaturi opisan kao insekt kojem više odgovara hladnija klima.

*Plemeliella abietina* (Seitn.), nasuprot, pokazuje veću učestalost posljednjih godina nego ranije. Ona je opisana kao insekt koji više preferira topliju klimu.

U radu je također identificiran *Megastigmus strobilobius* (Ratz.) na rentgenskim fotografijama. On nije ranije istraživan u Norveškoj, ali je pronađen u nekoliko uzoraka nakon 1980. godine, i učestaliji je u toplijim područjima i na nižim nadmorskim visinama.

Srednja godišnja temperature u južnoj Norveškoj porasla je za 1,2 °C u toku zadnjih 110 godina Vjerovatno je to uticalo na učestaliji urod sjemena nego ranije.

Ovaj rad nudi precizne podatke o značaju insekata šišarica i sjemena smrče u južnoj Norveškoj. Rezultati mogu da pruže praktičnu korist pri kontroli ovih insekata. Rezultati također ukazuju na mogućnost da je promjena klime već započela svoj utjecaj na populacioni nivo i rasprostranjenost insekata šišarica i sjemena u južnoj Norveškoj.