Fruiting and sporulation of cone rusts on *Picea* spp. and alternate hosts

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High amounts of good quality seed of Norway spruce are needed for seedling production. Irregular seed crops and young age of seed orchards are limiting factors for effective seed production. Cone rusts also reduce seed crop of *Picea* especially in good cone years. The frequency of fruiting and sporulation of *Thekopsora areolata*, *Chrysomyxa pirolata* and *C. ledi* in the form of aecia were investigated in 5600 cones collected from 9 seed orchards and 23 seed tree stands in Finland in 2006. Cone rusts were more common with 10-89% of infected cones of *P. abies* in seed orchards than in seed tree stands with 0-10% of infected cones. The most common cone rust was *T. areolata* in seed orchards, while *C. ledi* was the most common cone rust in seed tree stands. *Chrysomyxa pirolata* infected cones throughout Finland, but it was less common than the other rusts. *Thekopsora areolata* colonized cones entirely and sporulated in one-year-old or older cones, while *C. pirolata* colonized most cone scales and *C. ledi* did that for only single scales. Both *Chrysomyxa* rusts sporulated in current-year cones. The results indicated that *Thekopsora areolata* was the most important cone rusts in seed orchards damaging cones in 2006. Therefore, disease control should be headed against this rust.

In addition, the germination potential of *T. areolata* aeciospores on water agar was compared between 300 cones of various age in Muhos in 2009-2010 in a case study. The number of seeds was also compared between ca. 100 healthy cones and those infected with *T. areolata*, *C. pirolata* and *C. ledi*. The viability of 50 seeds from 8 healthy cones and 8 cones infected with *T. areolata* were also compared. Germination of *T. areolata* aeciospores was highest in 2-3 –years-old cones, while spores from current-year cones did not germinate. Some of the old cones contained spores with very high germination. Cones infected with *T. areolata* or *C. pirolata* contained less seeds than the healthy cones, while those infected with *C. ledi* contained equally seeds than the healthy ones. Germination of seeds was reduced significantly 10-fold by *T. areolata* compared to healthy seeds. Old cones serve as a chronic source of inoculum, and therefore, it is recommended that old cones should be removed from tree canopy along cone collection in seed orchards.

In another case study in the botanical garden of Oulu, the fruiting and sporulation of cone rusts in terms of fruiting stages on *Picea* spp. were investigated from 1100 cones collected in 2007-2012. In addition, the frequency of *T. areolata* uredinia were checked on ca. 100 *Prunus* spp. trees of 21 species and varieties in the botanical garden and 34 *Prunus padus* and *P. virginiana* cultivars in a field trial in Muhos in 2012. According to the results, all three cone rusts were most common on *P. abies* among *Picea* spp. in the garden. *Thekopsora areolata* was the most frequent rust on *P. abies* in 2010 and 2012, but also *C. ledi* was common with 22-28% of the cones infected in the respective years. *Chrysomyxa pirolata* occurred only in single cones on *P. abies* over the years. *Thekopsora areolata* aecia were also common on *Picea engelmannii*, while *C. pirolata* and *C. ledi* lacked on this host. *Thekopsora areolata* aecia occurred also sporadically on *Picea glauca*, and those of *C. ledi* occurred on *P. glauca* and *P. omorika*. These are the first observations of these rusts on these hosts. *Chrysomyxa pirolata* lacked on both of these hosts. Fruiting and sporulation of all three cone rusts were very similar on all *Picea* spp. shown in previous studies. Among *Prunus* in the botanical garden, all 13 exotic *Prunus* spp. were totally resistant to *T. areolata*, while the 8 *P. padus* and *P. virginiana* varieties were highly susceptible bearing abundantly uredinia on the leaves. In the field, all 34 Finnish and Russian cultivars of *P. padus* and *P. virginiana* were also highly susceptible to *T. areolata*. 