

Tree-killing fungi and insects benefit from climate change – and they also team up!

Tales from the SNS network: *Fung-i-insects. Bark beetles, their fungal associates and climate change: tackling multi-faceted risks with multidisciplinary research*

Climate change directly and negatively effects trees through drought, and fungal pathogens and pest insects take advantage of the situation by attacking and killing the drought-weakened trees. The focus of this SNS network is to build co-operation around this topical issue, which affects boreal forest health.

Many bark beetle species have become more abundant and expanded their range due to climate change. Such bark beetles transport various fungal symbionts with them, that are important for their ability to attack trees. A largely unanswered question is how climate change affects such symbiotic relationships. Can range-expanding beetles transfer new fungal species to areas where they have not been observed before, and if so, how does this affect forest damage risk? Furthermore, a novel collaboration has been discovered between the pathogenic fungus *Diplodia sapinea* and the bark beetle *Ips acuminatus* (**figure 1**). The *Fung-i-insects* network sets out to exchange the latest knowledge and experiences around this theme. With researchers from Finland, Norway, Iceland, Denmark and Sweden, the network was able to tackle the questions from a pan-Fennoscandian point of view.



Figure 1. Left: Scots pines attacked and killed by the co-operation of the bark beetle *Ips acuminatus* and the fungal pathogen *Diplodia sapinea*. Right: Scots pine trunks showing the bark beetle attacks: the beetle galleries (top) and sapwood colonization by the blue-stain fungi that the beetle transports (below). The underlying, predisposing factor behind the attacks was the 2021 drought. Pictures: Eeva Terhonen and Markus Melin / Luke.

The network kicked off with an online meeting on May 26, 2023 (**figure 2**).



Figure 2. Slides, slides and more slides. Online meetings in a nutshell

As fun as online meetings are, they cannot compete with what one can do physically. The online meeting was there to pave the way for the actual work ahead: deciding when to meet face-to-face, what themes to cover, etc. The actual on-site meeting was then held in Helsinki on October 19, 2023.

9:25-9:30 **Eeva Terhonen:** Welcoming words.

9:30-9:50 **Paal Krokene:** Ongoing research on *Ips typographus* in Norway.

9:55-10:15 **Jostein Gohli:** Bark beetle risk management in Norway - mapping outbreak risks using 45 years of pheromone trap data.

10:20-10:40 **Olli-Pekka Tikkanen:** On assessing insect damage risks of the future - case *Ips typographus*, *Lymantria monacha* and *Panolis flammea*.

Break 10 min.

10:50-11:10 **Ida Rönnqvist:** Bark beetle damage in uneven and even-aged forests

11:15-11:35 **Mathias Just Justesen:** Are secondary bark beetles a problem?

11:40-12:00 **Ari Hietala:** Relation between wood decay and livestock summer pasture in Norway spruce forests.

Lunch at the restaurant (buffet) 12:00-13:00

13:00-13:20 **Eeva Vainio:** First glimpse of the virome of *Ips typographus*

13:25-13:45 **Brynja Hrafnkelsdóttir & Thorhildur Isberg:** Iceland's National Plant Health Regulations: focus on tree health and future prospects.

13:50-14:10 **Johanna Witzell:** Dutch elm disease and the holobiont concept.

14:15-14:35 **Tiina Ylioja:** Recent increase in Scots pine (*Pinus sylvestris*) mortality and the role of sharp toothed bark beetle (*Ips acuminatus*).

A team of 21 researchers from all the participating countries were enjoying the food, the company and the atmosphere of Helsinki. And the cool winds of the autumnal forests – cold, but no mosquitoes! The physical meeting focused on the science, the core (figure 3). We had presentations from all participating countries, with topics ranging from insect monitoring, fungal pathogens, nocturnal moths, viruses of insects... you name it (**figure 3**).

Figure 3. The scientific program was, simply put, brilliant.

And finally, we went out in the field to see what fungi and insects can do to our beautiful trees when they work together. The field site was one where Scots pines were attacked by the insect pest *Ips acuminatus* and the fungal pathogen *Diplodia sapinea*, but which also had spruce trees attacked by the spruce bark beetle *Ips typographus*. The problems with the Scots pine trees started after massive droughts in 2021 and 2022, so it couldn't have been more topical to the theme of our network (**figure 4**).



Figure 4. Children at play. The participants examining trees attacked by *Ips typographus* (bottom left) and *Diplodia sapinea* (bottom right).

Since every crack in the forest cannot be examined, this network focuses on the most topical damage agents, the ones that also benefit from climate change. When investigating these complex forest damages, international co-operation is a must. We must share our experiences and since the Nordic countries have comparably similar forests Nordic co-operation is especially sensible. Here the network succeeded: we brought together junior and senior scientist from every Nordic country, sharing the experiences and issues of each country – and we met in person! This is the first step in any co-operation and also provided a valuable platform for the next generation of researchers to connect and establish essential relationships for future collaborations. Our network successfully orchestrated a gathering of researchers specializing in entomology and pathology/mycology.

The network's focus centered on emerging damage agents that remain largely unexplored. These challenges demand a collaborative approach, and our network served as an effective conduit for researchers to acquaint themselves with one another—a true and successful achievement. By addressing these unknown threats collectively, we are better positioned to tackle the challenges that lie ahead in the realms of entomology and mycology research.

Now, the aim is to apply for research funding to begin tackling the issues that face all of us. Hopefully, the future will see these plans being realized, proving that networking really does pay off.

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