Historically huge outbreak of the spruce bark beetle (*Ips typographus* (Linnaeus, 1758)) (Coleoptera, Curculionidae, Scolytinae) in Sweden 2018–2022

ÅKE LINDELÖW

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In the period 2018–2022 the volume of spruce forest killed by the spruce bark beetle (*Ips typographus* (Linnaeus, 1758) in Sweden is estimated to be 31,7 million m3 which is about 73 % of the total volume killed during 1961–2022. In 2021, 8,1 million m³ was killed which correspond to 1,2 % of the total spruce forest volume and 25,1 % of the total growth of spruce in that year. In September–October, still 70 % of trees killed during the summer remained unlogged. The impact of sanitation logging in winter-time on the population of spruce bark beetle is discussed.

Key words: Spruce bark beetle, Coleoptera, Curculionidae, Scolytinae, *Ips typographus*, outbreak, control, sanitation logging, survey.

Åke Lindelöw, Swedish university of agricultural sciences, Department of Ecology, P.O. Box 7044, SE-750 07 Uppsala, Sweden. E-mail: ake.lindelow@slu.se

Introduction

Reliable data on volumes of spruce trees killed by the spruce bark beetle in Sweden date back to the 1970´s (Risberg 1993). The amount of killed trees in outbreaks before 1970 are not accurately documented. Even after 1970, the data are not exact because of methodological reasons (e.g., Risberg 1993). The aim of this paper is to present information on the outbreak 2018–2022 in Sweden which mainly affected Götaland and Svealand and to discuss the problems on management of spruce stands heavily damaged by the spruce bark beetle as a part of the control program. Control measures of the spruce bark beetle mainly involves sanitation logging and regulation of storage of unbarked timber in the forest. Regulations are formulated in the forest act supervised by the Forest Agency (Skogstyrelsen 2023).

Material and methods

This paper is based on data compiled from several sources, mainly from the Swedish National Forest Inventory (NFI) (e.g. Wulff & Roberge 2022) which presents figures about the volumes of spruce forest killed by the spruce bark beetle in 2018–2022, but also data about sanitation logging in summer time. Reports from the Swedish University of Agricultural Sciences (SLU) and the Forestry Research Institute of Sweden gives data about the efficiency of sanitation cutting in winter time (Weslien *et. al.* 2022, Weslien *et. al.* 2023, Weslien & Schroeder 2023). Efficiency is defined by % of bark left on the logs after cutting and before transportation. The survival of bark beetles and its enemies during cutting and during winter in loose bark left on the ground was studied. Information on legislation related to prevent and control the spruce bark beetle can be found on

Swedish Forest Agency (Skogstyrelsen 2023).

Results

During the years 2018–2022 the volume of Norway spruce killed by the spruce bark beetle is historically high. Schroeder & Kärvemo (2022) report that in 2018–2021, 26 million m^3 were killed. This correspond to 69 % of the total volume killed since 1961 (Schroeder & Kärvemo 2022). We may now conclude that the amount of dead spruce trees in 2018-2022 corresponds to 73 % of the total volume killed during 1961-2022 by adding the data for 2022 which is 5,7 million m^3. Before 2018, the maximum amount of killed spruce forest in a single year in Sweden was estimated to be 573 000 m^3 which occurred in 2006, the year after a large storm «Gudrun» in January 2005 (Wulff 2006).

In Götaland and Svealand the yearly growth of spruce is estimated to be 34 million m^3/year and the growing stock of spruce is 650,7 million m^3 (> 15 cm DBR) (Skogsdata 2023). In 2021, 8,1 million m^3 was estimated to be killed by the spruce bark beetle. This corresponds to 1,2 % of the standing volume and 25,1 % of the yearly growth. It must be emphasized that the forest structure has changed a lot during the last century, e.g., the total amount of forest volume has increased from 1,5 billion m^3 to 3,2 billion m^3 and especially the volume of spruce and pine, now constituting > 80 % of the standing volume (Skogsdata 2023).

Control

In Southern Sweden (Götaland and most of Svealand) a temporary area of control is proclaimed by the Swedish Forest Agency. According to regulations in this area, forest owners are not allowed to leave more than 3 m^3/ha of wind-felled or cut spruce (defined as suitable for bark beetle breeding) in the forest (Skogstyrelsen 2023). Also, forest owners may be forced to cut and remove lying or standing trees colonized by spruce bark beetles from the forest before beetles emerge. To do sanitation logging is theoretically the best method to control the population. Removing colonized trees just after the main flight period includes removal of parent beetles, thus no sister brood and no reproduction is possible. Also, only part of the natural enemy complex have by then colonized the trees and thus few are removed from the forest. And the quality of the timber is not reduced to colonization of blue stain fungi. But in practice, according to inventories by NFI in September–October 2022, around 70 % of colonized standing trees remained in the forest (Wulff & Roberge 2022). At this time, parent beetles have already left and produced a sister brood, and a large proportion of the new generation has left the tree for hibernation in the duff.

Sanitation logging in winter time. Approximately 50 % of adults hibernate in the tree and the rest in the duff. Harvesting dead spruces in the winter results in 10–40 % of the beetles being removed from site. The proportion of adults hibernating in the duff and condition (frost) during logging affect the proportion of adults removed. Predators like *Medetera* (Fischer von Waldheim, 1819) flies (Diptera, Dolichopodidae) hibernating under the bark are thus removed by logging (Weslien *et al.* 2022, 2023). A proportion of other natural enemies also hibernate in the bark. Bark from colonized trees will loosen during cutting and transport, and therefore remain on the ground. Both spruce bark beetles and *Medetera* larvae survive until next season in such bark. The impact (reduction of killed trees in the coming season) of sanitation logging during winter time is thus questionable as a method of control.

Scenarios. To forecast damages caused by the spruce bark beetle in a coming year is not yet possible (e.g. Schroeder 2023). The number of killed trees during one season is influenced by the size of the hibernating population, stand characteristics as tree size, density of trees, tree vigor and weather (e.g. Wermelinger 2004). Monitoring, using pheromone traps indicate population size and can be used as a part of risk rating (Weslien *et. al.* 1989) The level of tree vitality influences the tree defense against attacking beetles and suitable weather conditions during the flight period is essential for the beetles

to coordinate the colonization of the tree and thus overcome the defense. Stand and site conditions are used in risk rating and used in forestry planning/practice. Mortality among beetles during flight and colonization is still unknown and thus a black box. Few studies have been done to estimate the mortality rate during dispersal and colonization phase of bark beetles. The impact of natural enemies during different phases of an outbreak is to a large extent still unknown although Weslien & Schroeder (2023) claim that natural enemies may reduce the endemic population level able to reproduce in an excess of breeding material after e.g. a storm felling. Also, in the end of an outbreak, natural enemies may contribute to a reduction of the population and thus the amount of killed trees.

Research and monitoring. Ongoing studies at SLU and Forestry Research Institute of Sweden is focused on reproduction rate during start and end of outbreaks including impact of natural enemies. Also conditions for the spruce bark beetle to kill trees in mixed forests compared to pure spruce stands as well as the efficiency of sanitation logging during the summer.

Discussion

The historically large outbreak during 2018–2022 has not yet ended and also in 2023 millions of cubic meters of spruce is expected to be killed (Schroeder 2023). The weather conditions in July-August was characterised by rain and moderate temperatures (SMHI 2023). Tree defence in spruce trees may have been improved and on the same time the spruce bark beetle activity as flight and colonisation of trees may be reduced. Thus, lower number of dead trees can be expected. It is a general pattern that outbreaks end after a few years, although the mechanisms behind is not fully understood. Reduced reproduction rate in trees recovered from drought being more resistance to colonisation, i.e. more beetles are needed to overcome the defence of the tree. Higher density of colonising beetles to kill the tree, which is necessary for reproduction, involves higher intra-specific completion and thus reduced population growth (Schroeder & Kärvemo 2022). The impact of control measures is unclear. Theoretically, the sanitation logging just after the main flight is the most efficient way to reduce the population of the spruce bark beetle. As shown by Wulff and Roberge (2022), only a minor part of killed trees are cut and removed from the forest in time. The explanation for this involve bottle-necks like capacity of harvesting dead trees spread out in the landscape and the economic conditions to handle small amounts of timber in many places. Evaluation of management performed in practise indicate that control of the outbreak development is not very efficient. Methods involving mass-trapping is problematic due to the large areas affected by the outbreak and thus is not a realistic complement to sanitation logging. Difficulties to manage large outbreaks implies that salvage logging must be considered for forest owners to save as much as possible of the timber value. Condition for this option is to create assortments out of killed trees which can make an economic return (Schroeder 2010).

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References

Risberg, B. 1993. Insektsskador på skog: inventering och ekonomisk konsekvensbedömning. Sveriges lantbruksuniversitet. Inst. f. Växt- och skogsskydd. Lic-avhandling. Uppsala. 4 pp.

Schroeder, M. 2010. Colonization of storm gaps by the spruce bark beetle: influence of gap and landscape characteristics. *Agricultural and Forest Entomology* 12, 29–39.

Schroeder, S. & Kärvemo, S. 2022. Rekordstort utbrott av granbarkborre – orsaker och vad man kan göra. Kungliga Skogs- och lantbruksakademiens tidskrift nr 7, 16–19.

Skogsdata 2023. Aktuella uppgifter om de svenska skogarna från SLU Riksskogstaxeringen Tema: Gammal skog enligt miljömålsdefinitionen – vad kännetecknar den och var finns den? https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/

skogsdata/skogsdata_2023_webb.pdf

Skogstyrelsen 2023. Regler för bekämpning av skadliga insekter https://www.skogsstyrelsen.se/lag-och-tillsyn/regler-for-bekampning-av-skadliga-insekter/

SMHI 2023. Swedish Meteorological and Hydrological Institute. https://www.smhi.se/klimat/klimatet-da-och-nu/arets-vader/sommaren-2023-sommaren-som-bytte-karaktar-1.198319

Weslien, J., Annila, E., Bakke, A., Bejer, B., Eidmann, H.H., Narvestad, K., Nikula, A. & Ravn, H.-P. 1989. Estimating risks for spruce bark beetle (*Ips typographus* (L.)) damage using pheromone-baited traps and trees. *Scandinavian Journal Forest. Research* 4, 87–98.

Weslien, J., Rosenberg, O. & Schroeder, M. 2023. Granbarkborren och dess fienders övervintring i stående träd vintern 2021/2022. Arbetsrapport 1151-2023. SkogForsk. 14 pp. arbetsrapport-1151-2023-gbb-overvintring-slutversion.pdf (skogforsk.se)

Weslien, J., Öhrn, P. & Schroeder, M. 2022. Effekt på granbarkborren och dess fiender vid vinteravverkning av dödade granar. Arbetsrapport Skogforsk 1110–2022. 38 pp. weslien-j-et-al-20230911.pdf (slu.se)

Weslien, J. & Schroeder, M. 2023. Granbarkborrens fiender – vilka är de och vilken betydelse har de? Fakta Skog 2023-3. weslien-j-et-al-20230915.pdf (slu.se)

Wulff, S. 2006. Inventering av granbarkborre-angrepp i Götaland and Svealand 2022. Nationell Riktad Skadeinventering (NRS). SLU. 3 pp. wulff-s-et-al-20220829.pdf (slu.se)

Wulff, S. & Roberge, C. 2022. Inventering av granbarkborreangrepp i Götaland and Svealand 2022. Nationell Riktad Skadeinventering (NRS). SLU. nrs_granbarkborreinventeringen_2022.pdf (slu.se)

The Swedish National Forest Inventory https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/skogsdata/skogsdata_2022_webb.pdf (accessed 2023-02-15)

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