

# ODORIFEROUS COMPOUNDS FROM THE FLOWERS OF THE CONIFERS *PICEA ABIES*, *PINUS SYLVESTRIS* AND *LARIX SIBIRICA*

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(Revised received 24 August 1984)

**Key Word Index**—*Picea abies*; *Pinus sylvestris*; *Larix sibirica*, Pinaceae; flower scent; monoterpenes; benzoic acid esters; salicylic acid esters.

**Abstract**—A GC/MS analysis of the volatile constituents from the flowers of Norway Spruce, *Picea abies*, has been carried out. The volatile constituents of the female flowers were distinctly different from those of the male flowers and the twigs. Characteristic constituents are methyl and ethyl benzoate, methyl and ethyl salicylate, methyl and ethyl butanoate, borneol and bornyl acetate. In the scent from the male flowers we could only detect the same monoterpenes as in the twigs. In *Larix sibirica* methyl benzoate, methyl salicylate, borneol and bornyl acetate were detected in the female flowers and, in the female flowers of *Pinus sylvestris*, methyl salicylate was found.

## INTRODUCTION

In order to obtain information about host plant–insect interactions and possible primary host attraction to spruce cone insects, a GC/MS analysis of the volatile constituents from the flowers of Norway Spruce, *Picea abies* (L.) Karst., was performed. Some specific compounds characteristic of the flower scents were identified. The female flowers emit odoriferous compounds that commonly occur among many insect pollinated flowers of angiosperms. To our knowledge, flower scents from gymnosperms have previously not been reported and we extended our investigation to some related Pinales species, *Pinus sylvestris* L. and *Larix sibirica* Ledeb.

## RESULTS AND DISCUSSION

The odoriferous compounds of female and male flowers of *Picea abies* and *Pinus sylvestris* were compared with those of twigs with needles. The amounts of odoriferous compounds emitted from the twigs were low compared to those of the flowers. The flowers of *Larix sibirica* were unfolded before the needles were developed, thus no analysis of the twigs with needles was made. For monoterpene composition in the trees, see refs [1–3]. Some monoterpenes and a series of aliphatic hydrocarbons were common to both twigs and flowers. The female flowers emit additional compounds which are characteristic of the flower scent. Such characteristic compounds, detected among the volatiles from the female flowers of *Picea abies* are: aliphatic alcohols and esters, methyl and ethyl benzoate, methyl and ethyl salicylate, borneol and bornyl acetate (see Table 1). None of these compounds was detected in the male flower scent.

Flowers of *Pinus sylvestris* and *Larix sibirica* were also

Table 1. Major and characteristic compounds from female flowers and twigs of *Picea abies* (P.a.), *Pinus sylvestris* (P.s.) and female flowers of *Larix sibirica* (L.s.)

	P.a.	P.a. twig	P.s.	P.s. twig	L.s.
α-Pinene	*	*	*	*	*
β-Pinene	*	*	*	*	*
3-Carene	*	**	***	***	***
Myrcene	***	***	**	**	**
Limonene	***	***	*	*	*
β-Phellandrene	**	**	*	*	**
Terpinolene	*	—	*	—	*
Borneol	*	—	—	—	*
Bornylacetate	*	—	—	—	*
Methyl benzoate	*	—	—	—	—
Ethyl benzoate	*	—	—	—	*
Methyl salicylate	***	—	*	—	*
Ethyl salicylate	*	—	—	—	*
Methyl butanoate	*	—	—	—	—
Ethyl butanoate	*	—	—	—	—
Hexyl acetate	*	—	—	—	—
1-Hexanol	*	—	*	—	—

\*, < 1% of total amount of volatile compounds as determined by GC/MS; \*\*, 1–20% \*\*\*; > 20%.

analysed. Borneol, bornyl acetate, methyl benzoate and methyl salicylate were detected in the female flowers of *Larix sibirica*, whereas methyl salicylate was the only one of the above enumerated compounds found in the female flowers of *Pinus sylvestris*. This may be due to the difficulties in collecting the odoriferous compounds from the relatively small flowers of *Pinus sylvestris*.

Benzoates and salicylates commonly occur in flowers

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pollinated by bees or moths, as attractants, e.g. in orchids [4, 5] and in honeysuckle [Nilsson, L. A., personal communication]. Conifers are wind pollinated. Therefore, it is of interest to note, from both an evolutionary and a biological point of view, that the conifer flowers emit scents which are considered to be characteristic of insect pollinated flowers.

#### EXPERIMENTAL

The scents were collected and enriched by passing *ca* 100 ml/min of clean air over the objects and onto a cartridge (50 × 5 mm filled with *ca* 70 mg of the porous polymer TENAX GC, 50–80 mesh [6]. The volatile compounds were eluted with 4 ml of p.a. *n*-pentane. The eluate was carefully concd at 42° and analysed by GC/MS, LKB 2091 and/or Finnigan 4021, using WG-11 coated glass capillary columns (50 m, i.d. 0.2–0.3 mm, 60° isothermal for 4 min followed by 4°/min up to 200°). MS data and RR<sub>s</sub> were compared with authentic samples.

*Acknowledgements*—This work forms part of the joint research project "Odour Signals for Control of Pest Insects", sponsored by various Swedish research councils and funds. Financial support from 'Axel och Margaret Ax: son Johnsons Stiftelse' for the purchase of the chromatographic equipment is gratefully acknowledged.

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