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STEROL AND *N*-ALKANE BIOMARKER COMPOSITION OF MODERN FEN PLANTS – POTENTIAL APPLICATION FOR PALAEOECOLOGICAL ANALYSES

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SUMMARY

In this study we apply selected organic geochemistry methods to fen plant species to investigate the potential for biomarkers to characterise different fen plants. Samples were treated with solvent extraction with repeated ultrasonication and analysed by gas chromatography/mass spectrometry (GC-MS). The preliminary results are promising, confirming some previously established relationships in peat-forming plants e.g. *n*-alkane chain length differs between the main plant types (e.g. *Sphagnum* versus non-*Sphagnum*). However, we also found that biomarker composition, and thus interpretation of the chemical fingerprints of fen plants, is not as straightforward as in bog plants.

KEY WORDS: Peat, fen, *Sphagnum*, sedge, biomarker

INTRODUCTION

Historical variations in climate and hydrology are recorded in peat layers as alteration in the assemblages of different biological organisms. Past vegetation assemblages play a key role when reconstructing the past moisture conditions that control peatland carbon dynamics. In order to evaluate the role of northern peatlands as carbon sinks or sources in changing future climate, it is important to understand the past mechanisms: how peatlands have earlier responded to climate forcing. An especially useful proxy method to reconstruct past environmental changes is the plant macrofossil method (e.g. Barber et al. 1998; Mauquoy et al. 2002; Tuittila et al. 2007; Väliranta et al. 2007).

Northern peatlands generally develop towards ombrotrophic bog stage via minerotrophic fen stage while they accumulate peat. Large parts of northern peatlands are still in fen phase. There seems to be a vexatious lack of suitable proxies that have a clear response to specific climate or other environmental parameter(s) in fen environments. Additionally, in fens the surface decay is fast and accordingly the major parts of the peat below the surface layer are highly humified (Moore et al. 2007). A high degree of humification constrains palaeo-botanical and -climatical studies because reliable identification of different fossil vegetation components is difficult. Previously studied bog peats, in turn, usually contain relatively well

preserved plant material for palaeoecological examination, but highly humified layers can also be found underneath the top layers of bog peats. Previous work on bog plants and peats has shown that plant biomarkers (compounds that can be linked to specific plant types) can be successfully applied to indentify modern and fossil plant groups from less-humified bog peat (e.g. Xie et al. 2004, Jia et al. 2008; Bingham et al. 2010).

In this study we analyze 12 fen plant species to investigate the potential for biomarkers to characterise different fen plants. We focus on plant types that would give insight into major palaeoecological challenges and report their *n*-alkane and sterol distributions.

MATERIAL AND METHODS

We sampled 5 bryophytes: *Sphagnum papillosum*, *S. fimbriatum*, *S. subsecundum*, *S. riparium* and *Warnstorfia exannulata*, and 7 vascular plants: *Carex livida*, *C. nigra*, *C. rostrata*, *C. lasiocarpa*, *Eriophorum angustifolium*, *Menyanthes trifoliata* and *Comarum palustre* (*Potentilla palustris*). Samples were collected from three fens that are located in Siikajoki, Finland (64°45´N, 24°42´E). The study site represents mid-boreal ecoclimate zone.

Mosses were treated as whole shoots and vascular plants were divided into leafs, stems and roots. Samples were washed with distilled water, freeze dried and ground. Lipids were extracted using repeated ultrasonication following the methods of Bingham et al. (2010). Samples were saponified and the neutral lipids were removed from the samples. From the neutral lipids were further separated apolar and polar compounds. Apolar and polar fractions were analyzed using a gas chromatograph. Compounds were identified using the NIST mass spectral database and comparison to published spectra (e.g. Goad & Akihisa 1997). Quantification of compounds was achieved through comparison of integrated peak areas in the FID chromatograms and those of internal standards of known concentration.

RESULTS

Low molecular weight (LMW) *n*-alkanes dominated mosses: *n*-C_{23} in *Sphagnum riparium*, *S. subsecundum* and S. *papillosum*, and *n*-C_{25} dominated in S. *fimbriatum* (Fig.1.). In *Warnstorfia exannulata* sample *n*-C_{18} alkane concentration was the highest. In the above ground plant parts of *Carex livida* and *C. nigra* and *Eriophorum angustifolium* *n*-C_{27} alkane had highest concentration and *n*-C_{29} in *Carex rostrata* and C. *lasiocarpa* (Fig.1). Distributions of the *n*-alkanes in the below ground plant parts of sedges were more complex: *Eriophorum angustifolium* and *Carex nigra* root were dominated by *n*-C_{27}, *Carex livida* by *n*-C_{21}. In *Carex rostrata* and *C. lasiocarpa* roots most abundant alkane was *n*-C_{23} (Fig.1). In *Menyanthes trifoliata* above ground plant parts total *n*-alkane concentrations was the smallest of all samples. The below ground plant parts had much higher total concentration of *n*-alkanes and LMW *n*-alkanes dominated. In *Comarum palustre* high molecular weight alkanes (HMW) were dominating and alkane *n*-C_{31} had the highest concentration in all plant parts (Fig.1).

Main sterols found in all samples were phytol, cholesterol, campesterol, stigmasterol and β-sitosterol. Sterols 24-methylcholest-7-en-3β-ol and ergost-8.24(28)-dien-3β-ol were particular for *Sphagnum* mosses, but detected in smaller amounts in some of the vascular plants as well.

Vascular plants had greater amount of phytol and β-sitosterol than mosses. Sterol compositions in below ground plant parts were alike showing generally higher concentrations than above ground plant parts.

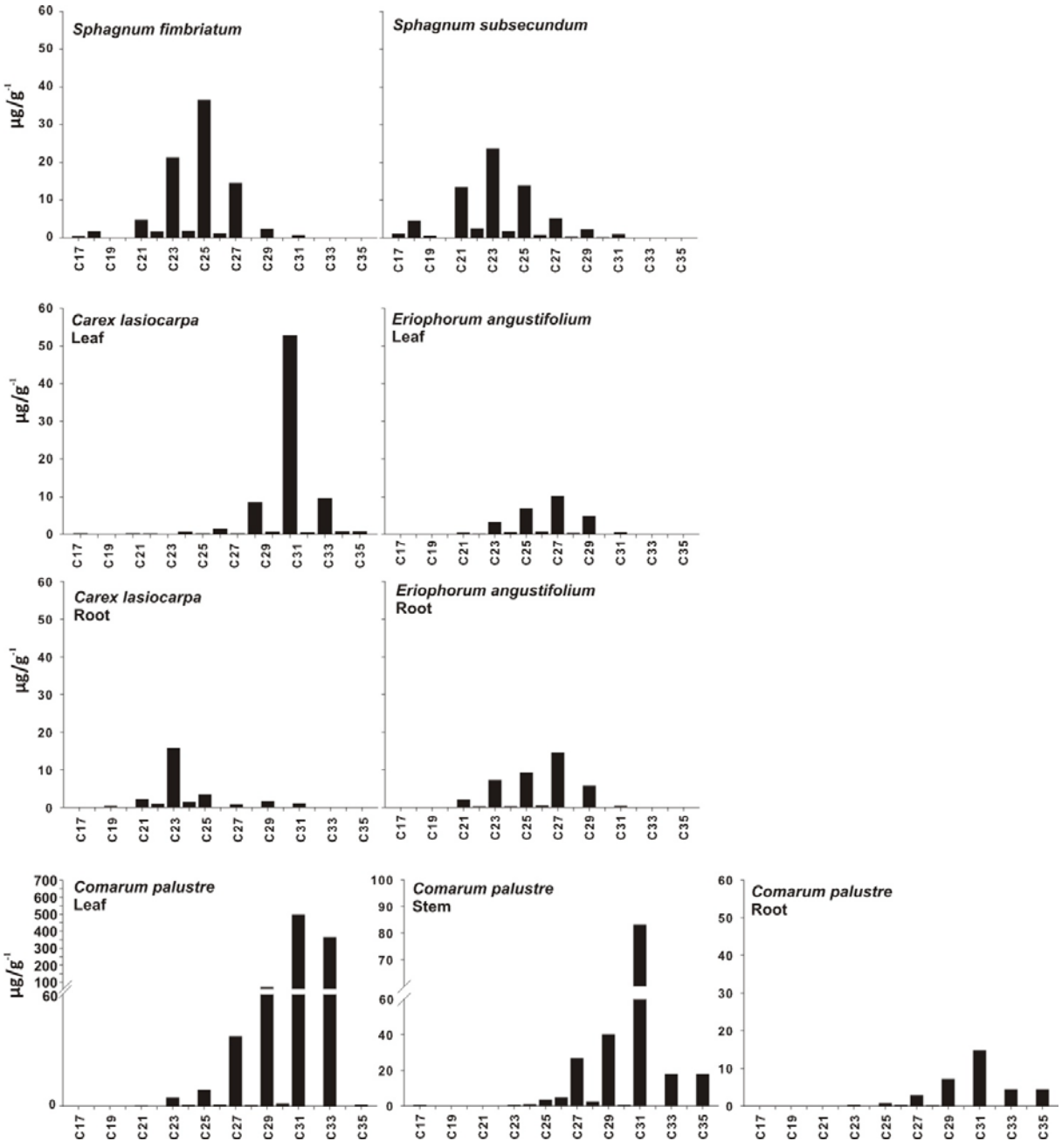

Fig. 1. *n*-alkane distribution and concentration (µg/g^{-1}) of *Sphagnum fimbriatum* and *subsecundum*, *Carex lasiocarpa* and *Eriophorum angustifolium* leafs and roots, *Comarum palustre* (*Potentilla palustris*) leafs, stems and roots.

DISCUSSION

Our results agree with previous studies on bog plants: LMW *n*-alkanes C_{23} and C_{25} are biomarkers for *Sphagnum* mosses and HMW *n*-alkanes C_{27} - C_{31} for vascular plants above ground parts (Ficken et al. 1998 Baas et al. 2000., Pancost et al. 2002, Nichols et al. 2006). Like Dawson et al. (2000) and Huang et al (2011), we also detected differences between leafs and roots of vascular plants: roots had smaller *n*-alkane concentrations than leafs, with exception of *Menyanthes trifoliata*, and higher concentration of sterols. However, our results also show that most of the sedges and *Menyanthes trifoliata* roots have similar *n*-alkane distribution as *Sphagnum* mosses. Similar LMW *n*-alkane dominance in the roots of *Menyanthes trifoliata* is reported by Huang et al. (2011). *Comarum palustre* and *Warnstorfia exannulata* might have potential biomarkers *n*-alkane C_{31} and C_{18}, respectively. Differences in sterol distributions between plant groups were detected in small range.

It might be possible to distinguish mosses and vascular plant leafs apart in fen environment by using *n*-alkanes, but because of the detected similarities between *n*-alkanes of vascular plant roots and mosses, separating these groups is more challenging in all peatland environments. By applying bog plant biomarkers to highly humified fen peat layers might result in false conclusions about past vegetation assemblages. Differences in sterol compositions between the studied plant groups may prove to be useful in determination of decomposed material, in spite of the relatively fast decay of these compounds.

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