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CHEMICAL CONSTITUENTS OF SOME MOSS SPECIES

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ABSTRACT. The composition of total lipids, polar lipids, phospholipids and fatty acids from three moss species was studied. The major phospholipid classes found were phosphatidylcholine (from 25.2 to 72.2%), phosphatidylglycerol (from 7.2 to 28.9%) and phosphatidylethanolamine (from 7.9 to 21.5%). Diacylglyceryltrimethylhomoserine was found in all moss species from 5.9 to 11.9%. The fatty acid composition of mosses was examined by way of capillary GC-MS in the neutral lipid, glycolipid and phospholipid fractions. 61 fatty acids in neutral lipids, 70 fatty acids in glycolipids and 73 fatty acids in phospholipids were identified. The neutral lipid fraction from *Anomodon viticulosus* yielded 11.7% acetylenic fatty acids among which, some unusual, rarely occurring acids were identified, i.e. 9a,12–18 : 2, 6a,9,12,15–18 : 4 and 8a,11,14–20 : 3.

INTRODUCTION

In the past 20 years much information has accumulated on the lipids and fatty acids of mosses. Of particular interest from the biotechnological viewpoint is the occurrence in many moss species of polyunsaturated fatty acids with 20 carbon atoms. The most abundant fatty acids of the bryophytes are also common to most other plants. Typical for many bryophytes, however, is a high content of arachidonic and eicosapentaenoic acids (Al-Hasan et al. 1989, 1990; Grimsley et al. 1981; Karunen 1982; Hansen & Rossi 1990); comparative to those in red (Dembitsky et al. 1991; Dembitsky 1994) and some marine green algae (Dembitsky 1994). Furthermore, a few musci are characterized by the presence of acetylenic fatty acids (Jamieson & Reid 1976; Kohn et al. 1978a, b, Dembitsky et al. 1993a, b). Polar lipids from mosses are not extensively studied.

Our previous studies concerned phospholipids and fatty acid compositions from moss species collected on t he Volga river basin (Dembitsky et al. 1993a, b). The present work deals with polar lipids and fatty acid composition of mosses growing near Togliatti (Europian part of Russia).

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ABBREVIATIONS:

CI: chemical ionization
DGDG: diglycosy diacylglycerol
DGTS: diacylglycerotrimethylhomoserine
EI: electron impact
GC-MS: gas chromatography-mass spectrometry
GL: glycolipid
LPE: liso-PE
MGDG: monoglycosyldiacylglycerol
mg/g dry wt: miligram per gram of dry weight
NL: neutral lipid
PC: phosphatidylcholine
PE: phosphatidylethanolamine
PG: phosphatidlgglycerol
PI: phosphatidylinositol
PL: phospholipid
PS: phosphatidylserine
SQDG: sulphoquinovosyl-diacylglycerol
TL: total lipid

EXPERIMENTAL

The mosses *Anomodon viticulosus* (Hedw.) Hook. et Tayl., *Mnium marginatum* (With.) P. Beauv., and *Plagiomnium ellipticum* (Brid.) T. Kop. were sampled in May 1992, in the Zhiguli nature reserve near Togliatti. Freshly collected mosses were thoroughly cleansed of extraneous matter, and only clean moss tissues were selected for homogenization in a high-speed unit.

The extraction of lipids, their analyses and quantification, the identification of individual phospholipid classes have been carried out as described elsewhere (Dembitsky et al. 1933a, b). The total lipid extract was separated on the silica gel column according to the method of (Rouser et al. 1976) into the neutral, glyco-, and polar lipid fractions. Polar lipids were isolated on 60×60 mm glass silica gel plates KSK using the following solvent systems for the separated polar lipids:

System 1: Chloroform/methanol/benzene/conc. ammonium (65 : 30 : 10 : 6, v/v/v/v),
System 2: Chloroform/methanol/benzene/acetone/HAc/water (70 : 30 : 10 : 5 : 4 : 1, v/v/v/v/v).

To identify polar lipids on thin-layer chromatography plates, the following specific reagents were used: ninhydrine 0.2% in acetone for free amino groups; Dragendorf's reagent for choline-containing lipids; modified Jungnickel's reagent for phosphorus-containing lipids (Vaskovsky & Latyshev 1975); periodate Schiff's reagent for PG.

Polar lipid with R_f DGTS were also checked chromatographically by comparison with standard DGTS isolated from the microphytic alga *Nephrochloris salina* (Dembitsky 1988). DGTS, non contained phosphorus, and PE was determined according to method of Kabara and Chem (1976) (using DGTS and PE as a standard lipids). When carrying out qualitative determination of polar lipids as well DGTS and PE using the method of Kabara & Chen (1976), 3–5 parallel determinations were made; mean values for each lipid class are given in Table 2.

The most challenging idea was to identify acetylenic fatty acids. Total neutral lipid fraction from *Anomodon viticulosus* were transmethylated (5% HCl in MeOH) and divided into two parts. The first part was analysed on polar capillary columns as methyl

esters of fatty acids. The second part was refluxed with $(CH_3CO)_2$ Hg and the total adduct was regenerated by HCl in MeOH (Christie 1989). The oriinal double bond(s) is regenerated, from triple bond(s) (reaction with 2 moles of mercuric acetate) the original bond(s) cannot be regenerated and keto (oxo) derivatives are formed by acidic hydrolysis.

The mixture was separeted by preparative thin-layer chromatography on silica gel G (Hexane-diethyl ether 90 : 10 v/v). Two spots (bands) were obtained (top R_f 0.9 i.e. unchanged methyl esters of fatty acids, bottom spot R_f 0.7 – keto methyl esters fatty acids). The keto methyl esters fatty acids were dissolved in MeOH and reduced 3 h by $NaBH_4$. After acidification (HCl) the OH-methyl esters of fatty acids were extracted and trimethylsilyl-oxazolines were prepared and analysed by GC-MS as described elsewhere (Dembitsky et al. 1992).

The position's isomers were not separated by capillary column, although in mass spectrum two hydroxy-isomers were identifed at every peak (as trimethylsilyl ethers).

All GC-MS separations were performed by using a Finnigan MAT (San Jose, CA, USA) 1020 B apparatus with EI or CI. Injection temperature (splitless injection) was 100°C and a fused silica capillary column (Supelcowax 10) (60 m × 0.25 mm ID, 0.25 μm film thickness) was used. The temperature programme was as follows: 100°C for 1 min, then increased at 20°C/min to 180°C and at 2°C/min to 250°C, which was maintained for 10 min. The carrier gas was hydrogen at the linear velocity of 60 cm/s. Isobutane (0.6 torr) was used as the CI reagent gas. The spectra were scanned within the range m/z 70–450.

Results and Discussion

Table 1 shows the lipid composition of the mosses considered here. Total lipids vary from 21.9 to 66.9 mg/g dry wt. Neutral lipids make up more than a half of total lipids while polar lipids are twice as low as glycolipids in two moss species *A. viticulosus* and *M. marginatum*.

The neutral lipids were the greatest amount (Table 1) according to various authors and supported by our own data (Hansen & Rossi 1990; Swanson et al. 1976; Al-Hasan et al. 1991; Koskimies & Simola 1980).

Triglycerols can reach as high as 66% among the neutral lipids. Some moss species are known to possess fairly high amounts of glycolipids; for example, in *Hygrohypnum*

Table 1. Lipid composition of mosses.

Family, species	TL*	NL**	GL	PL
THUIDIACEAE				
Anomodon viticulosus (Hedw.) Hook. et Tayl.	33.8	70.56	19.11	10.33
MNIACEAE				
Plagiomnium ellipticum (Brid.) T. Kop.	66.9	28.93	50.66	20.41
Mnium marginatum (With.) P. Beauv.	21.9	71.25	22.04	6.71

*TL, mg/g dry wt. **NL, GL and PL as % of TL.

Table 2. Phospholipid composition of mosses (% of PL).

Species	PG	PC	PE	PI+LPE*	PS	DGTS**
Anomodon viticulosus	7.2±0.2	72.2±1.1	7.9±0.3	4.2±0.3	2.6±0.1	5.9±1.1
Mnium marginatum	28.9±0.6	27.2±0.5	21.5±0.7	10.6±0.4	7.6±0.3	4.2±0.9
Plagiomnium ellipticum	27.0±0.8	25.2±0.6	18.5±0.5	10.0±0.4	7.4±0.3	11.9±1.2

*PI+LPE, the sum of PI and LPE. **DGTS, amount determined by method Kabara & Chen (1976), P content calculated on PE basis.

luridum they make up 73% in gametophores (Swanson et al. 1976).

Among polar lipid classes only six phospholipids were found, they were PC, PE, PG, PS, PI and LPE(Table 2). PC in the moss *A. viticulosus* exceeded 72.2%, the second in amount was PE followed by PG. PS was found in amounts in all species from 2.6 to 7.6%.

Among polar lipids, phospho- and glycolipids included, the later predominate (Table 1). So, according to Somersalo et al. (1986), *Ceratodon purpureus* is reported to possess 36.7% MGDG, 24% DGDG, and 20.9% PC. Individual polar lipids contained in various moss species are known to be highly varied but their distribution trends seem difficult to define. So, the major glycolipids in *Ctenidium molluscum* was found to be DGDG (30%) followed by MGDG (19.7%) and trace amounts of SQDG. PG was the major class among polar lipids and amounted to 65.8% while PC was practically absent (Al-Hasan et al. 1991). In the moss *Tortella tortuosa*, MGDG made up 20.6% and was the major one while DGDG amounted to 12.2%; noticeable among polar lipids was PE while PG and PC were detected in trace amount (Al-Hasan et al. 1991).

All the examined species yielded DGTS with R_f 0.75 in the first direction, and R_f 0.45 in the second direction when subjected to two-dimensional chromatography on silica gel plates. DGTS varing from 4.2% in *Mnium marginatum* to 11.9% in *Plagiomnium ellipticum*.

DGTS is widespead among marine green macrophytic algae in the class Ulotrichophyceae its content can be as high as 56.5% of total polar lipids including PLs, while PC is absent from the species of the mentioned class (Dembitsky & Rozentsvet 1989; Khotimchenko et al. 1991).

Sato and Furuya (1985) found DGTS in three moss and two liverwort species and he has investigated of DGTS biosynthesis in the cells of liverwort *Marchantia polymorpha* (Sato & Kato 1988). Recently, Eichenberger (1993) have found DGTS in moss *Polytrichum commune*. The data obtained from a greater number of examined species could help throw light on the role of DGTS. PC is completely absent from some moss species (Al-Hasan et al. 1991) similarly to the situation in the Ulotrichophycea algae (Dembitsky & Rozentsvet 1989).

GC-MS analysis of fatty acids in neutral fraction from mosses showed of acetylenic fatty acids in *Anomodon viticulosus* (Table 3).

Two acetylenic fatty acids were identified among dienes, they were 9a,12–18:2, 9,12a–18:2 and three acetylenic fatty acids were identified among polyunsaturated

Table 3. Fatty acid composition of neutral lipids.

	A. viticulosus	*P. ellipticum*	*M. marginatum*
12 : 0	1.58	0.91	0.97
13 : 0	0.46	0.26	0.27
14 : 0	0.46	1.35	1.18
15 : 0	0.93	0.49	0.47
16 : 0	10.22	22.60	13.74
17 : 0	1.39	0.78	0.83
18 : 0	6.22	11.69	6.06
19 : 0	0.22	0.39	0.55
20 : 0	1.12	1.69	0.97
21 : 0	2.83	0.73	1.07
22 : 0	4.04	0.44	0.60
23 : 0	0.36	0.79	0.61
24 : 0	0.46	0.52	0.97
25 : 0	0.68	0.39	0.35
26 : 0	0.68	0.33	0.41
iso-12 : 0	0.46	0.26	0.27
iso-13 : 0	0.46	0.26	0.27
iso-14 : 0	0.68	0.39	0.41
iso-15 : 0	0.46	0.26	2.27
iso-16 : 0	—	0.11	0.26
iso-17 : 0	—	0.26	0.27
anteiso-13 : 0	0.22	0.13	0.14
anteiso-15 : 0	0.68	0.39	0.34
anteiso-17 : 0	—	0.13	0.14
anteiso-19 : 0	—	0.26	0.41
Phytanic	—	0.26	0.27
Saturated	34.61	46.07	32.10
Iso-	2.06	1.54	1.75
Anteiso-	0.90	0.91	1.03
12 : 1 (n-5)	0.68	0.39	0.41
13 : 1 (n-5)	1.58	0.91	0.97
14 : 1 (n-5)	0.22	0.13	0.14
15 : 1 (n-9)	0.93	0.52	0.55
16 : 1 (n-9)	0.38	7.40	13.48
16 : 1 (n-7)	16.04	1.69	4.82
iso-17 : 1 (n-9)	0.46	0.39	0.41
anteiso-17 : 1 (n-9)	—	0.65	0.69
17 : 1 (n-9)	0.68	0.39	0.41
17 : 1 (n-7)	0.46	0.26	0.27
18 : 1 (n-11)	1.39	1.56	1.10
18 : 1 (n-9)	10.11	25.78	24.44
18 : 1 (n-7)	0.46	0.65	0.97
19 : 1 (n-8)	—	0.52	0.27
20 : 1 (n-11)	0.22	1.16	0.41

Table 3. (continued)

	A. viticulosus	*P. ellipticum*	*M. marginatum*
20 : 1 (n-9)	0.46	0.26	0.27
21 : 1 (n-8)	0.46	0.52	0.97
22 : 1 (n-11)	1.67	0.37	0.55
22 : 1 (n-9)	0.68	0.78	1.24
24 : 1 (n-11)	0.22	0.13	0.41
24 : 1 (n-9)	0.46	—	0.27
26 : 1 (n-11)	0.24	—	—
Monoenoic	37.80	44.46	53.06
14 : 2 (n-5)	0.46	0.26	0.27
18 : 2 (n-6)	8.51	6.11	10.11
18 : 2 (n-3)	—	0.26	0.41
9,12a–18 : 2[a,d]	2.78	—	—
9a,12–18 : 2[b,d]	0.22	—	—
22 : 2 (n-6)	—	0.21	0.09
Dienoic	11.97	6.84	10.88
Acetylenic	3.00	—	—
18 : 3 (n-6)	4.14	1.95	2.34
18 : 3 (n-3)	2.78	0.47	1.48
6a,9,12–18 : 3[c,d]	5.03	—	—
8a,11,14–20 : 3[c,d]	0.23	—	—
22 : 3 (n-3)	—	0.16	0.14
18 : 4 (n-3)	—	0.05	—
6a,9,12,15–18 : 4[c,d]	3.44	—	—
Polyenes	15.62	2.63	3.96
Acetylenic	8.70	—	—
The sum of acetylenic acids	11.70	—	—

[a] Known in nature. [b] Prepared only by synthesis. [c] Known in some mosses and/or liverworts. [d] Structure was confirmed by GC-Ms of trimethylsilyl-oxazolines after preseparation.

fatty acids, they were 6a,9,12–18 : 3, 8a,11,14–20 : 3 and 6a,9,12,15–18 : 4 (see Table 3). Total unsaturation in the individual species varied from 2.63% in *Plagiomnium ellipticum* to 15.62% in *Anomodon viticulosus.*

The glycolipid fraction had high unsaturation at levels above 48.48% in *Anomodon viticulosus* (Table 4). The levels of arachidonic and eicosapentanenoic acid were not high at 6% in *P. ellipticum*, 5% in *Mnium marginatum* and 7% in *Anomodon viticulosus.* Acetylenic fatty acids were not detected in the mentioned fraction.

The polar lipid fraction (Table 5) was found to contain the greatest variety of iso- (6) and anteiso- (4) acids. The summed content of arachidonic and eicosapentaenoic acids in the polar lipid fraction was somewhat higher than in the neutral or glycolipid ones ane reached 11% in *Plagiomnium ellipticum.*

Table 4. Fatty acid composition of glycolipids.

	A. viticulosus	*P. ellipticum*	*M. marginatum*
12:0	0.79	1.06	0.99
14:0	0.04	0.05	0.05
15:0	0.48	0.65	0.61
16:0	8.66	4.95	7.76
17:0	0.44	0.58	0.55
18:0	2.49	6.42	4.56
19:0	0.22	0.05	0.17
20:0	0.17	0.12	0.17
21:0	0.40	—	—
22:0	0.22	0.03	0.09
23:0	0.35	0.09	0.09
24:0	0.09	—	0.05
25:0	0.22	0.29	0.27
26:0	0.40	0.53	0.49
iso-13:0	0.04	0.05	0.05
iso-14:0	0.53	0.70	0.66
iso-15:0	0.04	0.05	0.05
iso-17:0	0.13	0.17	0.17
anteiso-13:0	0.09	0.12	0.10
anteiso-15:0	0.22	0.29	0.27
anteiso-19:0	0.09	—	0.05
Pristanic	0.04	0.05	0.05
Phytanic	0.35	0.48	0.44
Saturated	16.50	16.73	17.69
Iso-	0.74	0.97	0.93
Anteiso-	0.40	0.41	0.42
12:1 (n-5)	0.53	0.70	0.66
13:1 (n-5)	0.79	1.06	0.99
14:1 (n-5)	0.09	0.12	0.10
15:1 (n-9)	0.44	0.58	0.55
15:1 (n-7)	0.13	0.17	0.17
16:1 (n-9)	5.25	5.65	5.94
16:1 (n-7)	0.61	5.36	2.88
trans-16:1 (n-13)	0.30	0.41	0.39
iso-17:1 (n-9)	0.13	0.17	0.17
anteiso-17:7 (n-9)	0.09	0.12	0.10
17:1 (n-9)	0.54	0.70	0.66
17:1 (n-7)	0.26	0.36	0.33
18:1 (n-11)	0.40	1.42	0.91
18:1 (n-9)	13.32	14.56	9.76
18:1 (n-7)	0.40	1.59	0.99
19:1 (n-8)	0.13	0.12	0.14
20:1 (n-11)	0.26	0.12	0.22
20:1 (n-9)	0.09	0.17	0.14

Table 4. (continued)

	A. viticulosus	*P. ellipticum*	*M. marginatum*
21:1 (n-8)	0.09	—	0.05
22:1 (n-11)	0.57	0.08	0.05
22:1 (n-9)	—	0.17	0.08
24:1 (n-11)	0.04	0.12	0.08
24:1 (n-9)	0.03	0.11	0.03
25:1 (n-9)	0.13	0.17	0.17
26:1 (n-11)	0.09	0.12	0.10
26:1 (n-9)	0.35	0.48	0.44
Monoenoic	25.05	34.63	26.10
14:2 (n-5)	0.13	0.17	0.17
16:2 (n-4)	0.22	0.29	0.27
18:2 (n-6)	8.05	9.30	9.41
18:2 (n-3)	0.83	1.00	0.99
20:2 (n-6)	0.74	0.82	0.85
22:2 (n-6)	—	0.43	0.56
Dienoic	9.97	12.01	12.25
16:3 (n-6)	0.48	0.65	0.61
16:3 (n-3)	0.30	0.41	0.39
18:3 (n-6)	11.41	1.23	7.76
18:3 (n-3)	18.67	13.78	18.19
20:2 (n-9)	0.22	1.11	0.66
20:3 (n-6)	0.35	0.41	0.41
20:3 (n-3)	0.04	0.12	0.29
22:3 (n-6)	2.06	7.72	4.90
22:3 (n-3)	0.40	0.82	0.63
24:3 (n-3)	0.13	0.48	0.35
16:4 (n-3)	1.05	1.42	1.32
18:4 (n-3)	3.23	1.71	2.83
20:4 (n-6)	2.53	5.82	4.32
20:4 (n-3)	0.69	0.05	0.56
22:4 (n-3)	2.53	0.42	0.44
20:5 (n-5)	4.45	0.48	0.30
Polyenoic	48.48	36.63	43.96

The main fatty acids in *Anomodon viticulosus* were 16:0, 16:1 (n-7), 18:1 (n-9) and 18:2 (n-6) (NL fraction); 18:1 (n-9), 18:3 (n-6) and 18:3 (n-3) (GL fraction), 18:1 (n-9), 18:3 (n-6) and 18:3 (n-3) (PL fraction). The main FAs in *Plagiomnium ellipticum* were 16:0, 18:0 and 18:1 (n-9) (NL fraction); 18:1 (n-9) and 18:3 (n-3) (GL fraction); 18:1 (n-9), 18:1 (n-6) and 18:3 (n-3) (PL fraction). The main FAs in *Mnium marginatum* were 16:0, 16:1 (n-9), 18:1 (n-9) and 18:2 (n-6) (NL fraction); 18:1 (n-9), 18:2 (n-6) and 18:3 (n-3) (GL fraction); 16:1 (n-9), 18:2 (n-

Table 5. Fatty acid composition of phospholipid.

	A. viticulosus	*P. ellipticum*	*M. marginatum*
12:0	0.41	0.43	0.48
13:0	0.04	0.04	0.05
14:0	0.15	0.16	0.17
15:0	0.63	0.66	0.74
16:0	5.89	9.32	5.68
17:0	0.63	0.66	0.74
18:0	3.56	1.93	1.22
19:0	0.29	0.07	0.09
20:0	0.38	0.20	0.30
21:0	0.08	0.11	0.07
22:0	0.29	0.06	0.07
23:0	0.08	0.07	0.06
24:0	0.11	0.04	0.13
25:0	0.33	0.37	0.40
26:0	0.67	0.70	0.74
iso-12:0	0.04	0.04	0.05
iso-13:0	0.15	0.16	0.17
iso-14:0	0.29	0.31	0.35
iso-15:0	0.11	0.11	0.13
iso-16:0	0.11	0.11	0.13
iso-17:0	0.18	0.20	0.22
anteiso-13:0	0.18	0.20	0.22
anteiso-15:0	0.45	0.46	0.52
anteiso-17:0	0.07	0.07	0.09
anteiso-19:0	0.18	—	—
Pristanic	—	0.07	0.09
Saturated	15.30	16.55	12.91
Iso-	0.88	0.93	1.05
Anteiso-	0.88	0.73	0.83
12:1 (n-5)	0.29	0.31	0.35
13:1 (n-5)	0.41	0.43	0.48
14:1 (n-5)	0.18	0.20	0.22
15:1 (n-9)	0.60	0.62	0.70
15:1 (n-7)	0.22	0.23	0.27
16:1 (n-9)	3.28	5.72	10.09
16:1 (n-7)	2.78	0.46	4.36
iso-17:1 (n-9)	0.33	0.34	0.40
anteiso-17:1 (n-9)	0.18	0.20	0.22
17:1 (n-9)	0.67	0.70	0.79
17:1 (n-7)	0.41	0.43	0.48
18:1 (n-11)	1.03	1.43	0.83
18:1 (n-9)	14.78	12.18	9.46
18:1 (n-7)	1.15	0.81	1.35
19:1 (n-8)	0.41	0.11	0.22

Table 5. (continued)

	A. viticulosus	*P. ellipticum*	*M. marginatum*
20:1 (n-11)	0.26	0.11	0.09
20:1 (n-9)	0.11	0.07	0.13
21:1 (n-8)	0.11	0.04	0.13
22:1 (n-11)	0.67	0.05	0.07
22:1 (n-9)	0.04	0.07	0.40
24:1 (n-11)	0.07	0.11	0.05
24:1 (n-9)	0.04	0.07	0.09
25:1 (n-9)	0.22	0.23	0.27
26:1 (n-11)	0.41	0.43	0.48
26:1 (n-9)	0.07	—	—
Monoenoic	28.72	25.35	31.93
14:2 (n-5)	0.26	0.27	0.30
16:2 (n-4)	0.71	0.73	0.83
18:2 (n-6)	8.76	11.45	13.93
18:2 (n-3)	0.85	1.27	1.32
20:2 (n-6)	0.33	0.73	1.00
22:2 (n-6)	0.05	1.32	0.71
Dienoic	10.96	15.77	18.09
16:3 (n-6)	0.85	0.89	1.00
16:3 (n-3)	0.89	0.93	1.05
18:3 (n-6)	11.43	0.97	1.97
18:3 (n-3)	12.40	16.07	10.92
20:3 (n-9)	0.45	1.31	1.49
20:3 (n-6)	0.63	0.89	0.52
20:3 (n-3)	0.07	0.35	0.51
22:6 (n-6)	3.53	2.23	4.11
22:3 (n-3)	1.00	1.82	1.00
24:3 (n-3)	0.22	0.34	0.83
16:4 (n-3)	1.30	1.36	1.52
18:4 (n-3)	3.67	3.63	1.84
20:4 (n-6)	2.33	9.66	8.65
20:4 (n-3)	0.95	0.44	0.33
22:4 (n-3)	2.33	1.10	0.50
20:4 (n-3)	2.97	0.34	0.83
Polyenoic	45.02	42.33	37.07

6) and 18:3 (n-3) (PL fraction).

Moss lipids possessing the acids characteristic for plants also have FAs featurino 4 or 5 double bonds like arachidonic (20:4) or eicosapentaenoic (20:5) (Hansen & Rossi 1990; Karunen 1982; Anderson et al. 1972; Gellerman et al. 1975; Karunen & Aro 1979; Al-Hasan et al. 1989). Certain species also contain acetylenic acids maily

9,12,15-octadecatrien-6-ynoic acid, in smaller amounts 9,12-octadecadien-6-ynoic and 11,14-eicosadien-8-ynoic acid (Kohn et al. 1987a; Anderson et al. 1974; Jamieson & Reid 1976).

We did not find acetylenic acids either in GL or in PL fractions (Tables 4 and 5). All acetylenic acids were found to be contained in the neutral lipids.

Using our own original technique of the triple bond determination (Dembitsky et al. 1993a) we found common acetylnic acids having the triple bond in position 6, 8, 9 and 12. Among dienes, we identified the acids having the triple bond in positions 9 and 12 (Table 3). Among polyunsaturated fatty acids, of interest were acids 6a,9,12,15–18:4 and 8a,11,14–20:3. Acid 20:2 with the triple bond in position 8 had been previously identified (Anderson et al. 1974; Jamieson & Reid 1976). While we identified acid 20:3 with the acetylenic bond also in position 8.

The order Dicranales is peculiar for the rather large amounts of acetylenic acids (Kohn et al. 1987a) which are completely absent from, or present in small amounts, in other families (Dembitsky et al. 1993b).

Thus, the attempted analyses of TLs, Pls and fatty accids from three moss species demonstrated the need to further investigate further a grater number of moss species from various families in order to elucidate the distribution trends that exist for polar lipids and acetylenic acids that they may contain.

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