LIPIDS OF SOME AQUATIC PLANTS OF THE CENTRAL VOLGA REGION

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The lipid characteristics of five species of aquatic plants of the Central Volga region have been investigated. The total amount of lipids and the ratio of neutral lipids and glyco- and phospholipids have been found and the amounts of individual phospholipids and also the fatty-acid composition and the distribution of the fatty acids over the lipid classes have been determined.

Aquatic plants are secondary water organisms — terrestrial plants that have become adapted to life in an aqueous environment [1]. They are of great importance in the life of aquatic ecosystems, playing the roles of producers of organic matter [2] and of biofilters in water self-purification processes [3, 4], and also that of indicators of the pollution of water bodies [5-7]. The lipids of fresh-water plants have been studied to a smaller degree than the lipids of marine plants [8]. Continuing a study of the lipid composition of fresh-water plants [8-11], we have investigated five species of plants gathered in water bodies of the Central Volga region during the summer of 1993: *Salvinia natans* (L.) Allioni, *Potamogeton natans* L. (floating-leaf pondweed), *Potamogeton filiformis* Pers., *Lysimachia nummularia* L. (moneywort), and *Rorippa amphibia* (L.) Bess (amphibious marsh cress).

In accordance with V. G. Papchenkov's classification, the first four species are typical hydrophytes, while *R. amphibia* belongs to the near-water plants of the hygroheliophyte group [12].

In a number of publications [13, 14] a link between lipid characteristics and habitat has been pointed out. It appeared of interest to us not only to study the lipid compositions of these plants but also whether features of the habitat affect the lipid composition. In view of this we have determined the following characteristics of the plants mentioned: total amount of lipids (TLs), ratio of neutral lipids and glyco- and phospholipids (NLs, GLs, and PLs), and their fatty-acid (FA) compositions, and also the ratio of the individual phospholipid subclasses. The results obtained are given in Tables 1-3.

The total lipids amounted to 4.5-24.5% on the dry mass of the plants. As in earlier investigations of macrophyte species [8], the main lipid class consisted of glycolipids, amounting to 41.6-47.6% (except for *L. nummularia*). The proportion of phospholipids was 18.0-33.5%. It is known that phospholipids are "sensitive" to various types of external action [15], and, therefore, their composition was studied in more detail.

The phospholipid compositions of the macrophytes studied have no appreciable differences or, rather, show definite features of similarity. In all species of plants, one and the same set of phospholipids was identified, with the exception of *R. amphibia*, in which the unidentified lipid X was detected. In practically all the species investigated, PC was the main class of phospholipids.

The fatty-acid (FA) compositions of the lipid classes of the macrophyte species studied are shown in Table 3. It must be mentioned that only those acids present in an amount of not less than 1% are given. Our analyses showed that the FA compositions of aquatic plants are less complex than those of algae in general [16] and of marine algae [17, 18], in particular. Thus, saturated acids are represented mainly by myristic, palmitic and stearic acids, with palmitic predominating, as in higher terrestrial plants. Among the unsaturated acids we identified palmitoleic (16:1), oleic (18:1), linoleic (18:2), and linolenic (18:3) acids.

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TABLE 1. Lipids of Fresh-Water Plants*

Plant	TLs	NLs	GLs	PLs
Salvinia natans (L.)All.	245.0	38.0	43.5	18.4
Potamogeton natans L.	45.5	23.5	46.8	29.7
Potamogeton filiformis Pers.	46.8	34.6	47.4	18.0
Lysimachia nummularia	99.4	46.2	32.0	21.8
Rorippa amphibia (L.)Bess.	77.3	24.9	41.6	33.5

*TL content, mg/g dry mass; NLs, GLs, PLs — wt.%.

TABLE 2. Compositions of the Phospholipids of Fresh-Water Plants, % by Weight

Plant	DPG	PG	PE	PC	PI	PS	PA	X
S.natans	14.4	13.2	18.6	28.0	10.6	8.0	7.2	–
P.natans	15.4	11.4	16.9	38.7	6.1	4.0	7.4	–
P.filiformis	17.6	28.2	15.6	25.6	5.2	5.5	2.3	–
L.nummularia	21.7	13.8	16.0	25.9	13.0	4.7	4.9	–
R. amphibia	13.7	12.8	25.1	12.0	12.5	8.1	5.2	10.6

*DPG) diphosphatidylglycerol; PG) phosphatidylglycerol; PE) phosphatidylethanolamine; PC) phosphatidylcholine; PI) phosphatidylethanolamine; PS) phosphatidylserine; PA) phosphatidic acid; X) unidentified lipid.

TABLE 3. Relative Amounts of the Main Fatty Acids of Fresh-Water Plants, % by Weight

Plant	14:0	15:0	16:0	16:1	18:0	18:1	18:2	18:3
S. natans								
NLs	3.7	2.9	43.5	10.8	12.5	6.5	8.7	11.4
GLs	1.7	–	12.4	5.8	4.4	10.2	13.6	51.7
PLs	–	–	46.6	2.7	1.8	3.5	26.3	20.1
P. natans								
NLs	1.2	–	30.2	10.9	14.7	16.0	6.7	19.3
GLs	3.4	1.6	19.6	11.8	5.5	16.1	8.9	33.1
PLs	3.1	1.1	33.0	6.4	3.0	10.5	23.9	18.9
P.filiformis								
NLs	4.6	2.8	30.4	14.7	5.5	18.2	12.35	11.3
GLs	2.3	1.6	21.3	4.2	1.8	5.5	8.0	54.3
PLs	2.9	–	27.5	6.2	7.7	13.9	25.4	16.4
L.nummularia								
NLs	7.1	1.8	22.1	11.0	11.7	17.3	9.0	20.0
GLs	7.2	1.5	20.0	4.2	14.0	6.2	14.3	32.2
PLs	3.4	–	19.5	13.9	17.4	14.9	18.1	12.3
R. amphibia								
NLs	3.9	2.8	26.4	18.5	14.4	10.7	9.7	13.6
GLs	9.0	6.2	14.0	13.2	15.6	13.3	5.4	23.3
PLs	8.2	–	23.4	9.0	6.5	5.9	14.1	32.9

In addition to the fact that all the plants species investigated had similar sets of FAs it is possible to see some common features in the distribution of the FAs over the lipid classes. For example, in practically all the species palmitic acid was present in the highest concentrations in the neutral lipids (23.1-43.5%) and the phospholipids (19.5-46.6%), while in the glycolipids the amount of this acid was 12.4-20.0%.

The 18:3 acid was concentrated in the glycolipids (32.2-51.7%), with the exception of *R. amphibia* where its amount in the glycolipids was 23.3% and in the phospholipids 32.9%. Characteristic for all the species was a predominance of 18:3 trienic acids over 18:2 dienic acids in all the lipid classes. In our view, the distribution of the other acids is an individual characteristic of each species.

EXPERIMENTAL

Samples of macrophytes were collected in lake Svetlom, in the suburban zone of Tol'yatti, in June-July 1993. Uniform plants were washed free from particles of mud, and were ground and fixed with a mixture of the purified solvents chloroform and methanol (1:1). After homogenization, the lipids were extracted for two minutes with chloroform—methanol (1:2) by the Bligh—Dyer method. The combined extract was washed with a 0.9% solution of KCl. The total lipids were separated by column chromatography on silica gel L 100/250 [19].

The isolated lipid fractions were analyzed by TLC with standards. The method of [20] was used for the identification and quantitative determination of the phospholipids.

Fatty acids were converted into methyl esters and analyzed by GLC on a Chrom-5 chromatograph with a flame-ionization detector using a glass column 3 m long filled with 10% of PEGS on Chromaton AW, at 198°C. The fatty acids were identified by comparing the retention times of the peaks in question with those of standard acids.

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