Attempt to accurate the palaeophytosociological method in peat deposit investigations

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Abstract

Productivity of fruits and seeds of some more important plant associations of lowland mires in the valley of Biebrza river has been investigated. The results obtained were compared with results of stratigraphic analyses. These investigations aimed into accuration of the palaeophytosociological method of reconstruction of the subfossil plant association. The productivity of fruits and seeds of some species is in accordance with quantities occurring in peat-samples. Some other species do not exhibit such an accordance. Reasons are diversified. Of great importance is that the modern quantitative data explain reasons why seeds of given species dominate in peat-samples and clearly show that the subfossil plant communities can be reconstructed, especially if accompanying species represented by seeds and vegetative remnants are also considered. Data on productivity of seeds and fruits of all peat-forming with regard to the particular plant association should be elaborated. This would make interpretation of results of stratigraphic analyses easier and the reconstruction of subfossil plant associations more reliable.

Key words: peat deposit, stratigraphy, palaeophytosociology, subfossil plant association, botanical archives

INTRODUCTION

In the investigations of peat deposits, accordingly to the purposes, various degree of precision of identification of specific composition of plant remnants building the peat layer is used. Sometimes it is enough to state — using microscopic preparations — the participation of the vegetative remnants of organs of peat-forming plants, i.e. roots, sheaths of leaves, wood and also bryophytes etc.

Peat deposits contain, however, together with the components mentioned above also spores, seeds and fruits of these plants (Tołpa et al. 1967).

Vegetative remains, as rule, can not be classified to a particular species. Seeds and often fruits are easy to be identified.

A peat layer is a kind of a botanical archives (Pałczyński 1972). It contains plant remains of ancient peat-forming communities deposited and preserved in the chronological order. The construction of subfossil plant communities is based on the possibility of determination of the generic or specific affiliation of these plant remains (Tolpa 1958, Marek 1965). If, in addition to the peat science methods, the phytosociological method is introduced one can speak about such investigations as being palaeophytosociological (Pałczyński 1975). To study peat deposits drills or peat-samplers are used. They are constructed in such a way that they enable the collection of consecutive sections of peat profile from the roof to the floor of the deposit without the infraction of layer structure of this deposit. In Poland, as a rule, samplers with containers 50-cm long, 5 cm wide and semi-circular cross-section are in use. Hence the upper surface of the sample of a profile measures 9.8 cm². During investigations a 50-cm long sample is usually sliced into 5-cm long sections, unless the variation of peat layers forces another partition of the profile portion.

Phytosociological records, that are the foundation of description, distinguishing and classification of the contemporary plant communities are mostly taken from the surfaces ranging between 1 and several square metres, and in forest communities even more than 100 m² to estimate the quantitative participation of species accumulated patch of a community the quantitative scale based on proportional and quantitative participation of the species in the analysed patch is used. In the palaeophytosociological analyses of peat sample we estimate quantitative participation of species on the base of number of seeds and fruits found in the sample that is mostly 5-cm long and its cross-section area is 9.8 cm². Proportional participation of the vegetative remains in the microscopic preparation made of the investigated sample is also taken into consideration. Of course, the peat profiles can be taken in 2 or 3 repetitions and thus the more objective material for the reconstruction of a subfossil plant association can be obtained. However, it raises up the degree of difficulties of these time consuming studies. The question arises: to what degree the hitherto used methods of investigations of the stratigraphy of peat deposits, and in particular, quantities of seeds and fruits found, enable the reconstruction of subfossil plant associations and higher units of classification of vegetation. To answer the question, studies of seed and fruit productivity in contemporary peat-forming plants were carried out. Gaining of the comparative material in relation to stratigraphic analyses was aimed.

MATERIAL AND METHODS

Material for analyses of productivity of seeds and fruits of more important peat-forming plants was collected on lowland peat-bogs in the Biebrza valley. The opportunity arose in 1980 when 5-year research project on biomass productivity of five most important in this area peat-forming associations, i.e

Caricetum gracilis, *Caricetum elatae*, *Peucedano-Caricetum appropinquatae*, *Caricetum limoso-diandrae* and *Caricetum caespitosae* started. Fruiting shoots of plants of the above associations were collected separately and their numbers within the 1 cm² were started. Number of 1-cm² sampling areas ranged from 6 to 12-15 and depended upon the floristic diversification and structure of the association. In 1987 additional analyses of two associations, *Caricetum elatae* and *Caricetum limoso-diandrae*, were made. To estimate the productivity of seeds and fruits 20 to 100 shoots were collected for 3 years. To avoid a loss caused by falling down of seeds, shoots were collected just before the period of full ripening (July, beginning of August). Ripe as well as young seeds or fruits were counted assuming that before the end of vegetative period of maturation of all seeds would be completed. The results obtained were expressed as the productivity of a single shoot (Table 1), as number of seeds or fruits on 1 m² and on the area of a peat-sample, i.e. 9.8 cm² (Table 2).

Since the length of peat-sample as a rule is 5 cm, it was necessary to find out what time is required for the deposition of the peat layer 5-cm thick. The assumption has been made that the thickness of a lowland peat deposit increases 2 mm yearly. Hence, the 5-cm long peat-sample is adequate for the period of 25 years. Number of seeds falling to the area of 9.8 cm² were multiplied by 25 and theoretical numbers of seeds or fruits that should be present within the 5 cm long peat sample were obtained.

RESULTS

Data on the average of number of seeds or fruits falling on one shoot were obtained for 17 species of *Carex* and 12 species of another fen plants. They are presented in Table 1 (names of plants after Szafer et al. 1976).

Table 1
Number of seeds (fruits) per one shoot on the average

Species of <i>Carex</i>			
<i>C. pseudocyperus</i>	638.0	<i>C. lepidocarpa</i>	90.7
<i>C. gracilis</i>	483.1	<i>C. appropinquata</i>	83.6
<i>C. acutiformis</i>	395.1	<i>C. lasiocarpa</i>	58.6
<i>C. elata</i>	280.0	<i>C. diandra</i>	55.9
<i>C. rostrata</i>	266.6	<i>C. panicea</i>	25.5
<i>C. fusca</i>	259.6	<i>C. limosa</i>	18.6
<i>C. vesicaria</i>	145.8	<i>C. dioica</i>	17.8
<i>C. buxbaumii</i>	133.2	<i>C. chordorrhiza</i>	4.9
<i>C. caespitosa</i>	111.8		
Other species			
<i>Comarum palustre</i>	889.8	<i>Caltha palustris</i>	51.2
<i>Pedicularis palustris</i>	594.7	<i>Lysimachia thyrsiflora</i>	47.8
<i>Cirsium palustre</i>	327.4	<i>Stellaria palustris</i>	22.3
<i>Menyanthes trifoliata</i>	153.7	<i>Eriophorum angustifolium</i>	21.5
<i>Rorippa amphibia</i>	124.0	<i>Lychnis flos cuculi</i>	16.4
<i>Ranunculus lingua</i>	73.2	<i>Eleocharia pauciflora</i>	5.0

Table 2

Number of seeds (fruits) per 1 m² and per the surface and the volume of a peat-sample in some peat-forming plant associations in Biebrza valley

Association and species	No of seeds (fruits) per 1 m ²	No of seeds (fruits) per area of 9.8 cm ²	No of seeds (fruits) per volume 9.8 × 5
1	2	3	4
<i>Caricetum gracilis</i>			
<i>Carex gracilis</i>	8937.3	8.8	220.0
<i>C. rostrata</i>	13.3	0.013	0.3
<i>C. lasiocarpa</i>	2.9	0.003	0.075
<i>C. vesicaria</i>	262.4	0.26	6.5
<i>Lysimachia thyrsiflora</i>	4.8	0.005	0.12
<i>Caricetum elatae</i>			
<i>Carex alata</i>	4900.0	4.8	120.0
<i>Comarum palustre</i>	978.8	0.96	24.0
<i>Paucedano-Caricetum appropinquatae I</i>			
<i>Carex appropinquata</i>	9940.0	9.7	242.5
<i>C. rostrata</i>	5.3	0.005	0.125
<i>Stellaria palustris</i>	20.1	0.02	0.5
<i>Peucedano-Caricetum appropinquatae II</i>			
<i>Carex appropinquata</i>	4932.4	4.8	120.0
<i>C. rostrata</i>	586.5	0.57	14.2
<i>C. elata</i>	112.0	0.11	2.7
<i>Stellaria palustris</i>	11.1	0.011	0.27
<i>Menyanthes trifoliata</i>	92.2	0.09	2.2
<i>Lysimachia thyrsiflora</i>	4.8	0.005	0.12
<i>Caricetum limoso-diandrae I</i>			
<i>Carex diandra</i>	1328.0	1.3	32.5
<i>C. rostrata</i>	746.5	0.73	18.2
<i>C. chondorrhiza</i>	2.0	0.002	0.05
<i>C. limosa</i>	7.4	0.007	0.17
<i>C. appropinquata</i>	33.4	0.03	0.8
<i>Lysimachia thyrsiflora</i>	50.1	0.05	1.2
<i>Caltha palustris</i>	174.1	0.17	4.2
<i>Comarum palustre</i>	2847.4	2.8	70.0
<i>Stellaria palustris</i>	252.0	0.2	6.2
<i>Menyanthes trifoliata</i>	123.0	0.12	3.0
<i>Ranunculus lingua</i>	7.3	0.997	0.17
<i>Eriophorum angustifolium</i>	0.4	0.0004	0.01
<i>Caricetum limoso-diandrae II</i>			
<i>Carex diandra</i>	1173.9	1.15	28.7
<i>C. lepidocarpa</i>	1433.1	1.4	3.50

1	2	3	4
<i>C. panicea</i>	204.0	0.2	5.0
<i>C. rostrata</i>	4105.6	4.0	100.0
<i>C. fusca</i>	103.8	0.1	2.5
<i>C. limosa</i>	7.4	0.007	0.17
<i>C. chordorrhiza</i>	20.6	0.02	0.5
<i>C. elata</i>	280.0	0.27	6.7
<i>Comarum palustre</i>	1083.6	1.1	27.5
<i>Pedicularis palustris</i>	3092.4	3.0	75.0
<i>Lychnis flos cuculi</i>	6.6	0.006	0.15
<i>Menyanthes trifoliata</i>	7.4	0.007	0.17
<i>Caricetum caespitosae</i>			
<i>Carex caespitosa</i>	5288.1	5.2	130.0
<i>C. elata</i>	1036.0	1.06	26.5
<i>Stellaria palustris</i>	89.2	0.09	2.2

From among species of *Carex* the highest productivity of nutlets occurs in *Carex pseudocyperus*, *C. gracilis*, *C. acutiformis*, *C. elata*, *C. rostrata*, *C. fusca*. The lowest productivity of nutlets and atriangles per a single shoot occurs in *Carex chordorrhiza*, *C. dioica*, *C. limosa*, *C. panicea*. Dicotyledonous plants are very diversified in respect of the productivity of fruits and seeds. Very high productivity was found in *Comarum palustre*, *Pedicularis palustris*, *Cirsium palustre*, *Menyanthes trifoliata*, *Rorippa amphibia*. Smaller numbers of seeds are produced by *Eleocharis pauciflora*, *Lychnis flos cuculi*, *Stellaria palustris* and *Eriophorum angustifolium*.

Table 2 presents numbers of seeds or fruits of plant belonging to five peat-forming associations in the Biebrza valley. These are plant species which produced fruiting shoots on the investigated sampling areas. Quantities are calculated for 1 m² and then for the surface of 9.8 cm² and 5-cm long peat-sample.

Numbers in the column 3 of Table 2 inform what quantities of seeds isolated from peat samples taken in a given plant community can be expected. Quantities of seeds of a particular species falling onto the surface of 9.8 cm² differ among each other dependently on the community the species grows within. For example the theoretical number of nuts per peat-sample for *Carex elata* is 120 in the *Cricetum elatae* association but in the *Caricetum caespitosae* association it is only 26.5. For *Carex rostrata* the number are 0.3 in *Caricetum gracilis*, 14.2 in *Peucedano-Caricetum appropinquatae* II, and 100 in *Caricetum limoso-diandrae* II. These numbers also indicate that quantities of seeds and fruits of a given species are characteristic of its quantitative role within a given plant community. In particular it refers to species of *Carex*. Such species as *Pedicularis palustris* (75 pieces) and *Comarum palustre* (24-70 pieces) stray from that rule.

In Table 3 comparison of theoretical quantities of seeds or fruits (Table 2) per 9.8 cm² x 5 cm peat-sample with quantities from stratigraphic analyses in synthetically presented.

Table 3

Comparison of contemporary productivity of seeds or fruits in some peat-forming plants with the results of stratigraphic analyses

Species	Theoretical quantity of seeds or fruits in a peat-sample 9.8 cm ² x 5 cm	Quantities of seeds or fruits in samples from various subfossil communities	
		Oświt (1973)	Pałczyński
<i>Carex gracilis</i>	220	15	10-16
<i>C. rostrata</i>	0.3-18.2-100	67-232	15-33
<i>C. lasiocarpa</i>	0.07	40-136	16-24
<i>C. vesicaria</i>	6.5	18-58	29
<i>C. elata</i>	2.7-26.5-120	70-146	11
<i>C. appropinquata</i>	0.8-242.5	60	12-51
<i>C. dinadra</i>	28.7-32.5	37-180	25-40
<i>C. chordorrhiza</i>	0.05-0.5	7	—
<i>C. limosa</i>	0.17-0.2	—	—
<i>C. lepidocarpa</i>	35	—	16-37
<i>C. panicea</i>	5.0	—	19
<i>C. dioica</i>	0.5	—	—
<i>C. fusca</i>	2.5	18-42	15-28
<i>C. caespitosa</i>	130	12	8
<i>Lysimachia thyrsiflora</i>	0.12-1.25	1	1-4
<i>Comarum palustre</i>	24-70	6-8	1-24
<i>Stellaria palustris</i>	0.27-6.2	3	1
<i>Menyanthes trifoliata</i>	2.2-3.0	50-250	10-25
<i>Caltha palustris</i>	4.2	—	—
<i>Ranunculus lingua</i>	0.2	22.6	1-10
<i>Eriophorum angustifolium</i>	0.01	—	—
<i>Lychnis flos cuculi</i>	0.15	—	2
<i>Pedicularis palustris</i>	75.0	—	1-3

To illustrate how quantitative ratios appear within some plant communities they are presented in Table 4.

DISCUSSION

The quantitative material obtained during investigations explains a.o. why in peat samples with great numbers of seeds as a rule seeds or fruits of one, sometimes two species dominate. It is in accordance with contemporary quantitative participation of species in peat forming associations where 1 or

Table 4

Comparison of quantitative participation of seeds or fruits in subfossil plant associations of peat in Biebrza valley with their participation in contemporary associations

Species	Subfossil average	Theoretical	
1	2	3	
<i>Caricetum gracilis</i>			
<i>Carex gracilis</i>	4.1	220	
<i>C. vesicaria</i>	1.1	6.5	
<i>C. rostrata</i>	0.9	0.3	
<i>C. elata</i>	0.05	—	
<i>C. caespitosa</i>	0.5	—	
<i>C. appropinquata</i>	0.3	—	
<i>C. pseudocyperus</i>	0.1	—	
<i>C. fusca</i>	0.3	—	
<i>C. panicea</i>	0.05	—	
<i>C. lasiocarpa</i>	—	0.075	
<i>Lysimachia thyrsiflora</i>	0.1	0.12	
<i>Menyanthes trioliata</i>	1.8	—	
<i>Ranunculus lingua</i>	0.6	—	
<i>Lycopus europaeus</i>	0.1	—	
<i>Glyceria aquatica</i>	0.5	—	
<i>Schoenoplectus lacustris</i>	0.2	—	
<i>Peucedano-Caricetum appropinquatae</i>		I	II
<i>Carex appropinquata</i>	27.7	120	242.5
<i>C. rostrata</i>	2.7	14.5	0.12
<i>C. gracilis</i>	0.1	—	—
<i>C. flava</i>	0.1	—	—
<i>C. panicea</i>	0.2	—	—
<i>C. elata</i>	—	—	2.7
<i>C. fusca</i>	1.0	—	—
<i>Pedicularis palustris</i>	0.3	—	—
<i>Comarum palustre</i>	3.1	—	—
<i>Lysimachia thyrsiflora</i>	0.1	—	0.12
<i>Stellaria palustris</i>	—	—	0.27
<i>Caricetum limoso-diandrae</i>			
<i>Carex diandra</i>	5.9	32.5	28.7
<i>C. elata</i>	0.2	—	6.0
<i>C. lasiocarpa</i>	0.13	—	—
<i>C. rostrata</i>	5.8	18.2	100.0
<i>C. limosa</i>	2.6	0.17	0.17
<i>C. fusca</i>	3.8	—	2.5
<i>C. chordorrhiza</i>	3.4	0.05	0.5
<i>C. lepidocarpa</i>	0.87	—	35.0
<i>Menyanthes trifoliata</i>	1.47	3.0	0.17

1	2	3
<i>Bidens cernuus</i>	1.2	— —
<i>Eleocharis quinqueflora</i>	0.93	— —
<i>Comarum palustre</i>	0.07	70.0 27.5
<i>Eriophorum angustifolium</i>	0.07	0.01 —
<i>Lysimachia thyrsiflora</i>	—	1.2 —
<i>Caltha palustris</i>	—	4.2 —
<i>Stellaria palustris</i>	—	6.2 —
<i>Ranunculus lingua</i>	—	0.17 —
<i>Pedicularis palustris</i>	—	— 75.0
<i>Lychnis flos cuculi</i>	—	— 0.15
<i>Carex appropinquata</i>	—	0.8 —
<i>C. panicea</i>	—	— 5.0

2 species also dominate. Hence, it is possible on the basis of dominance of fossil seeds or fruits in a particular peat-sample to determine community or peat-forming association of which this particular peat-layer originated. Accompanying seeds of another species and also determinable vegetative remains support such a diagnosis. From Tables 3 and 4 it comes out that the correlation between theoretical number of seeds or fruits and numbers obtained through analyses of peat material is rather weak. On that score there are also differences between data of Oświt (1973) and Pałczyński (1975). The latter showed greater correlation. In particular it refers to such species as *Carex rostrata*, *C. diandra*, *C. lepidocarpa* and, to lower degree, *Comarum palustre*, *Menyanthes trifoliata*, *Lysimachia thyrsiflora* and *Ranunculus lingua*. Of course what one can expect is only certain approximation and not the full correlation of data.

Contemporary material, the base for the theoretical quantities of seeds and fruits differs very much from the subfossil one. Also, there can be another reasons of a disagreement between both sets of data. Big differences in *Carex gracilis* can be created by the yearly inundation and flow of the part of urticles and nutlets as the *Caricetum gracilis* association develops within the flood zone. The quantitative role of same species was greater in the past than it is now, and *vice versa* (f.e. *Carex appropinquata*) and this can be yet another reason. Data obtained from the stratigraphic analyses (Pałczyński 1972) indicate a.o. that in the past *Carex rostrata* was much more important than it is now (it is opposite in Biebrza valley). The above probably true also for *Carex vesicaria*, *C. lasiocarpa*, *C. chondorrhiza*.

Fortuitousness of occurrence of seeds and fruits in the eat-profile can not be excluded, too. In extremal cases portions of a peat profile totally lack seeds. It is possible that some animals (rodents, birds) selectively consume seeds and fruits. Data included in Table 4 show the big floristic variety of subfossil plant communities. Presented numbers are average for 20-30 samples. In a single

peat-sample the number of species represented by seeds and fruits is usually 3-4-8. Floristic variety causes that the synthetical presentation includes many species. Particularity it refers to associations *Caricetum gracilis* and *Peucedano-Caricetum appropinquatae*.

Results presented in this paper clearly show elaboration of data on the productivity of fruits and seeds of all plant species composing the peat-forming associations and estimation of their participation within the particular association is purposeful and useful. Numbers obtained should help to put the proper interpretation upon results of stratigraphic analyses to reconstruct subfossil plant associations and make them more consistent with reality. One should remember that a sampler with a container 50-cm long and 5 cm in diameter has to be used. In other case, proper calculation should be made.

REFERENCES

- Marek S., 1965. Biologia i stratygrafia torfowisk olszynowych w Polsce. Zesz. Probl. Post. Nauk Roln. 57: 67-158.
- Oświt J., 1973. Warunki rozwoju torfowisk w dolinie dolnej Biebrzy na tle stosunków wodnych. Roczn. Nauk Roln. Ser. D 143: 33-37, 49-56.
- Pałczyński A., 1972 Palaeophytosociology development perspectives in the new research methods applied in Poland. The proceedings of the 4th International Peat Congress-Otaniemi. Finland, pp. 361-370.
- Pałczyński A., 1975. Bagna Jaćwieskie. Pradolina Biebrzy. Roczn. Nauk Roln. Ser. D 145: 94-106, 153-232.
- Szafer W., Kulczyński S., Pawłowski B., 1976. Rośliny polskie. PWN, Warszawa.
- Tołpa S., 1958. Nowa metoda badań stratygrafii torfowisk. Zesz. Probl. Post. Nauk Roln. 17: 11-42.
- Tołpa S., Jasnowski M., Pałczyński A., 1967. System der genetischen Klassifizierung der Torfe Mitteleuropas. Zesz. Probl. Post. Nauk Roln. 76: 10-99.

Próba uściślenia metody paleofitosocjologicznej w badaniach złóż torfowych

Streszczenie

Zbadano produkcję owoców i nasion roślin torfotwórczych z kilku ważniejszych zespołów roślinnych torfowisk niskich doliny Biebrzy. Uzyskane wyniki porównano z wynikami analiz stratygraficznych. Celem tych badań było uściślenie paleofitosocjologicznej metody rekonstrukcji subfosylnych zespołów roślinnych. Produkcja owoców i nasion niektórych gatunków jest zgodna z ilością znajdowaną w próbach torfu. Inne gatunki nie wykazują tej zgodności. Przyczyny są różnorodne. Istotne jest to, że współczesne dane ilościowe wyjaśniają przyczynę dominacji w próbach torfu nasion określonego gatunku. Utwierdza to nas w przekonaniu, że na tej podstawie można rekonstruować subfosylne zbiorowiska roślinne, przy udziale pozostałych gatunków reprezentowanych przez nasiona i szczątki wegetatywne. Powinno się dążyć do opracowania danych o produkcji owoców i nasion wszystkich roślin torfotwórczych z uwzględnieniem poszczególnych torfotwórczych zespołów roślinnych. Ułatwiłoby to interpretację wyników analiz stratygraficznych i przybliżyło do rzeczywistości rekonstrukcję subfosylnych zespołów roślinnych.