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Importance of Quaternary Materials for Research on the Historical Evolution of Plants

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In the Tertiary and Quaternary floras of Poland we encounter abundant materials of fruits and seeds, composed in the separate sediments of even several hundred specimens of one genus, and sometimes, of one species. This abundance of fossil materials was the reason why biometrical studies were undertaken in order to determine the changes in the fruits and seeds of certain plants in the course of geological epochs.

In explaining such difficult problems of evolution, the Quaternary materials played the leading rôle. These disdained fossil remains, often completely ignored by palaeobotanists, have frequently become the key for explaining many problems.

Present-day fruits and analogical fossil Tertiary fruits carbonized and compressed are apparently such different things that they seem to be incomparable, it seems therefore improbable that one could determine the changes to which were subjected these organs during evolution. Consequently in the study of the evolution of various genera or species, the most important thing was to distinguish the changes brought about by fossilization from the essential changes that could take place in organisms during the process of evolution. In order to attain this aim, it was necessary to begin the investigations not with fossil materials, but with the recent ones and, having become acquainted with their characters, to go backwards, step by step, carefully observing the changes that occured in the characteristics of the given object in the course of prolonged stay underground. Only by proceeding in such a manner, is it possible to discern the essential changes that are independent of fossilization, i. e. the ones that have the character of evolutionary changes.

In order to facilitate an understanding of the applied methods of investigations, I shall present two examples.

In the Pliocene sediments occuring at the foots of the Carpathian Mountains, discovered at Mizerna and Krościenko (both these floras has been elaborated by Prof. SZAFER), among plants no longer living in our present climate, were the fruits and seeds of numerous plants which grow in Poland up to the present day. Two of these plants had a common property: their fruits, or seeds, were completely similar to those of present-day species, being however considerably smaller. These were fruits of the genus *Carpinus* and seeds of the genus *Menyanthes*. In one case and the other, the small dimensions were characteristic only of the Pliocene, while the dimensions of interglacial forms hardly differed from those of present-day forms. The question arose: can we consider the Pliocene forms of the above-mentioned plants as the protoforms of present-day species, or else, in the Pliocene, did we have other species, now perhaps extinct, possessing fruits or seeds that were only externally similar to the ones existing at present?

The nutlets of *Carpinus betulus*, at present the only representative of the genus *Carpinus* in Middle Europe, possess specific characters of their anatomical structure, such that are absent in other species of *Carpinus*. These characters are the following: thickness of the walls of the pericarp, its ribbing, and cells with large lumina in the middle part of the walls.

These properties were difficult to discern in cross-sections of Pliocene fossilized materials. However, all the above-mentioned anatomical properties characteristic of the species *Carpinus betulus* were discoverable in Pliocene nuts, if one began the investigations with present-day materials, and then proceeded lower and lower down, i. e., if one compared present-day materials with subfossil ones, then subfossil ones with materials from the Riss-Würm interglacial, next those with materials from the Mindel-Riss interglacial, and finally the latter with Pliocene materials. This is demonstrate on Fig. 1.

Thanks to such gradual comparison of a large material it was possible to prove the supposition that the fruits of *Carpinus* from the Pliocene sediments encountered in Poland at the foot of the Carpathian Mountains, had the same anatomical structure as *Carpinus betulus*, only more and more changed by fossilization, and that the only essential difference between them were the dimensions of the nuts. This conclusion is of primary importance in the attempt to reconstruct the history of the genus *Carpinus* in Poland. As a matter of fact we possess no proof that the Pliocene *Carpinus* was the parent-plant of the living at present, but we do have proof that it could have been such a protoform since its fruits differed from the now-living species *Carpinus betulus* by nothing else than their dimensions.

In the above-quoted example, an accurate examination of the anatomical structure of Quaternary materials belonging to the genus *Carpinus*, confirmed our conviction as to the close relationship between the Tertiary species and the *Carpinus* that grows in Poland at present. In the second example, pertaining to *Menyanthes*, the conclusions that can be deduced, will be based upon the anatomical characters and on the biological properties of the Quaternary and Pliocene plants.

The specific position of the *Menyanthes* seeds found in the Pliocene was decided by the anatomical examination. The anatomical structure of these seeds was preserved so well that it was possible to compare them directly with those of now-living plants. A biometrical examination of both the morphological characters and the anatomical ones, demonstrated that the Pliocene seeds of the genus *Menyanthes* differed

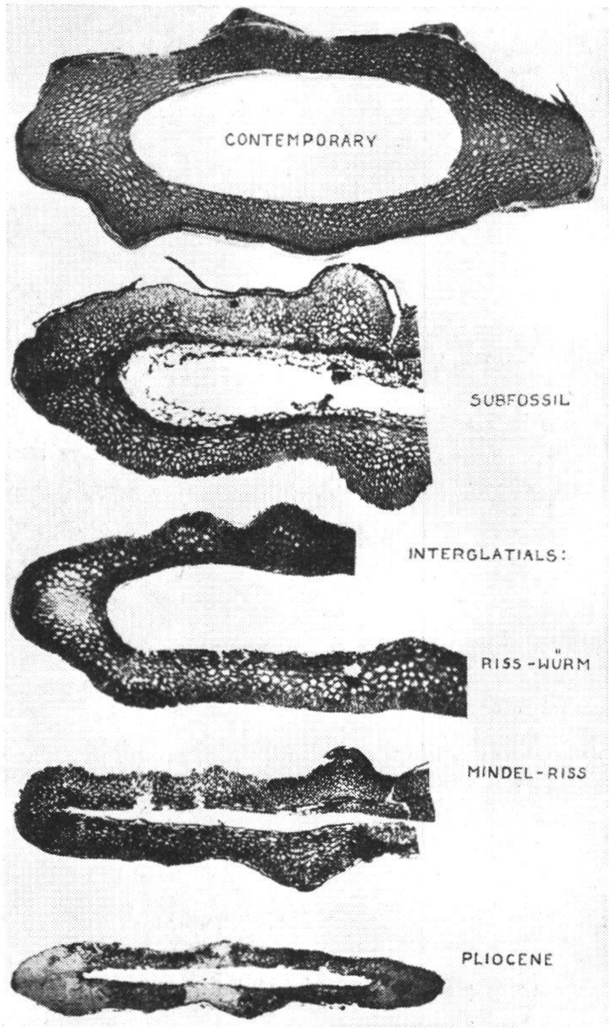

Fig. 1. Cross-sections of the nutlets of *Carpinus betulus* and the corresponding species of the Pliocene.

from the interglacial and present-day ones in an essential manner with regard to eight characters of the nine examined. Only ratio length to width was the same in both seeds. Since in the seeds themselves such large structural differences did exist, there are foundations to assume that in the whole plant there also must have existed a correspondingly large number of such differences: we have therefore a basis for considering the Pliocene species to be a separate one. Consequently, I gave it the name of *Menyanthes carpatica.* The interglacial seeds were identical with seeds of the present-day *Menyanthes trifoliata.*

The above-mentioned sediments at Mizerna, elaborated by Prof. SZAFER, possessed the valuable property that they were composed of several overlying layers with plant remains which belonged to various geological periods. The bottom layers had been deposited in the Pliocene, the top ones during the oldest Polish interglacial, i. e., the Günz-Mindel interglacial. All of the layers contained *Menyanthes* seeds. In the Pliocene, exclusively the small seeds of *Menyanthes carpatica* were present; in the top layers there were the bigger seeds similar to the present-day *Menyanthes trifoliata.* The discovery, at one locality, of seeds belonging to the Pliocene and to the oldest interglacial, stirred up the appetite of a scientist in quest of the paths of evolution. Hope was born that perhaps one might succeed in finding here in situ some intermediate form which would enable us to bind the Pliocene species to a now-living one. This hope, unfortunately, was dispersed in consequence of a detailed study of the biological properties of the present-day form and of interglacial forms.

It seems to be somewhat absurd to say that it is possible to compare fossil forms with present-living ones as to their biological properties. This, however, is indeed possible. In the case of the genus *Menyanthes* it is a matter of the peculiar property of the monotopic genus *Menyanthes trifoliata* which occurs in our present flora in two local biotypes. The seeds of one biotype have low and wide cells of the epidermis, while those of the other biotype have narrow and high ones. The interglacial seeds of this species had the same property; this was demonstrated by means of biometrical studies carried out on seeds of *Menyanhes trifoliata* collected at 14 localities. The seeds from the Günz-Mindel interglacial, derived from the above-mentioned top layers at Mizerna, belonged to the biotype which has seeds with narrow and high epidermal cells. In contrast to this, the Pliocene seeds, found at the same locality several metres lower down, had markedly low and wide epidermal cells. I shall demonstrate this in the figures.

At the top of Fig. 2 we have cross-sections of seeds of *Menyanthes trifoliata,* belonging to the biotype with low epidermal cells, and to the biotype with high ones. Below them we have the same in seeds derived from the Mindel-Riss interglacial, while in the third row we have cross-section of a seed derived from the Günz-Mindel interglacial, the oldest one in Poland, from the top layers at Mizerna. It is a local biotype with high epidermal cells. At the bottom we have seeds of the Pliocene fossil species *Menyanthes carpatica* from the same locality, with markedly small, almost square epidermal cells. In the next figure (Fig. 3) we have a graph representing the ratio of length to width of the epidermal cells in both of the described biotypes. At the top we have graphs characterizing both biotypes of *Menyanthes trifoliata,* present-day and interglacial ones. Below them there is a graph of the biotype from the Günz-Mindel interglacial at Mizerna, and at the bottom, graphs of *Menyanthes carpatica* from the Pliocene at Mizerna.

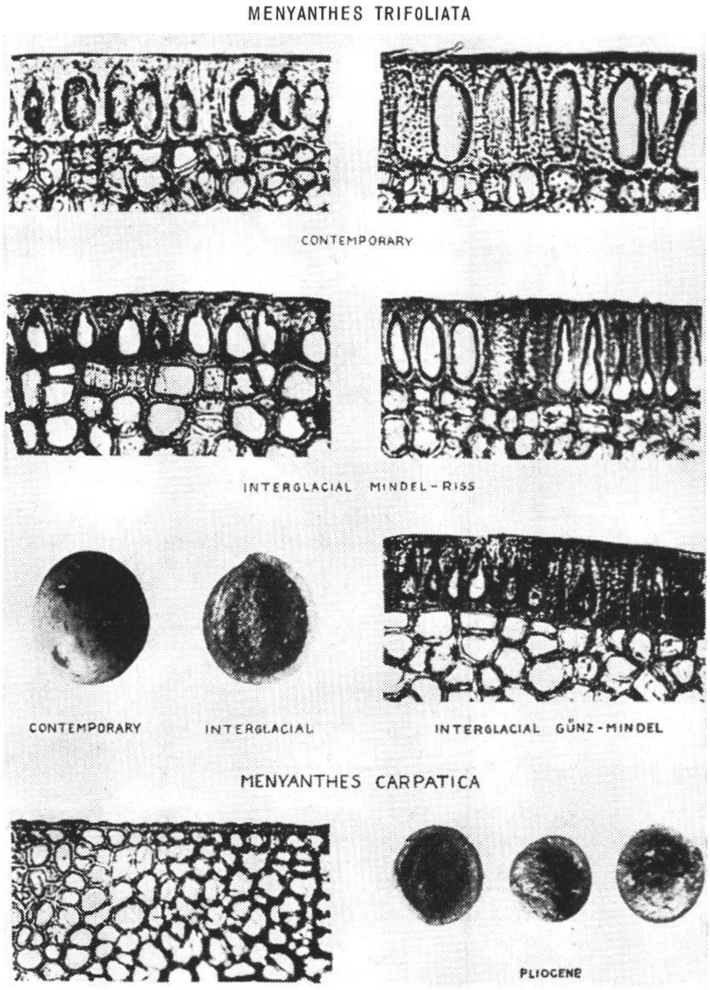

Fig. 2. Epidermal cells of *Menyanthes trifoliata* L. and the fossil species *Menyanthes carpatica*. Left the biotypes with low cells, right the biotypes with high cells.

It is not known whether the Pliocene species *Menyanthes carpatica* occurred, the same as the species *Menyanthes trifoliata*, in two biotypes, the fact being that up to the present moment it has been found only at Mizerna, so that we have but one local sample. However, if the seeds from the Günz-Mindel interglacial, discovered in the same sediments several metres higher up, were to constitute an intermediate link between *Menyanthes carpatica* and *Menyanthes trifoliata*, then they would have to occur in the same biotype. The fact is that we cannot conceive such a chain of evolution in which, at a certain locality, not only the anatomical characters would undergo a change, but there would also be a leap from one biotype to the other. The Pliocene species *Menyan-*

thes carpatica probably perished during the cooling which, at the close of the Pliocene, was caused by the approaching Günz glaciation; its place at Mizerna was then occupied by the species *Menyanthes trifoliata,* coming there from one of its Tertiary refuges. It seems that the latter species lived side by side with *Menyanthes carpatica* already in the Pliocene, and being more resistant, it survived.

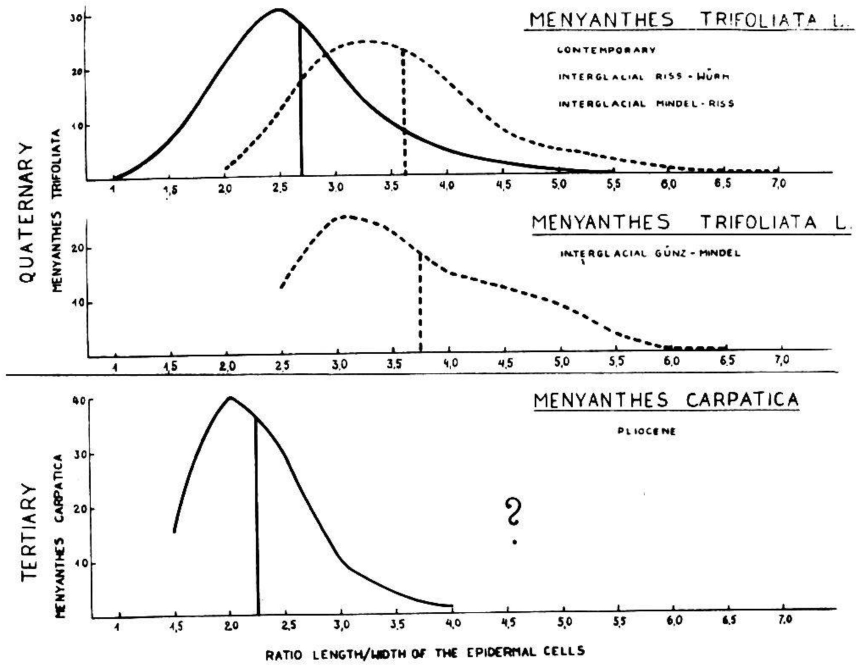

Fig. 3. Ratio length width of the epidermal cells of *Menyanthes.*
———— The biotype with low cells.
-------- The biotype with high cells.

It was on purpose that I have selected here two apparently similar examples where, superficially judging, one could have imagined to detect an evolutionary chain in one case and the other, and where a very conscientious study of the anatomical and biological properties of the Quaternary materials preserved us from arriving at light-minded and unfounded conclusions, and at the same time shed some light upon the history of the two above-mentioned genera.

I am not going to pursue the subject any more, as I am not concerned in quoting numerous fact. It was only my intention to demonstrate by means of examples the important role which can be played by Quaternary materials in the study of the historical evolution of plants, if such studies are not to have a speculative character but are to be based upon scientific evidence.

Finally I should like to mention the role which can be played by the examination of Quaternary fossil materials in the study of the history and variability of present-day plants, the natural distributional area of which has now become altered by man. *Pinus silvestris* can serve as an example; nowadays it is encountered in wild state in but a few places.

We all know very well what has been the fate of the forests, not only in Poland but in other countries as well, as the result of their thoughtless exploitation and the introduction of alien species and alien races. Consequently, it seems at present impossible to reconstruct the local races of pine adapted to the proper climatic and edaphic conditions. However, if we reach out for Quaternary materials, especially Holocene materials, it becomes evident that in many places it is possible to find abundant layers of subfossil pine-cones so perfectly preserved that they can be examined biometrically just the same as cones of now-living trees. The study of such materials, derived from periods during which surely no one planted pines, will undoubtedly shed some light both upon the postglacial history of the above-mentioned species and upon the properties of local forms. In such a way, on the basis of fossil materials, it will probably be possible to trace the variability and natural character of one of the very important elements of our forests, and to draw conclusions which may be of importance for the future rational cultivation of the above-mentioned tree.

It follows from the examples presented above that it is necessary not only to collect assiduously in scientific institutions the fossil remains of Quaternary materials, but also to collect them in as large quantities as possible, in order to enable them to be elaborated statistically. Only detailed data based upon tedious but accurate examination of abundant materials will assist us in the future to discover the history of the youngest but, for us, the most important stage in the chain of evolution, i. e., the history of flowering plants.

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