

EFFECT OF THE HIGH TEMPERATURE ON THE MORPHOLOGICAL CHARACTERISTIC FEATURES OF THE SPOROMORPHS II

M. KEDVES, A. TÓTH and E. FARKAS

*Department of Botany, József Attila University,
H-6701 Szeged, P. O. B. 657, Hungary*

(Received: December 29, 1989)

Abstract

Globular surface elements and connections between two pollen grains as new morphological characteristic features were occasionally observed on the pollen grains of *Ginkgo biloba* L. cultivated in Szeged. After the separation of the connected pollen grains, the bases of the connectives are peculiar pores. In contrast to the inter-apertural exine the annulus-like thickenings around the pores stained differently by Toluidin blue.

Preliminary results on the change of the qualitative and quantitative morphological characteristic features in consequence of high temperature effect are also presented herein. Detailed methodological investigations were carried out on two kinds of recent inaperturate pollen grains (*Juniperus virginiana* L., *Taxus baccata* L.). In consequence of high temperature, secondary changes for angiosperm characteristic features appeared on these pollen grains. Monoporate (type Gramineae), tricolpate (early Longaxones, dicotyledonous type), and Brevaxones (plicate forms, Normapolles type) were observed. The frequency distribution of the diameter of the non-experimental, and the different kinds of experiments on the same species are also discussed herein. As an important new parameter the proportion of the data of the non-experimental and the experimental frequency distribution diagrams are introduced in this paper.

Key words: Palynology, Gymnospermae, monosulcate, inaperturate types, high temperature effect.

Introduction

The pollen grains of the recent gymnosperms may be classified into the following morphological groups: saccate, inaperturate, monosulcate and polyplacate. Between them, probably the saccate type is the earliest (cf. *Archaeoperisaccus* NAUMOVA). TEM data from are MEYER and RASKATOVA (1984), and from MEYER-MELIYAN and TELNOVA (1989).

The first Carboniferous disaccate pollen grains of the genus *Pityosporites* SEWARD 1914 em. MANUM 1960 are characteristic disaccate pollen grains. The importance of the monosulcate gymnosperm pollen grains in the fossil palynomorph record was recognized a long time ago. The Ginkgoalean-Cycadacealean botanical affinity was also discovered. Results on comparative and/or morphological variations of the recent *Ginkgo biloba* L. were published by ERDTMAN (1954, 1957), KEDVES (1961b) and LIEUX (1980). Carbon-replica method for the ultra-relief was first published by ERDTMAN (1965). Using the electron-microscope method, AUDRAN and MASURE (1978) established; p. 363: „The *Ginkgo biloba* sporoderm, when examined

with transmission and scanning electron microscopes, shows a sculpture and texture which are very different from those observed in Cycads." Later the extremely great importance of the monosulcate (-colpate) forms in the evolution of the first angiosperm pollen grains was recognized (cf. DOYLE 1977, HUGHES, DREWRY and LAING, 1979). The phylogenetic significance of the exine ultrastructure, especially of the infratectal layer was emphasized several times by M. VAN CAMPO (1973), M. VAN CAMPO and LUGARDON (1973), and by DOYLE et al. (1975). In this way in several cases on fossil pollen grains, it is the exine ultrastructure only, which may be the unique arbitrary characteristic feature for the separation of the Cycadalean-Ginkgoalean pollen grains from the early angiosperm pollen grains. Following the DOYLE (1977) scheme, from the basic monosulcate type the tricolpate, then the tricolporate may develop. From the tricolporate pollen grains the first brevaxonate pollen grains are appearant. KEDVES (1981); p. 77/78: „The most important changes in the form and symmetry are as follows:

- I. Longaxones; monosulcate — tricolpate — tricolporate
- II. Brevaxones; tricolporate — triporate, triatriate, etc.
 1. Monosulcate — Tricolpate; change in number of the germinal apertures
 2. Tricolpate — Tricolporate; change in the character of the aperture
 3. Tricolporate Longaxones — Probrevaxones; shortening of the polar axis.

Therefore the three major evolutionary changes in the form and the symmetry of the early angiospermous pollen grains exhibit different characters."

The inaperturate pollen grain types have been several times problematic regarding their botanical affinity: Taxodiaceae, Cupressaceae, Taxaceae, etc. among the gymnosperms, *Cinnamomum*, *Populus* from the angiosperms, but planctonic organisms may also be taken into consideration. Back up to the monosulcate forms, the inaperturate pollen grains were not believed as important representatives of one step of the angiosperm pollen grains. During our transmission electron microscope investigations, angiosperm type ectexine (without endexine) was found at the peculiar inaperturate pollen grains of *Spheripollenites scabratus* COUPER 1958 (KEDVES and PÁRDUTZ, 1973). Later, inaperturate — monoporate evolutionary lineages were presumed; EL-SAADAWI and KEDVES (1991). The first results about the consequences of high temperature to the morphological characteristic features of some recent brevaxonate pollen grains are published in 1989 (KEDVES and KINCSEK). The aim of our research program has different aspects, namely methodological, taxonomical and phylogenetical. The application of these results to the secondary changes during the diagenesis of the organic material. This paper is the first part of our experimental studies in this field.

Materials and Methods

1. *Ginkgo biloba* L., cultivated in the Garden of the Museum of Szeged, collected by M. KEDVES ON 3.4.1989. Fresh pollen grains were stained with Toluidin blue, and mounted in glycerin jelly hydrated of 39,6%.

Experiment No 583 — 5 mg air dried pollen grains were heated at +200 °C during one hour.

2. *Juniperus virginiana* L., and *Taxus baccata* L. collected by I. KINCSEK in the Botanical Garden of the A. József University on 14.3.1989. Unstained and pollen grains heated at +200 °C during different hours were examined. The experiments are as follows:

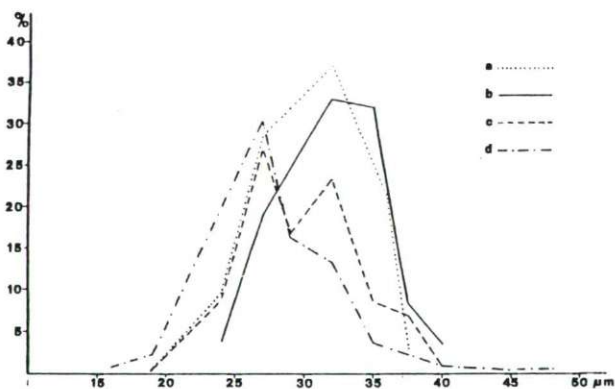
T. baccata

J. virginiana

No of experiment		length of time in hours
491	479	1
492	480	2
493	481	3
494	482	4
495	483	5
496	484	10
497	485	15
498	486	20
499	487	30
500	488	40
501	489	50
502	490	100
	651	125
	652	150

Results

Ginkgo biloba L. (Plate I, II, text-figs. 1—3)



text-fig. 1

Variation-statistical graphs of the polar axis of the pollen grains of *Ginkgo biloba* L.

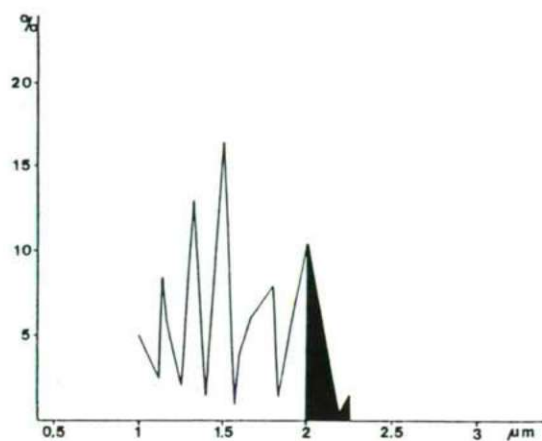
a: Fresh pollen grains without experiment.

b: Pollen grains after experiment No 583.

c: Acetolyzed pollen grains from Japan.

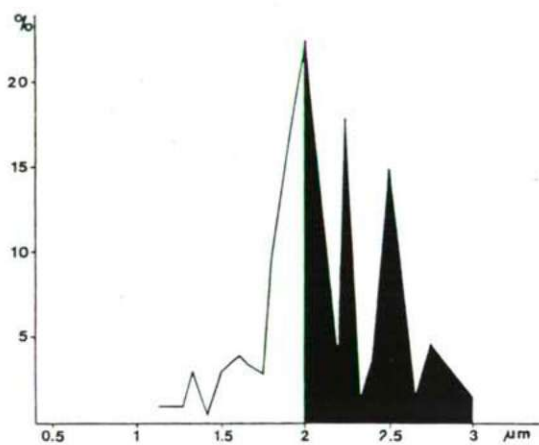
d: Acetolyzed pollen grains from Hungary.

The last two graphs follow the paper by KEDVES (1961b).



text-fig. 2

Variation-statistical diagram of the polar-equatorial axis ratio (P/E) of the fresh collected pollen grains of *Ginkgo biloba* L. without preparation.



text-fig. 3

Ginkgo biloba L. recent. Variation-statistical diagram of the polar-equatorial axis ratio (P/E) of the fresh collected pollen grains after experiment No 583.

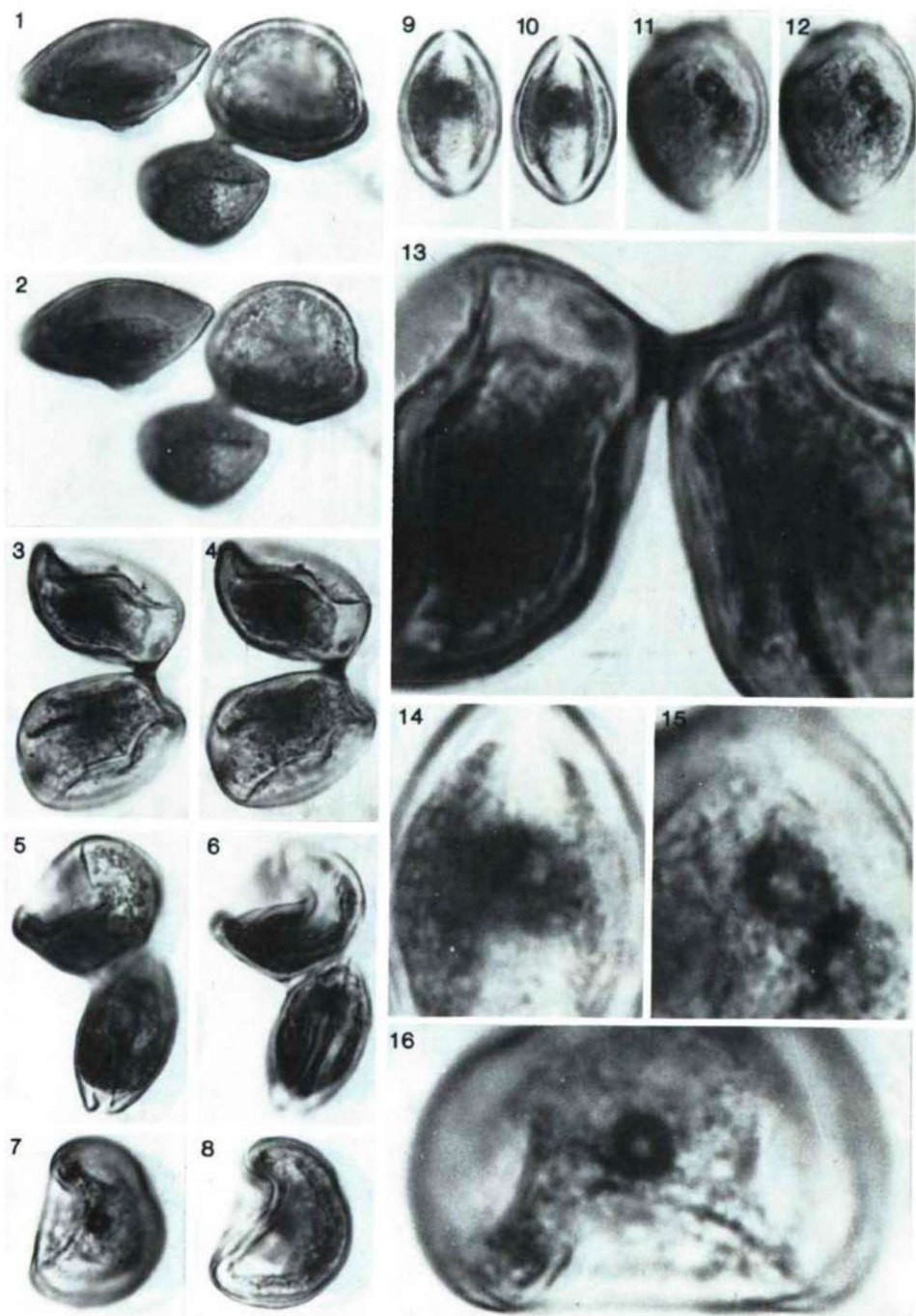


Plate I 1—16. *Ginkgo biloba* L., recent.
 Pollen grains stained with Toluidin blue. Magnifications: 1—12 \times 1000, 13—16 \times 3000.

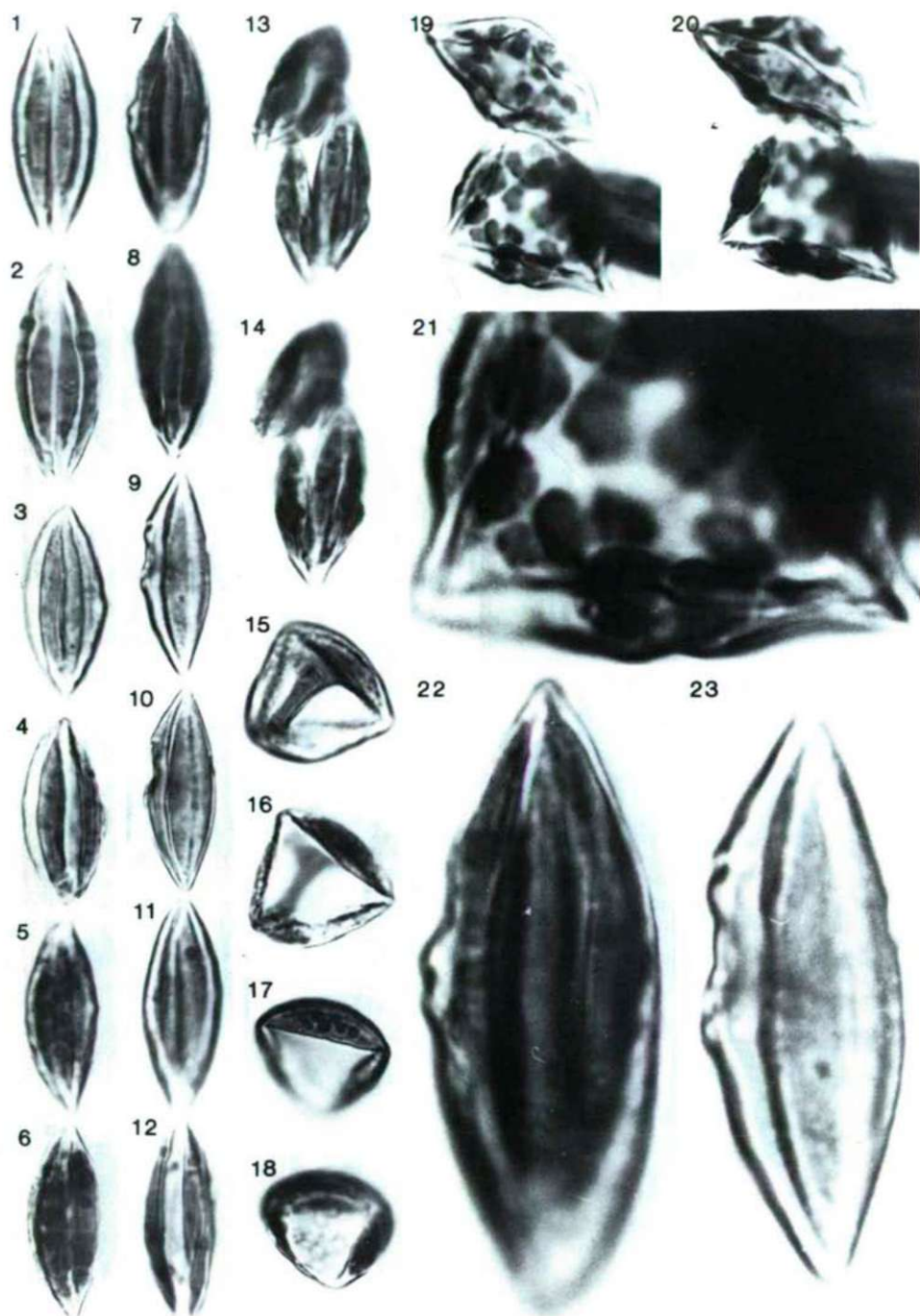


Plate II 1—23. *Ginkgo biloba* L., recent.
 Pollen grains after experiment No 583. Magnifications: 1—20×1000, 21—23×3000.

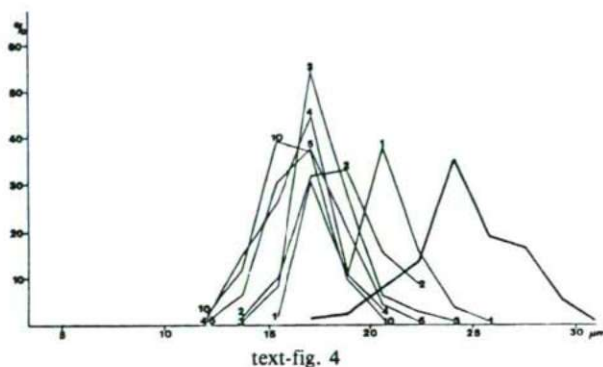
1. New observations on the qualitative morphological characteristic features of this species (Plate I, figs. 1—16). The most important new observations: pollen grains may occur in pairs. The quantity is low, about 1 per cent of the pollen grains investigated (Plate I, figs. 1,2,3,4,5,6, 13). Occasionally more (about three) connections were also observed (Plate I, figs. 5,6). After separation of the two pollen grains pores or pseudopores appear. Their diameter is $0.7-1.5 \mu\text{m}$, bordered with irregular „annulus-like” thickening, breadth $1-2 \mu\text{m}$. The whole diameter of this „polar area” is $2.8-4.2 \mu\text{m}$. (Plate I, figs. 7,8,9—12, 14, 16). With the stain Toluidin blue, the so-called germinal area is violet-coloured, the other parts of the exine are greenish-blue. In this way characteristic difference in the chemistry of the two parts of the exine can be established. On the pollen grains after experiment No 583 several times the pseudo-pore region with annular thickenings may be well shown (Plate II, fig. 7,8,9, particularly 22, 23). The form varieties, similar to the trichotomosulcate forms occur in 2.5 per cent at the pollen grains without experiment, and 4 per cent after experiment. The change in the basic monosulcate morphological characteristic features is well shown on Plate II, figs. 1—14, 22,23. Taking into consideration the Synopsis of POTONIÉ (1958) these forms are similar to the form-genera *Bennettitaceaeacuminella* MALYAWKINA 1953, and *Ginkgoretectina* MALYAWKINA 1953. These are early morphological characteristic features due to the experiment. But as advanced forms the „porate” and the trichotomosulcate-like forms may be pointed out.

2. As regards the length of the polar axis for comparison we used the earlier measurements, too (KEDVES, 1961). Pollen grains from two localities (one from Japan, another from Hungary) both herbarium material were treated with the acetolysis method (ERDTMAN, 1954). Our new data from fresh collected material mentioned previously stained with Toluidin blue and after experiment, No 583 (text-fig. 1). The statistical variety of the polar axis of the acetolyzed pollen grains from the locality of Japan have a graph with two maximums in contrast to the pollen grains collected from Hungarian locality. The recently investigated specimens, without experiment resulted in this respect in a frequency distribution graph with one single peak.

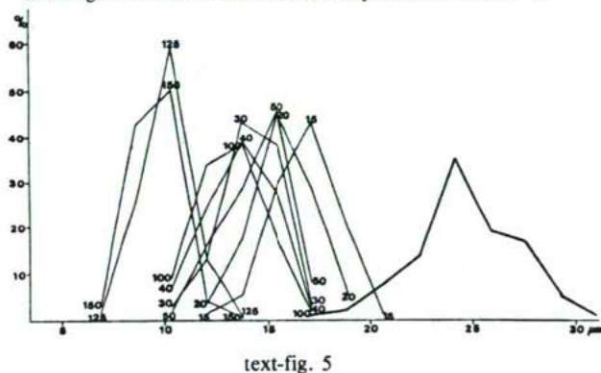
In contrast to this, the pollen grains after high temperature experiment have polar axis maximum between $32-35 \mu\text{m}$, so this has, not an expressed maximum at one single value. It is worth of mentioning, that the frequency distribution graphs of the non-experimental, and the acetolyzed pollen grains from Japan are essentially the same, between $17-27 \mu\text{m}$.

The polar/equatorial axis ratio seems to be a very important characteristic feature in phylogenetical Palynology and/or in experimental respect. For an expressive graph we prepared as follows: (text-fig. 2,3). The per cents of value 2 or more than 2 are represented with black area, the lower than 2 a single graph. At the pollen grains without experiment (text-fig. 2), it can be established the following: 5.0 per cent of the pollen grains are isodiametric. 87.5 per cent of the pollen grains have P/E ratio 2 or lower than 2. After heating, following the experiment No 583, the values are as follows: No isodiametric pollen grain, 71.5 per cent of the pollen

grains have P/E ratio 2 or more than 2. Nearly the opposite to the previous. The pollen grains during one hour at 200 °C, the polar-equatorial axis changed in a significant manner.



Juniperus virginiana L., recent. Variation-statistical diagrams of the diameter of the fresh collected pollen grains. Graph with thick line represents the pollen grains without experiment, the other ones the results of experimental investigations on relatively short length of time. Numbers on the graphs indicate the length of time in hours of the experiments at 200 °C.



Juniperus virginiana L., recent. Variation-statistical diagrams of the diameter of the fresh collected pollen grains. Graph with thick line represents the pollen grains without experiment, the other ones the results of experimental investigations on relatively long length of time. Numbers on the graphs indicate the length of time in hours of the experiments at 200 °C.

Juniperus virginiana L. (Plate III, text-figs. 4,5)

The fresh collected pollen grains (Plate III, fig. 1) are spherical apparently inaperturate the pseudo-pores (M. VAN CAMPO-DUPLAN, 1953) are in several cases not so well discernible. On the pollen grains of non-experimental sample, no new supplementary qualitative morphological characteristic features have been observed, in contrast to the previously discussed species.

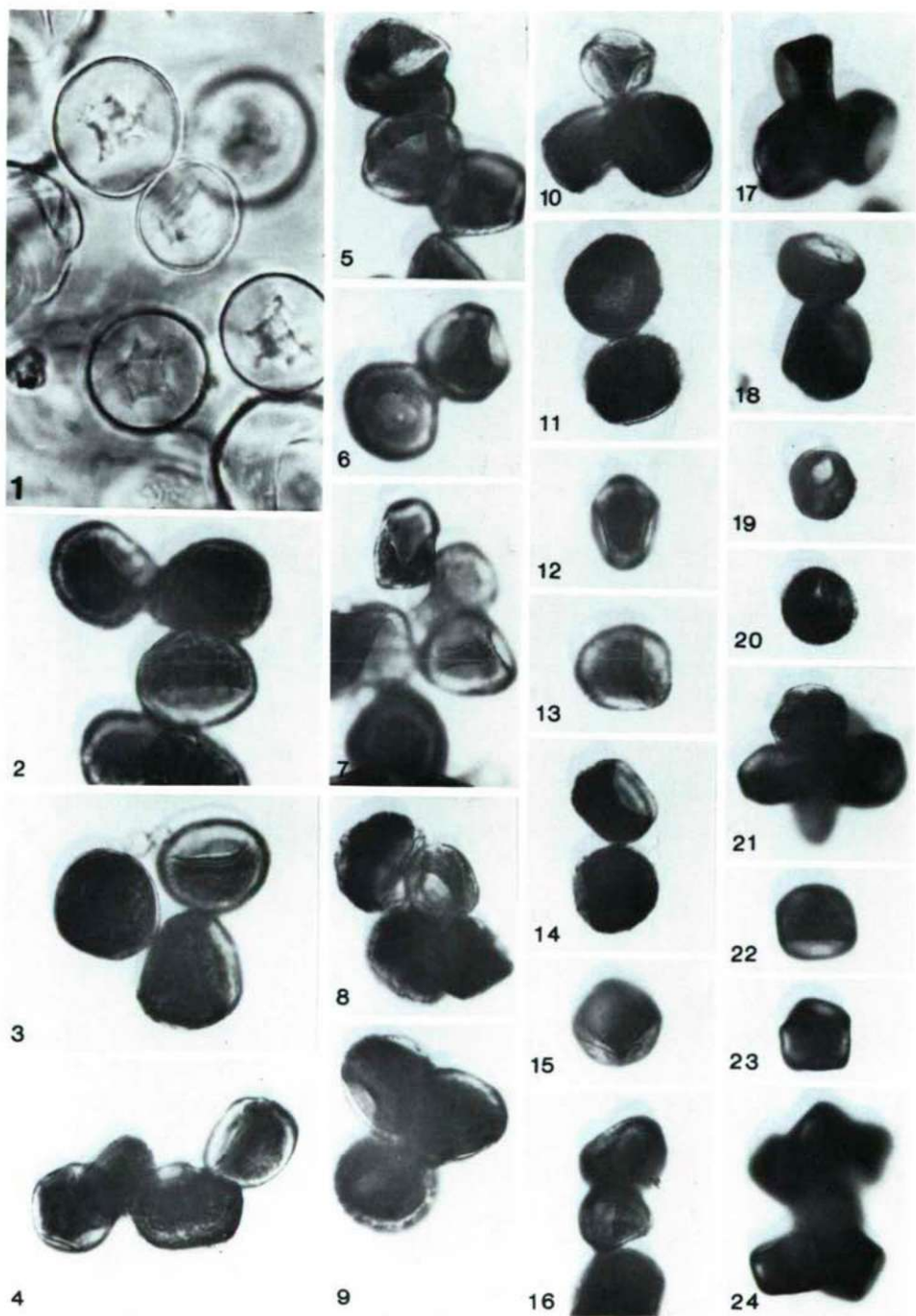


Plate III

Plate III

- 1—24. *Juniperus virginiana* L., recent.
 1. Pollen grains without stain and experiment.
 2—4. Pollen grains after experiment No 479.
 5—7. Pollen grains after experiment No 480.
 8, 9. Pollen grains after experiment No 481.
 10, 11. Pollen grains after experiment No 482.
 12, 13. Pollen grains after experiment No 483.
 14, 15. Pollen grains after experiment No 484.
 16—18. Pollen grains after experiment No 485.
 19—21. Pollen grains after experiment No 486.
 22—24. Pollen grains after experiment No 487.
 Magnification: $\times 1000$.

After the experiments at high temperature at $+200^{\circ}\text{C}$ by different length of time several qualitative morphological changes have been observed. These secondary morphological characteristic features rank as follows:

1. New basic morphology, inside the so-called inaperturate gymnosperm pollen grains: the „cup form”, which is common at some Taxodiaceae pollen grains.

2. Secondary morphological characteristic features, which are similar to the angiosperm pollen grains:

2.1. Plicate forms, similar to the early Normapolles pollen grains (extinct Dicotyledonous pollen grains from the Upper Cretaceous) or to the trilete spores (Plate III, fig. 6,7,10, plate IV, fig. 19, 22, 23 — the pollen grain in the upper left corner of the picture).

2.2. Inside the plicate forms „tetraexitus” (Plate III, fig. 15,23, plate IV, fig. 2,12,16) and „pentaexitus” types (Plate III, fig. 12,23), were also observed.

3. „Tricolpate forms” (Plate IV, fig. 6,9,15,20,21).

Plate IV

- 1—23. *Juniperus virginiana* L., recent.
 1—3. Pollen grains after experiment No 488.
 4—6. Pollen grains after experiment No 489.
 7, 8. Pollen grains after experiment No 490.
 9—15. Pollen grains after experiment No 651.
 16—18. Pollen grains after experiment No 652.
 Magnification: $\times 1000$.
 19. Enlarged part of photo 10, plate III;
 experiment: No 482.
 20. Enlarged part of photo 10, plate IV;
 experiment: No 651.
 21. Enlarged picture of photo 15, plate IV;
 experiment: No 651.
 22. Enlarged picture of photo 13, plate III;
 experiment: No 483.
 23. Enlarged picture of photo 6, plate III;
 experiment: No 480.
 Magnification: $\times 3000$.

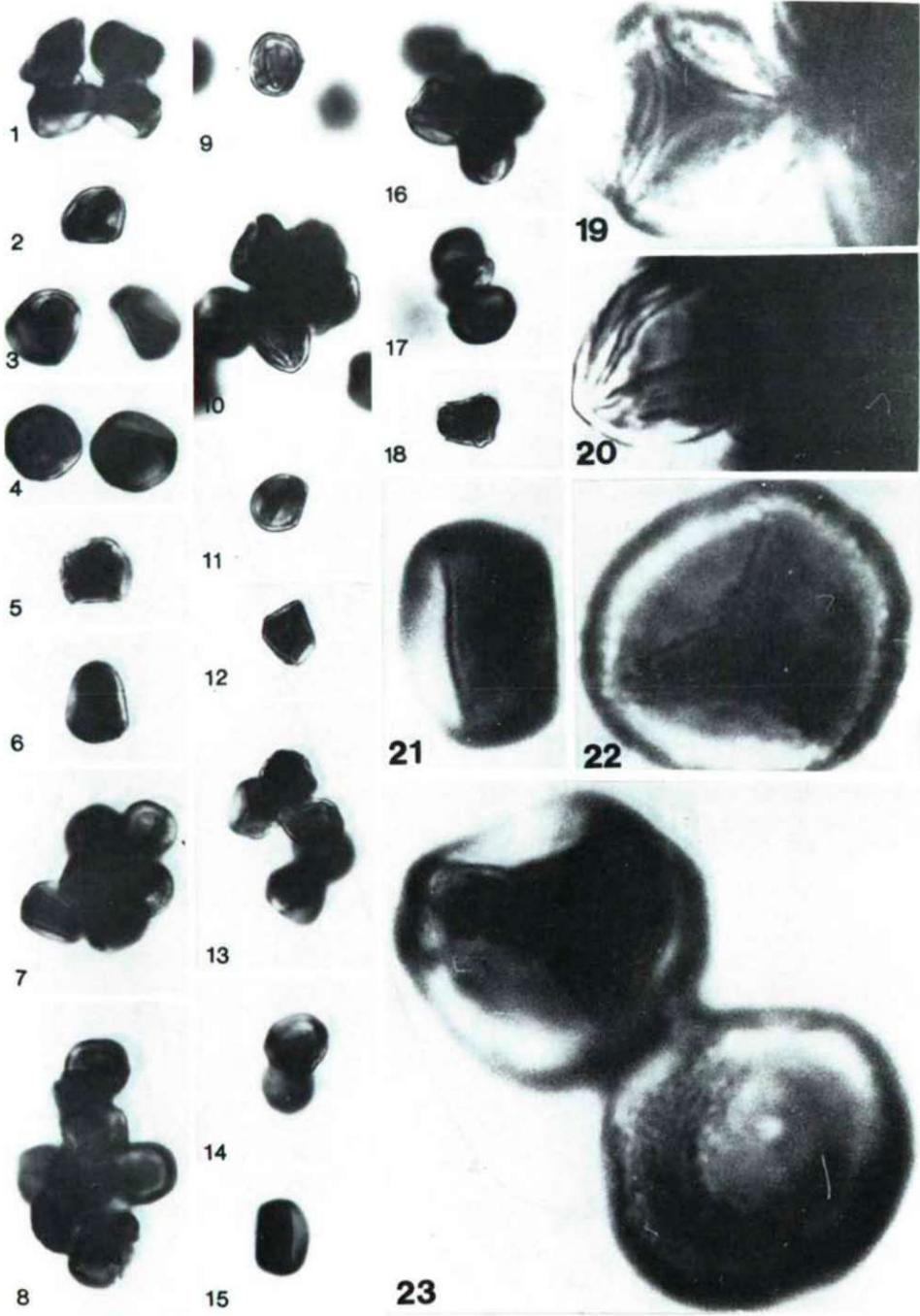


Plate IV

4. „Gramineoid-like” monoporate forms (Plate III, fig. 6, and plate IV, fig. 23, the lower right pollen grain).

As regards the changes in size, at this species the different dimensions of pollen grains are represented in text-figs 4, and 5. The basic data, e.g. the variation-statistical graph of the pollen grains without experiment are represented with thick line. Diameter from 17.24 μm to 31.03 μm , maximum, 35.0 per cent at 24.13 μm . The graph have a striking single maximum. At experiment No 479, two maximum values were established. Experiments No 480 and No 484 resulted in not conspicuous maxima, there are two higher values near of the same per cents, 31.5 resp. 33.0. At experiments 481, 482, 485, the maxima are on the same diameter, but the per cent values diminish nearly regularly; 55.0, 45.0, 37.5. It is also worth of mentioning that this size is identical with the smallest pollen grain from the non-experimental sample, 17.24 μm . Moreover this value is the same as the second maximum of experiment No 479. Experiments No 485—490 (text-fig. 5)

The maximum diameter values of the experiments of 15 and 20 hours (No 485, 486) are inside the minimum—maximum value distance of the non-experimental sample. We emphasize that the largest forms after heating at 30, 40, 50 and 100 hours are on the same value, which is identical with the smallest pollen grains of the basic non-experimental samples.

It may be mentioned, as an important phenomenon, that the great change in the diameter of the pollen grains happened between the experiments of 100 and 125 hours. The largest size, after heating for 125 hours is much more smaller than at 100 hours. In this way the point of separation of the non-experimental and experimental variation-statistical graphs is between 100 and 125 hours. It is also worth of mentioning that the experiment at 150 hours resulted in not so much news, the minimum/maximum values are identical. Regarding the characters of the variation-statistical graphs, not explicit maxima were observed at the experiments at 30, 100, and 150 hours. Finally, it is also important that the graphs of the experiments at 125 and 150 hours are distinct from all the previous ones.

Plate V

- 1—22. *Taxus baccata* L., recent.
 1. Pollen grains without stain and experiment.
 - 2—4. Pollen grains after experiment No 491.
 - 5—7. Pollen grains after experiment No 492.
 - 8—10. Pollen grains after experiment No 493.
 - 11—13. Pollen grains after experiment No 494.
 - 14—16. Pollen grains after experiment No 495.
 - 17—19. Pollen grains after experiment No 496.
 - 20—22. Pollen grains after experiment No 497.
- Magnification: $\times 1000$.

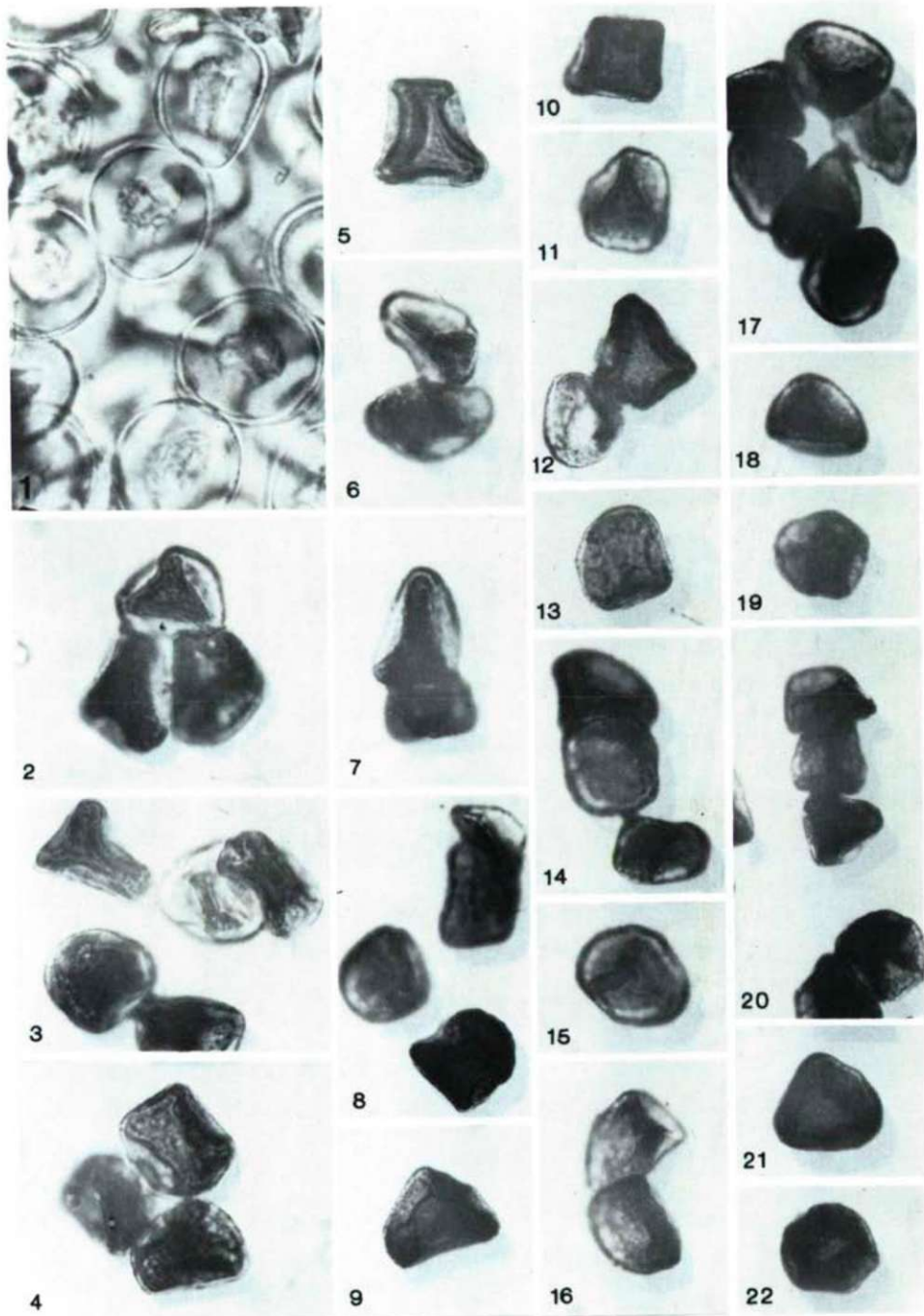


Plate V

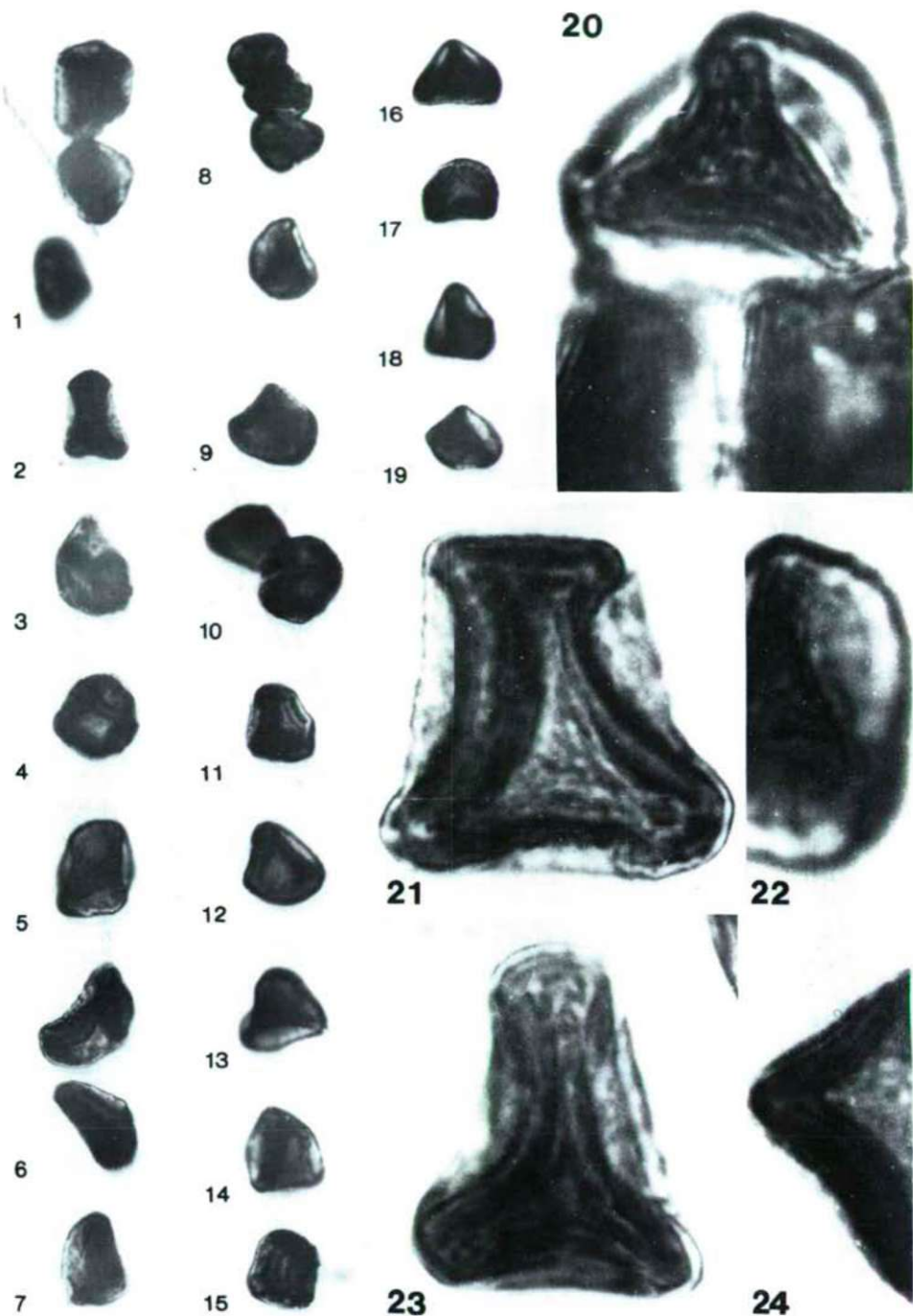


Plate VI

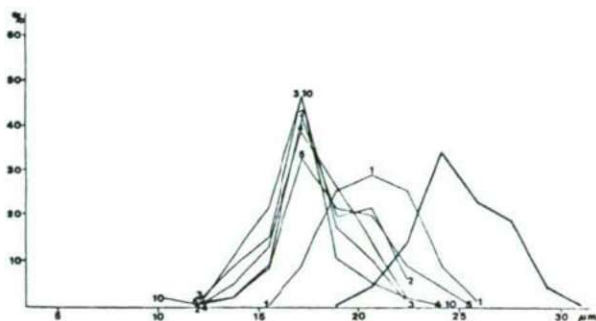
Plate VI

- 1—24. *Taxus baccata* L., recent.
1—3. Pollen grains after experiment No 498.
4—7. Pollen grains after experiment No 499.
8—11. Pollen grains after experiment No 500.
12—15. Pollen grains after experiment No 501.
16—19. Pollen grains after experiment No 502.
Magnification: $\times 1000$.
20. Enlarged part of photo 2, plate V;
experiment: No 491.
21. Enlarged picture of photo 5, plate V;
experiment: No 492.
22. Enlarged part of photo 11, plate V;
experiment: No 494.
23. Enlarged part of photo 3, plate V;
experiment: No 491.
24. Enlarged part of photo 12, plate V;
experiment: No 494.
Magnification: $\times 3000$.

Taxus baccata L. (Plate V, VI, text-figs 6,7)

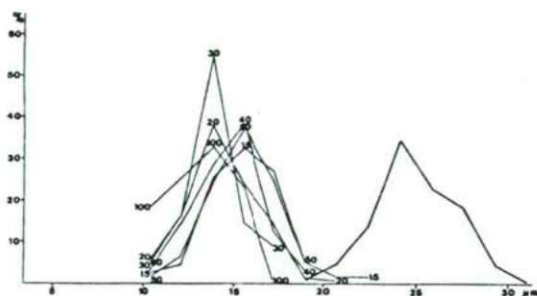
The fresh collected pollen grains without any treatment regarding their most important morphological characteristic features are identical with the previously discussed species. The qualitative changes in the morphological characteristic features in consequence of the experiments are also not so different from the pollen grains of *Juniperus virginiana* L. The most important secondary forms are almost exclusively plicate „Normapolles-like” types. These forms are in some cases really so similar to the early extinct brevaxonate pollen grains that at the fossil forms it is too difficult to distinguish the real angiosperm and the secondary forms of inaperturate gymnosperm pollen grains. At the terminal parts of the secondary plicae of our pollen grains pores or pseudopores may also occur (Plate V, fig. 2, plate VI, fig. 20, 23, etc.). Between these forms two types may be distinguished, the so-called „*Plicapollis* form” which is the most frequent, and the „*Interpollis* type” (Plate VI, fig. 24). So-called „tetraexitus form” was also observed (Plate V, fig. 4, 12, 13).

Our results concerning the quantitative changes in consequence of the experiments (text-figs 6, 7) may be summarized as follows:



text-fig. 6

Taxus baccata L., recent. Variation-statistical diagrams of the diameter of the fresh collected pollen grains. Graph with thick line represents the pollen grains without experiment, the other ones the results of experimental investigations on relatively short length of time. Numbers on the graphs indicate the length of time in hours of the experiments at 200 °C.



text-fig. 7

Taxus baccata L., recent. Variation-statistical diagrams of the diameter of the fresh collected pollen grains. Graph with thick line represents the pollen grains without experiment, the other ones the results of experimental investigations on relatively short length of time. Numbers on the graphs indicate the length of time in hours of the experiment at 200 °C.

The basic variation-statistical graph of the pollen grains, without experiment are represented as previously with thick lines. Diameter from 18.96 μm to 31.03 μm , maximum. 34.5 per cent at 24.13 μm . In this case the graph has a characteristic maximum. After heating at 200 °C during one hour, an important change may be established (text-fig. 6). The maximum of the graph is not so characteristic, there are two values (18.96, 22.41 μm) the same per cent, and the difference between these values, and the maximum is 3.50 per cent only. It is also worth of mentioning that the experiments during 2, 3, 4, 5, and 10 hours, at 200 °C have the maximum on the identical value of diameter (17.24 μm). The changes are not regular in contrast to

the previously investigated species. Pollen grains of the experiments of 3 and 10 hours are of the same per cent, this is followed by the 2, 4, and 5 hours. In this way in contrast to the diameter of the fresh material, remarkable change is at 1 hour of heating, the further ones, until 10 hours are near at the same variation-statistical value. The variation-statistical graph of the experiment during 15 hours is a little similar to those of 1 hour. Here also two values (13.79, 17.24 μm) are almost identical, and the differences in the maximum are 7.0 and 5.5 per cent. The maxima of the experiments of 40 and 50 hours is at this diameter. The two latter are near at the same value. Another group is the 30, 20 and 100 hours of experiments from the point of view of the maxima of the graphs. It is interesting that the minimum diameter is at the same value 13.79 μm . Changes in the per cents are irregular, they increase as follows: 50, 15, 40, 30, 20 and 100 hours. As regards the maxima of these experiments those during at 15 and 20 hours are in the dominion of the non-experimental pollen grains.

The maximum diameter of the experiments of 40 and 50 hours are at the minimum value of the non-experimental material. The separation of the graphs, in contrast to the previously mentioned species in between 50—100 hours.

Discussion

1. Concerning the new morphological characteristic features observed on the pollen grains of the recent *Ginkgo biloba* L., we may presume the following:

The connections between gymnosperm pollen grains in tetrad may be considered as an early morphological characteristic feature. TREVISAN (1971) described peculiar interconnections between the pollen grains of *Dicheiropollis etruscus* n.gen. et sp. from the Cretaceous layers of Tuscany, Italy. Similar connections between *Classopollis* pollen grains are represented in fig. 1, Plate X, and at the tetrad of *Callialasporites* in fig. 4, plate XII, by BALDONI and ARCHANGELSKY (1983). This early morphological characteristic feature was well elaborated by COURTINAT (1980) at the pollen grains of the genus *Classopollis* PFLUG 1953. The connections between the pollen grains were named as „pont”. The filaments in the triangular tetrad squar „brachyosomes”, when these filaments joint two pollen grains as „dolichosome”. The globular surficial elements around the triangular squareas „pleurospheres”. In this way the connections observed by us at the recent *Ginkgo biloba* L. may be analogues or identical with the „pont” of COURTINAT (1980). The spherical bodies around the apertural zone correspond to the „pleurospheres” those on the distal surface as „ataxospheres”. But taking into consideration the publication of TAYLOR and ALVIN (1984) concerning the exine ultrastructure evolution of the *Classopollis* type pollen grains, it may be presumed that these are orbiculi (Ubisch bodies). Till this time these morphological characteristic features were not observed at the recent and fossil Ginkgoalean pollen grains. Based on the fact that the monosulcate pollen type is earlier (Paleozoic) than the *Classopollis*, *Dicheiropollis* *Callialasporites* (Early Mesozoic) these primary and/or secondary morphological characteristic features are advanced.

The secondary angiospermid characteristic features at the recent pollen grains of the genera *Juniperus* and *Taxus* are also without doubt advanced characters. We presumed that the inaperturate pollen type (including the gymnosperm and angiosperm taxa) has more much phylogenetical importance as we previously believed.

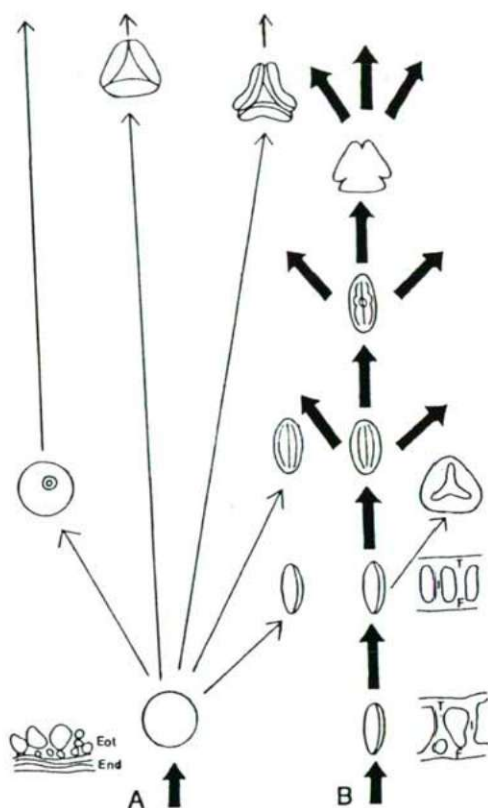
Regarding the methodological problems we must point as follows:

1. It seems that for the inaperturate pollen grains the high temperature effect experiments are in general elaborated, for LM observations. TEM studies must be projected later. The portion of the variation-statistical graphs seems to be important. This is really significantly different between the two species investigated (*Taxus baccata* L.: 50—100 hours, *Juniperus virginiana* L.: 125—150 hours).

2. It is probably important to investigate the changes within one hour, by 5 or 10 sec. This will be the subject of further methodical studies. But on the basis of our up-to-date knowledge, the most important changes in the morphological characteristic features which are important from taxonomical and phylogenetical point of view, appear after heating at 200 °C during one hour. Because this, for the first attempt this method was used at the pollen grains of *Ginkgo biloba* L. On the other hand, as it was emphasized earlier, the methods concerning the monosulcate forms or in general at the Longaxones pollen grains may not be taken as a settled, and completely elaborated problem. It seems that the methodical problems of the high temperature effect at the Longaxones gymnosperm and angiosperm pollen grains are much more difficult and different than at the inaperturate forms. Further sporomorph types (trilete, monolet spores, further gymnosperm, e.g.: saccate, and angiosperm pollen grains) are under elaboration in this respect. The spores with perine, and with elateres (*Equisetum*) are particularly interesting.

Our new results carried new supplements to the evolution of the angiosperm pollen grains (text-fig. 8). So, there are at least two early basic types, the monosulcate (+colpate), and the inaperturate. The heterogeneous origin of for example early brevaxonate pollen grains, and its great diversity in form, shape, sculpture, etc. It is also worth of mentioning that the angiosperm pollen grains in consequence of the high temperature effect resulted earlier forms and types in contrast to the present results of the gymnosperm pollen grains. The preliminary observations on the recent spores of *Equisetum arvense* L., and further Filicinae spores with perispore resulted that these spores lost the elateres, respectively the perispore. In this way earlier types appear. There is a number of problems to be solved in the future in this respect.

3. It is also worth of mentioning that at the fossil pollen grains, during the diagenesis secondary forms may appear. This problem was first investigated circumstantially at the spores, nearer the trilete-triplane-poroplane form-varieties (PFLUG, 1953) were believed as evolutionary lineage. Later, on the basis of the results on recent trilete spores it was established that these diversities may appear during the preparation method, or other influences (cf. DEÁK, 1959, KEDVES, 1960, 1961a, etc.). The form-varieties of further Schizaeaceae spores were described by KEDVES and JURAY (1968).



text-fig. 8

Scheme of secondary forms of the investigated inaperturate gymnosperm pollen grains important from the evolutionary point of view (A) in comparison with the „DOYLE' s scheme" (B) about the most important steps of the angiosperm pollen grains. The light microscopical data are completed by the most important TEM characteristic features.

4. Finally we need to emphasize that the effect of high temperature on the spores and pollen grains may not be confound with the harmomegathy established first by WODEHOUSE (1935), because in this case the changes of the turgescence and non-turgescence conditions are the subject of investigation. It seems that the results of further researches will be important in phylogenetical and taxonomical point of view of the sporology.

Acknowledgements

These researches were supported by the grant OTKA-2, 24/88.

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