

JURASSIC FLORAS OF THE USSR

V. A. VAKHRAMEEV

Geological Institute of the Academy of Sciences of the USSR, Moscow

TWO palaeofloristic areas were located on the territory of Eurasia during the Jurassic: Indo-European and Siberian. The first included Western and Central Europe, the southern regions of the USSR, India and China. During the Early and Middle Jurassic periods the boundary between these areas crossed Scandinavia, Southern Urals, and then passed north of lake Issyk-Kul.

Especially characteristic for the Indo-European area is a wide development of big horse-tails, ferns of the families Marattiaceae, Matoniaceae and Dipteridaceae and different Cycadales and Bennettitales. Ginkgoales and conifers were also abundant.

THE EARLY JURASSIC

The following provinces may be isolated in Early and Middle Jurassic within the Indo-European paleofloristic area: Middle Asian, Indian and East Asian provinces. The floras of Greenland, South Sweden, France, Italy, Germany, Rumania, Hungary, Poland, the Ukraine and Caucasus the author refers to the European province.

The European province is distinguished almost everywhere by the presence of *Lepidopteris ottonis* during the Rhaetian (some time ago *L. ottonis* was found in Donetz Basin) and by the representatives of *Thaumatopteris*, *Dictyophyllum* and *Phlebopteris* genera during the Lias. The *Cladophlebis* genus is represented, as a rule, by 2-3 species, usually *Cladophlebis denticulata*, *C. haiburnensis*. Almost in every one of the most important localities *Todites* is encountered side by side with *Cladophlebis*. *Coniopteris* is almost unknown (TEXT-FIG. 1).

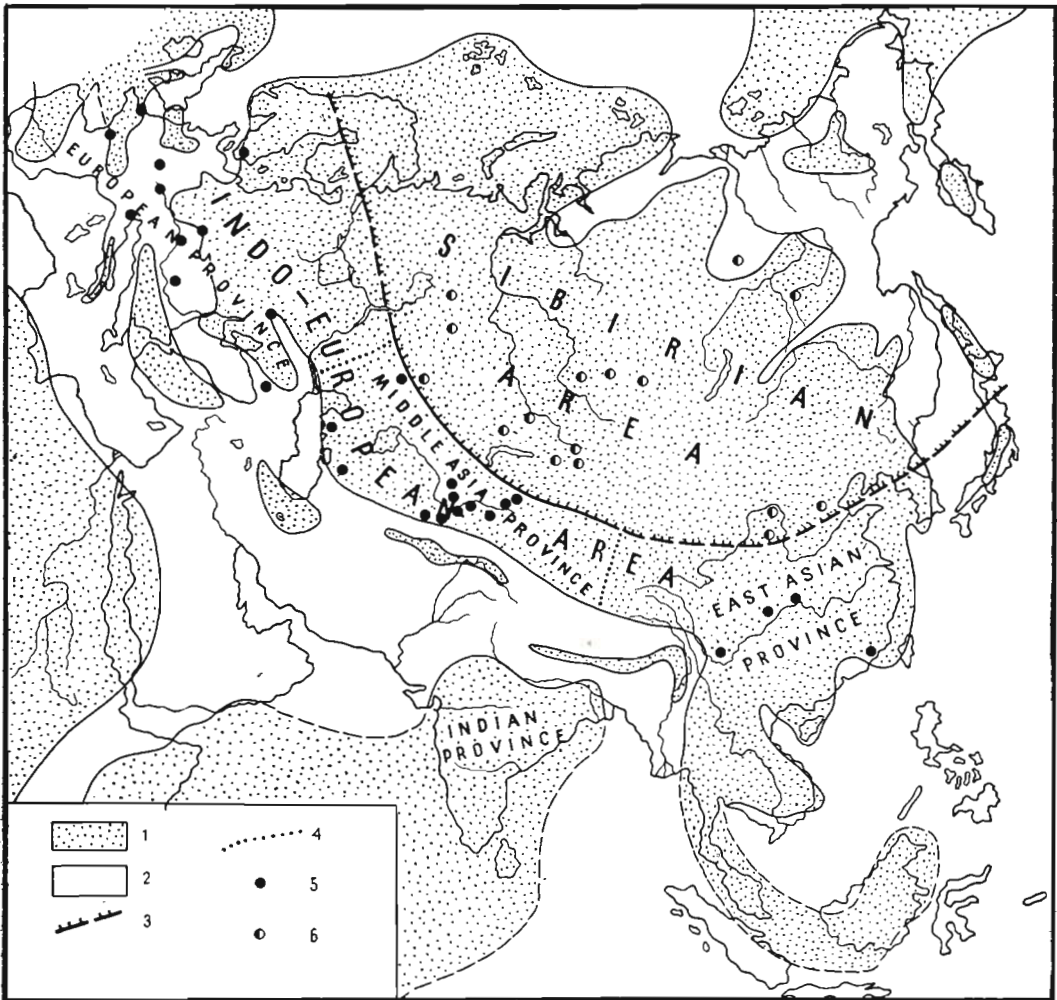
Among the Gymnospermae characteristic of the European province *Sagenopteris*, some pteridosperms (usually *Thinnfeldia*), *Brachyphyllum* and *Pagiophyllum* should be mentioned, as well as the less frequently encountered *Palyssia* and *Stachyotaxus*.

Cycadophyta are represented by several species of *Anomozamites*, *Otozamites*, *Nilssonia*, *Pterophyllum* and *Taeniopteris*; much less frequently *Ctenis* is encountered.

To the Middle Asian province the author refers the Liassic floras of Mangyshlak, Tuarkyr, the Guissar Range and Ferghana. The Liassic floras of the Middle Asian province differ from those of the European province in that *Thaumatopteris* and *Dictyophyllum* are less frequently encountered. The diversity of *Cladophlebis* sharply increases (up to 20 species). Side by side with such cosmopolitan species as *Cladophlebis haiburnensis*, *C. nebbensis*, *C. denticulata* such provincial species as for instance *Cladophlebis suluktensis*, *C. aktaschensis*, *C. bidentata*, *C. magnifica*, unknown or almost unknown in Europe, are widely spread. Another distinctive feature is the relative abundance of *Coniopteris*. While in the European province only solitary representatives of this genus are observed, among the floras of South and East Ferghana up to five species of *Coniopteris* are known. They are mostly represented by local provincial species: *Coniopteris angustiloba*, *C. lobata*, *C. porcina*, *C. spectabilis*. The constant presence of *Osmundopsis* found sporadically among the Liassic floras of Europe is highly characteristic.

Sagenopteris and *Thinnfeldia* have not been found so far among Gymnospermae. Cycadophyta are widely spread in the southern part of the province (South and East Ferghana, the Guissar Range), where diverse *Nilssonia* (up to 15 species) and several species of *Anomozamites*, *Pterophyllum*, *Ctenis*, *Taeniopteris* are known. The diversity of Cycadophyta speedily decreases to the northward. In the Middle Asian province Ginkgophyta show a greater diversity than in the European province: along with *Ginkgo-Sphenobaiera*, *Phoenicopsis* and *Czekanowskia* are widely spread here. In the upper part of the Lias the *Ferganiella* genus appears among the conifers. This genus is known only from the Middle Asian province and from Siberian areas.

During the Early Jurassic epoch the Siberian paleofloristic area included the whole of the Urals, Kazakhstan, the whole of the West and East Siberia and, evidently, the north-east part of China.



TEXT-FIG. 1 — 1. Land. 2. Sea. 3. Boundary between paleofloristic areas. 4. Boundary between paleofloristic provinces. 5. The main localities of Early Jurassic floras of Indo-European area. 6. The main localities of Early Jurassic floras of Siberian area.

The best known Liassic floras of this region are those of the Turghai, Cheljabinsk, Bogoslovsk, Chulym-Enisei, Kuznetsk and Kansk basins. In East Siberia Liassic floras are known only in the coal-bearing Lena and Aldan basins, but they are as yet insufficiently studied.

The principal distinctive features of the Liassic floras of the Siberian region are as follows: absence of many Dipteridaceae, diversity of *Cladophlebis*, frequent appearance of *Coniopteris* and -most essential of all abundance of Ginkgophyta and *Podozamites* and rarity of Cycadophyta. Among

Equisetales *Equisetites* are predominant; less frequent are *Neocalamites*. Dipteridaceae are represented here only by a number of *Clathropteris* and *Hausmannia*, and by the only species of *Dictyophyllum*. In the Lias of the Kuznetsk and Chulymo-Enisei basins Teslenko has recently detected *Phlebopteris polypodioides* and *Marattiopsis muensteri*; These forms, however, which are so common among the Liassic floras of the Indo-European area (especially in the European province) are very seldom found in some localities of the Siberian area.

Side by side with widely spread species of *Cladophlebis*, species of Middle Asian origin (*C. aktaschensis*, *C. bidentata*, *C. magnifolia*, *C. suluktensis*, etc.) are known. *Coniopteris* is observed mainly in the upper portion of the Lias. *Raphaelia* is widely spread only in the Middle and Upper Jurassic of the Siberian area and almost unknown among the floras of the Indo-European area makes its appearance here.

In the Lias of the Siberian area Cycadophyta are known only from occasional findings of *Pterophyllum*, *Nilssonina*, *Anomozamites* and *Taeniopteris*, represented by 1-2 species. Especially abundant are remains (leaves and sprouts) of Ginkgophyta—*Ginkgo*, *Sphenobaiera*, *Phoenicopsis*, *Czekanowskia* and in a lesser degree *Baiera*, as well as various reproductive organs — *Ixostrobus*, *Leptostrobus*, *Stenorachis* and seeds perhaps belonging to Ginkgophyta. Occasionally *Pseudotorellia* is observed. *Podozamites* and *Pitvophyllum* are most widely spread among conifers, *Elatides* and *Taxocladus* are less frequently encountered *Brachyphyllum* and *Pagiophyllum* are quite rare.

Within the Siberian area it is as yet difficult to isolate individual provinces both for the Early Jurassic and the Middle Jurassic epochs.

The Liassic floras of the Siberian area most closely approach the coeval floras of the Middle Asian province of the Indo-European area, since the majority of ferns and Ginkgophyta is represented here by common forms. In the Lias of the Kuznetsk basin A. Teslenko has detected a representative of the *Ferganiella* genus widely spread in the Lias of Middle Asia.

THE MIDDLE JURASSIC

In the course of the Middle Jurassic epoch the Indo-European and the Siberian paleofloristic areas occupied approximately the same territories as during the Lias. The character, however, of the Middle Jurassic flora suffered some alterations. The most intense changes took place among the floras of the Indo-European area.

Among the ferns the intensively flourishing *Coniopteris* are becoming a predominating group. The diversity of Dipteridaceae decreases slowly. The same refers to *Marattiopsis* and *Phlebopteris*. The number of the *Cladophlebis* species slightly decreases

and forms with large pinnules (*C. suluktensis*) disappear from among these. The first *Gleichenias* are encountered sporadically. *Eboracia lobifolia* and *Klukia marginata* are very frequently found (TEXT-FIG. 2).

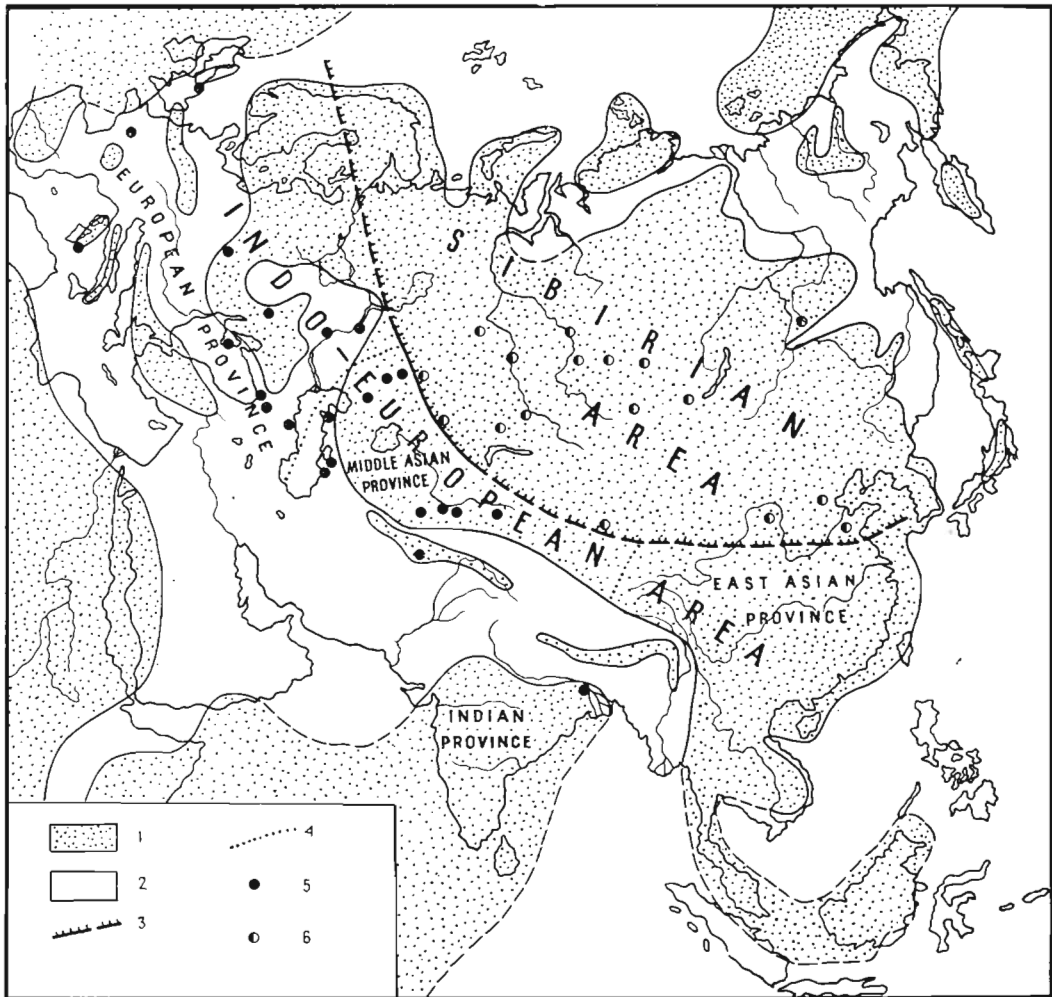
Among the Cycadophyta, *Nilssonias* are especially various and numerous. *Ptilophyllum* is widely spread. In some localities *Otozamites* is also encountered. Highly characteristic but rarely encountered *Pachypteris lanceolata* (evidently pteridospermous) makes its first appearance. The number of *Brachyphyllum* increases among the conifers towards the end of the Middle Jurassic.

The peculiar feature of the floras of the European province including those of West Ukraine, the Donetz Basin, the Crimea and Transcaucasia is as before the relative scarcity of Ginkgophyta. Findings of *Sphenobaiera*, *Phoenicopsis* and *Czekanowskia* are rare, more frequent are *Baiera* and *Ginkgo*. *Marattiopsis*, *Clathropteris*, *Dicthyophyllum*, *Thaumatopteris* and *Phlebopteris* are rather widely spread.

To the Middle Asian province I refer the Middle Jurassic floras of the Emba, the South Urals, Mangyshlak, Tuarkyr, Yagman, Guisar Range, Ferghana and Afganistan, the latter being link connecting the floras of the Middle Asian and Indian provinces.

They are distinguished by a great diversity and frequency of Ginkgophyta (including *Sphenobaiera* and *Phoenicopsis*) and by the presence of a number of Middle Asian species of *Coniopteris* (*C. angustiloba*, *C. furszenkoi*, *C. porcina*, *C. zindanensis*). As in the Liassic floras the variety and abundance of Cycadophyta decreases from the South to the North within the Central Asian province. While among the floras of Afganistan different species as *Ctenis*, *Pseudocycas*, *Ptilophyllum*, *Pterophyllum*, *Taeniopteris*, *Williamsonia* are detected side by side with various *Nilssonina* (9 species), among the floras of the South Urals only one species each of *Ctenis*, *Ptilophyllum* and *Taeniopteris* is known to be found together with *Nilssonina* represented here by 8 species.

The Middle Jurassic floras of the Siberian area are distinguished by a great uniformity. To these floras I refer floras of Turghai, West and East Siberia, Mongolia and North-East China. In these floras *Neocalamites*, *Clathropteris* and *Phlebopteris* are very rare. Widely spread are various *Coniopteris* (*C. hymenophylloides*, *C. maakiana*, *C. burejensis*)



TEXT-FIG. 2 — 1. Land. 2. Sea. 3. Boundary between paleofloristic areas. 4. Boundary between paleofloristic provinces. 5. The main localities of Middle Jurassic floras of Indo-European area. 6. The main localities of Middle Jurassic floras of Siberian area.

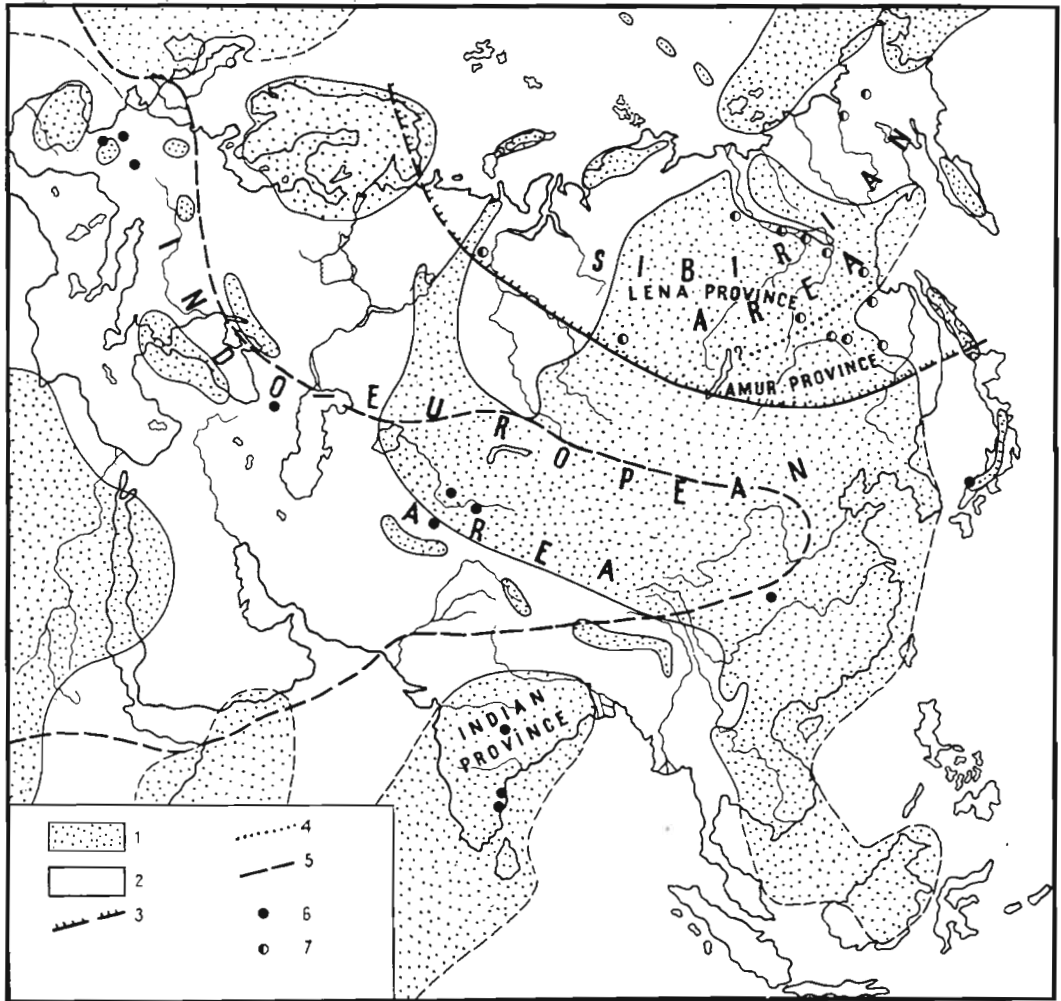
and *Raphaelia diamensis*, which together with Ginkgophyta and such conifers as *Podozamites* and *Pityophyllum* predominated among the Middle Jurassic floras of the Siberian area.

The most widely spread Ginkgophyta species encountered in great abundance throughout the three divisions of the Jurassic of Siberia are as follows: *Ginkgo digitata*, *G. huttonii*, *G. sibirica*, *Sphenobaiera longifolia*, *S. pulchella*, *Phoenicopsis angustifolia*, *P. speciosa*, *Czekanowskia rigida*. The most widely spread conifers are different *Podozamites* and *Pityophyllum*. Cycado-

phyta are represented by *Nilssonia* and occasional findings of *Anomozamites*, *Ctenis*, *Pterophyllum*, *Tyrnia* and *Taeniopteris*. The representatives of *Otozamites*, *Zamites*, *Cycadites*, *Dictyozamites* and *Sphenozamites* were not found in Jurassic floras of Siberia.

THE LATE JURASSIC

With the beginning of the Late Jurassic epoch the climate became more arid over a considerable part of the Indo-European region resulting in the cessation of the



TEXT-FIG. 3 — 1. Land. 2. Sea. 3. Boundary between paleofloristic areas. 4. Boundary between palaeofloristic provinces. 5. Boundary of zone of arid climate. 6. The main localities of the Late Jurassic floras of Indo-European area. 7. The main localities of Late Jurassic flora of Siberian area.

coal-bearing bed formation and in the appearance of red beds and locally of gypsum bearing deposits devoid or practically devoid of plant remains. The development of coal-bearing deposits continued only in India. The aforesaid serves to explain the rarity of Upper Jurassic foliated flora occurrences within the Indo-European area, which are known so only in Scotland, France, Caucasus, South Kazakhstan, Guissar Range and India.

These floras are rather heterogeneous, which might be explained by climatic differences in different parts of the region

(more or less arid or humid). Thus, for instance the flora of Scotland occurring near the northern margin of the Indo-European area north-ward of the zone of arid climate, is rich in various ferns, while among the floras of France and South Kazakhstan, situated inside the arid climate zone predominate Cycadophytes. The majority of Cycadophyta possessed coriaceous leaves with a well-developed cuticle. *Nilssonia* is encountered only occasionally. Among conifers *Brachyphyllum* and *Pagiophyllum* are abundant. Ferns are rare and *Ginkgophyta* are very rare. *Dictyophyllum*, *Thaumatopteris*,

Clathropteris completely disappear from among the Late Jurassic floras of the Indo-European area. Widely spread is also *Pachypteris lanceolata* found recently in the lowermost portions of the Upper Jurassic of Caucasus and the Guissar Range. By means of sporepollen analysis a noticeable predominance of pollen *Classopollis* connected with the *Brachyphyllum* and *Pagiophyllum* genera has been revealed in the Upper Jurassic of the European part of the USSR, the Caucasus, Kazakhstan and the southern part of the West Siberia. Abundant sprout imprints of these conifers are encountered in many deposits. The data available are as yet insufficient for individual characteristics of the floras of the European and Middle Asian provinces (TEXT-FIG. 3).

Late Jurassic floras within the Siberian area are known chiefly in East Siberia. At the eastern slope of the North Urals plant remains have been detected in the lowermost portions of the Upper Jurassic.

While continuing to develop under conditions of a humid and moderately warm climate which existed here during the earlier epochs of the Jurassic period, the Late Jurassic floras of the Siberian area were only slightly different in character from those of the Middle Jurassic. In East Siberia a number of new species of *Cladophlebis* appeared (*C. aldanensis*, *C. laxtipinnata*, *C. orientalis*, *C. serrulata*). Of these *C. aldanensis* should be noted especially: it possessed large pinnules highly similar to certain Liassic forms. Different *Coniopteris* are encountered in great abundance. As before, Ginkgophyta and ancient conifers (*Podozamites* and *Pityophyllum*) remain predominant together with ferns. Among the floras of the south-eastern marginal part of the Siberian region (the Amur River

and partly in Yakutia, the variety of Cycadophytes are encountered. Among them some new genera as *Heilungia*, *Butefia*, *Bureja* are appearing.

With the development of an arid belt southwards of the Siberian area, the southern boundary of the humid, moderately warm zone, and at the same time that of the Siberian paleofloristical area slightly shifted to the North.

The moderately warm and humid character of the climate of Siberian area with an alteration of warmer and colder seasons is confirmed beyond any doubt by the presence of annual rings in the wood, the shedding of the leaves and sprouts by Ginkgophyta and by certain conifers (*Phoenicopsis*, *Czekanowskia*, *Podozamites*, *Pityophyllum*).

It would be important to note also the fact that ferns of the Dipteridaceae, Matoniaceae and Marattiaceae families characteristic of the Indo-European area have not been developed to any extent in the Siberian area. At the present time ferns of families remain chiefly in the zone of tropical humid climate. The same refers to Cycadophyta (Bennettiales and Cycadales) which have been sparse in the Siberian area and abundant in the Indo-European area. Cycadales which continued to exist till the Recent epoch are developing at present only in zones of tropical and subtropical climate.

It is known also that at present the diversity of plant species and especially trees in tropical and subtropical forest is much greater than in the woods of the moderate zone. The Early and Middle Jurassic floras of the Indo-European area included over 120 genera represented by more than 500 species, which is nearly double the corresponding number of genera and species known in the Siberian area.