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Diversity of palmately lobed leaves in the early–middle Albian of eastern Russia

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ABSTRACT

Diversity of palmately lobed leaves of angiosperms of the early–middle Albian floras of the Kolyma River Basin, the Omsukchan Coal Basin, Khabarovsk and Primorye Regions was studied. Leaf fossils, previously compared with those of genera *Aralia, Sassafras* and *Lindera*, now reassigned to the fossil genus *Araliaephyllum*. Four new combinations and one new species are published: *A. kolymense* (Kryshtofovich) Golovneva, comb. nov., *A. luciferum* (Kryshtofovich) Golovneva, comb. nov., *A. ussuriense* (Krassilov) Golovneva, comb. nov., *A. ievlevii* (Samylina) Golovneva, comb. nov., and *A. popovii* Golovneva, sp. nov. The type material has been restudied in detail, and lectotypes have been selected to all newly typified species. These species share many lauralean morphological and venation features. They represent the most likely early members of this group. This relationship is based on detailed study of the leaf architecture and comparison with other fossils with studied epidermal features. This study expands our knowledge of radiation and biogeography patterns of early angiosperms in northeastern Asia.

1. Introduction

In eastern Russia angiosperm megafossils were firstly recorded in the Barremian–Aptian (Krassilov, 1967, 1997; Vakhrameev and Kotova, 1977; Bugdaeva and Markevich, 2012; Volynets and Bugdaeva, 2017). By the early–middle Albian this group extended across all Siberia from Kolyma River Basin and Yakutia to Primorye and Khabarovsk Regions (Kiritchkova and Budantsev, 1967; Krassilov, 1967; Samylina, 1968, 1976; Lebedev, 1974).

The Early Cretaceous floras of eastern Russia are assigned to the Siberian-Canadian floristic realm (Vakhrameev, 1991). This realm was characterized by humid temperate or warm temperate seasonal climate and by predominance of deciduous forests consisted of conifers, ginkgophytes, and czekanowskialeans. Open fern communities were developed mostly on periodically flooded areas of river valleys, and coastal plains. The angiosperm remains occur extremely rarely and irregularly in deposits preceding the upper Albian. Most species are represented by single or by few specimens. Usually angiosperm leaves are characterized by small sizes, up to 1–4 cm. This suggests predominance of herbaceous and shrubby life forms. There were few or no common species and few common genera of angiosperms from different regions, so that by this time, they already had attained a high taxonomic diversity. The diversity of leaf morphotypes is also rather high, ranging from entire leaves with palmate craspedodromous or pinnate festooned brochidodromous venation, to dissected leaves, palmate or pinnate.

Investigation of the early–middle Albian angiosperms provides important new data for our understanding of the early radiation of this group. In this paper the systematic position and relationships of species with palmately lobed leaves are revised, based on detailed analysis of the venation patterns. Besides that, we also improve the data about stratigraphic position and age of these fossils.

First records of the trilobate leaves from the lower–middle Albian deposits of eastern Russia have been described in the middle of 20th century (Kryshtofovich, 1929, 1938; Krassilov, 1967; Samylina, 1968) and assigned to the extant genera *Aralia, Sassafras*, and *Lindera*. Modern application of detailed analysis of venation patterns and epidermal anatomy shows, that many of the early identifications, based on direct, taxonomic comparisons between extant and fossil angiosperm foliage, were incorrect (Upchurch, 1984; Friis et al., 2011). N.N. Imkhanitzkaya (1968) transferred part of the Cretaceous trilobate species to the new genus *Sachalinella* Imchanitzkaja, which she related to Araliaceae. However, the characters of the genus *Sachalinella* are practically identical to those of the genus *Araliaephyllum* Fontaine. The type species *A. obtusilobum* Fontaine was described from Lower Cretaceous

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deposits of the Patapsco Formation (Potomac Group), Virginia, eastern United States (Fontaine, 1889). The name *Araliaephyllum* appears to be more suitable for our material, as having priority. After revision of previous data and detailed study of the type material, we suggest four new combinations of *Araliaephyllum*: *A. kolymense* (Kryshtofovich) Golovneva, comb. nov., *A. luciferum* (Kryshtofovich) Golovneva, comb. nov., *A. ussuriense* (Krassilov) Golovneva, comb. nov., and *A. ievlevii* (Samylina) Golovneva, comb. nov. One new species *A. popovii* Golovneva, sp. nov. is also described.

2. Material and methods

Araliaephyllum kolymense comes from the Buor-Kemyus Formation, distributed in the Zyryanka coal field between the Ozhogina and Zyryanka rivers in the middle part of the Kolyma River Basin (Fig. 1). The first specimens of *Araliaephyllum kolymense* were collected by geologists V.A. Zimin and P.N. Ushakov in 1933–1935 from the Zyryanka River. Their exact locality is unknown. They were described by A.N. Kryshtofovich (1938) as *Aralia kolymensis* and now are stored in the Central Scientific-Research Geological Exploration Museum (CNIGR Museum), St.-Petersburg (collection 5593). Additional specimens were collected by G.G. Popov and V.A. Samylina in 1957 in exposure at the left bank of the Zyryanka River above mouth of the Melegey Creek. They are housed at the Laboratory of paleobotany of the Komarov Botanical Institute of the Russian Academy of Sciences (BIN), St.-Petersburg (collection 508).

Araliaephyllum luciferum and *A. ussuriense* come from Lower Cretaceous deposits of the Partizansk Coal Basin in Primorye (Far East of Russia). Specimens of *A. luciferum* were discovered by geologist M.A. Pavlov in 1927 (Kryshtofovich and Pavlov, 1928) at the left bank of the Postyshevka River (previously Malaya Sitza River) near Novoveselaya village (now the territory of Partizansk city). There are four leaf impressions from 1.5 to 3.4 cm in length on one piece of rock. It was found in the Velikan (Giant) coal layer, the Severosuchan Formation. This specimen was described by Kryshtofovich (1929) and, at present time, it is stored in the Central Scientific-Research Geological Exploration Museum (collection 3031). Leaves of *A. ussuriense* were found on northern shore of the Palets Cape (eastern coast of the Ussuri Bay) in the black siltstones of the upper part of the Severosuchan Formation (previously the Frenzevo Formation) (Krassilov, 1967). Material is kept in the Institute of Botany and Soil Science (IBSS), in Vladivostok.

Unlike other early angiosperm, *Araliaephyllum ievlevii* was widely distributed in many lower–middle Albian localities of eastern Asia. We found the remains of this species in the deposits of the Omsukchan Coal Basin, the Torom Trough and the Bureya Coal Basin.

The type material was described from the Omsukchan Coal Basin, which is situated in the upper reaches of the Kolyma River between the Sugoy and Balygychan rivers (Fig. 1). Angiosperm remains were collected by the geologists S.I. Filatov and L.V. Ievlev and by paleobotanist V.A. Samylina. Leaves of *Araliaephyllum ievlevii* are characterized by significant variability from narrow and lanceolate to widely ovate and lobate. They were assigned by Samylina (1968, 1976) to several species and genera. Material is stored in the Komarov Botanical Institute (BIN) in St.-Petersburg (collection 511, 513, and 517).

A great number of *Araliaephyllum ievlevii* specimens was collected from the deposits of the Tyl' Formation that allows studying its shape variation and assigned all fossils to the same species. It was described previously by Lebedev (1974) as *Lindera jarmoljukii* E. Lebedev. The Tyl' Formation is distributed in the Torom Trough, which is located at the territory of Khabarovsk Region (Fig. 1). The locality is situated in the upper part of the Tyl' River Basin, in interfluve area between Tyl' River and Ilinurek-Makit

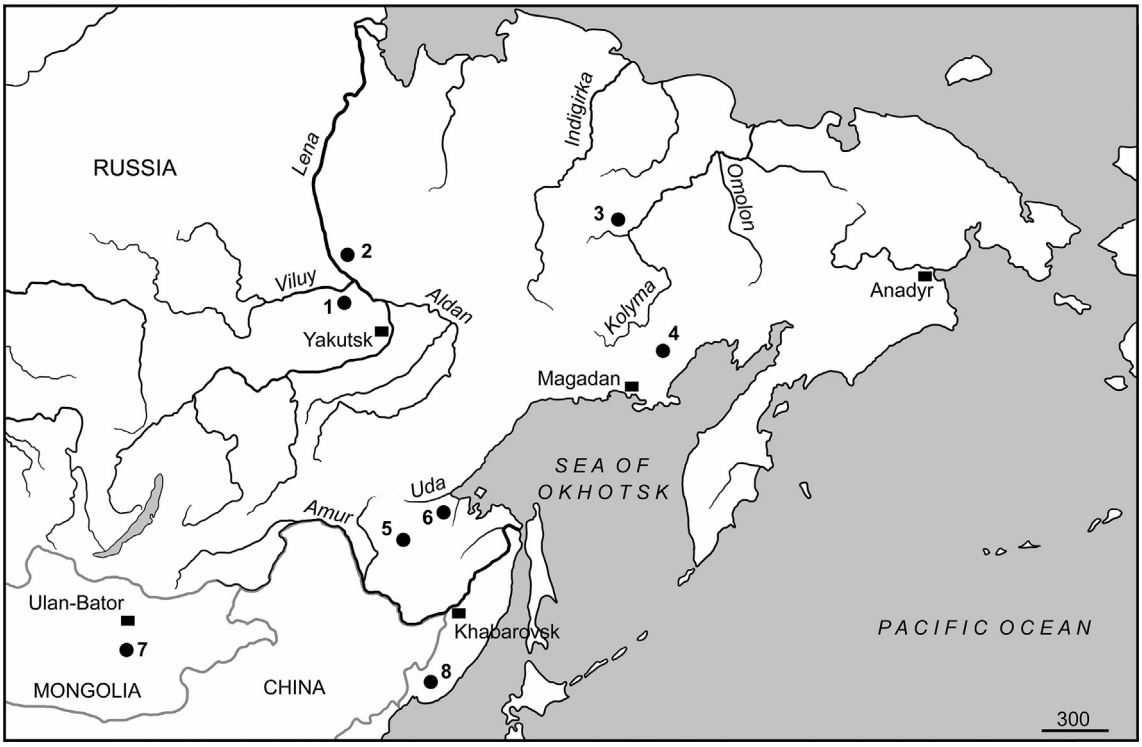

Fig. 1. Localities of early–middle Albian angiosperms in eastern Russia and Mongolia: 1 – Viluy River basin; 2 – Lampesce River; 3 – Zyrynka River basin, the Buor-Kemyus Formation; 4 – Omsukchan coal basin, the Aigur and Toptan formations; 5 – the Bureya coal basin, the Kyndal Formation; 6 – Tyl' River basin, the Tyl' Formation; 7 – Central Mongolia, the Barunbayan Formation; 8 – Partizansk coal basin, the Severosuchan Formation.