

THE GENUS *JUNIPERUS* L. (CUPRESSACEAE)
IN THE BULGARIAN CENOZOIC FLORA

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Abstract

A new find of *Juniperus* aff. *drupacea* from the Satovcha Middle Miocene flora connects the previously known levels of stratigraphic distribution of this taxon in Bulgaria. This find is a stratigraphic missing link between the Lower Oligocene and Upper Miocene-Lower Pliocene, specifically its presence in the Middle Miocene. Data on the distribution of the genus *Juniperus* on the territory of Bulgaria during the Paleogene and Neogene are presented and compared with the data on its distribution today. Out of six taxa established in fossil state, species *J. communis*, *J. excelsa*, and *J. oxycedrus* are found even today on the territory of Bulgaria.

Key words: Bulgaria, *Juniperus drupacea*, Middle Miocene, Oligocene, Pliocene, Satovcha

Introduction. The Satovcha Graben is located on the southern slopes of the Western Rhodopes (SW Bulgaria) and unfolds to the east of Satovcha village, in Blagoevgrad District (Fig. 1). The Sivik Formation is a part of this Graben and it is characterised by the presence of numerous plant fossils. Its macroflora is the richest local palaeoflora in Bulgaria, with over 130 fossil taxa from the Equisetophyta, Polypodiophyta, Pinophyta and Magnoliophyta (Magnoliopsida and Liliopsida). The first taxonomic data referring to Satovcha palaeoflora were presented by STEFANOV and GANTSHEV [1], but the consecutive research in this aspect was conducted within the period of 1991–2000 [2]. Palaeofloral, palaeoecological and phytogeographical analyses were also published [3]. Data relating to

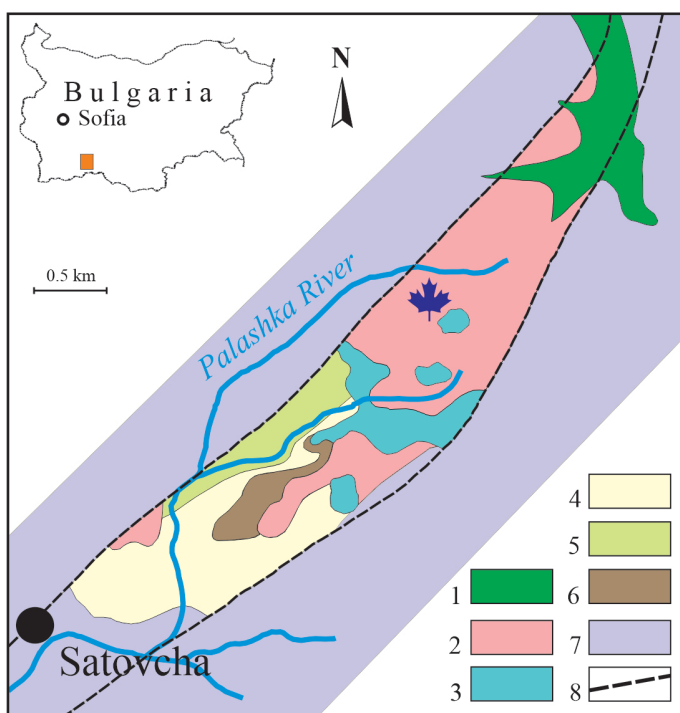


Fig. 1. Geological map of the Satovcha Graben (after [5]) and the location of the fossil site. Legend: 1. Breccia and conglomerates (Quaternary). 2. Sivik Formation (Miocene). 3. Rhyolites and Rhyodacites (Oligocene). 4. Satovcha Formation (Oligocene). 5. Stamatitsa Member of Satovcha Formation (Sands). 6. Palashka Member of Satovcha Formation. 7. Bedding of Satovcha Formation (Proterozoic metamorphic rocks). 8. Faults

the composition of this palaeoflora have recently been published by IVANOV [4]. These data are based on palynological analysis and bring additional information. As for the age of the Sivik Formation which includes the macroflora, VATSEV and PIRUMOVA [5] have identified it as Middle-Late Miocene based on its diatom flora. Once again, OGNJANOVA-RUMENOVA [6] has determined the age of the top layers of the Sivik Formation in the Belite Bregove area as Late Miocene, based on analysis of the diatom assemblages. BOZUKOV [7] used the total macroflora content of the Formation, to determine its Middle Miocene age. Based on the above, we assume that the age of the studied new fossil material is Middle Miocene. The species richness of this paleoflora is a prerequisite for the discovery of new taxa, as is the case described here.

Material and methods. The new fossil material consists of one imprint of a needle-like leaf on a fragment of diatomaceous rock. The specimen is kept in the paleobotanical collection of the Institute of Biodiversity and Ecosystem Research

at the Bulgarian Academy of Sciences under No Sat.-4618. The determination of the fossil material was made on the basis of the macroscopic morphological features of the imprint (ichnophytological method). The recent species of the genus *Juniperus* cited here follows FARJON [8]. The fossil material was photographed with a Panasonic DC-FZ82 camera.

Results.

Division Pinophyta

Family Cupressaceae Bartlett

Genus *Juniperus* L.

Juniperus aff. *drupacea* Labill.

1935. *Arceuthos* aff. *A. drupacea* Antoine & Kotschy; Stefanoff & Jordanoff, p. 25, Pl. 5, Figs 2–3; Fig.–text 23.

1967. *Juniperus* cf. *drupaceae* Labill. foss.; Palamarev, p. 92.

Material: A leaf imprint No Sat.-4618 (Fig. 2-A).

Comments. STEFANOFF and JORDANOFF [9] describe in detail fossil material that originates from sediments of Late Pontian – Early Dacian (= Messinian – Early Zanclean) age near the village of Podgumer (Sofia Basin) and which they identified as *Arceuthos* aff. *A. drupacea* Antoine & Kotschy (Fig. 2-B). PALAMAREV et al. [2] revise this view as *Juniperus* sp. aff. *J. drupacea* Labill. foss. We will use the combination *Juniperus* aff. *drupacea*, because it is sufficiently informative and means a taxon related to the recent *J. drupacea*.

The material studied by us has almost complete similarity with the morphological features of the one described by Stefanoff and Jordanoff [9]. The only difference is the 4 mm longer leaf length of the Satovcha specimen. This difference in leaf length is within the variability of this species [8] and is not significant. According to Farjon [8], the longer leaves of this species have an ovate-lanceolate shape (Fig. 2-C), while the shorter ones are narrowly ovate (boat-shaped), as indeed are those of Satovcha and Podgumer (Fig. 2-A, B).

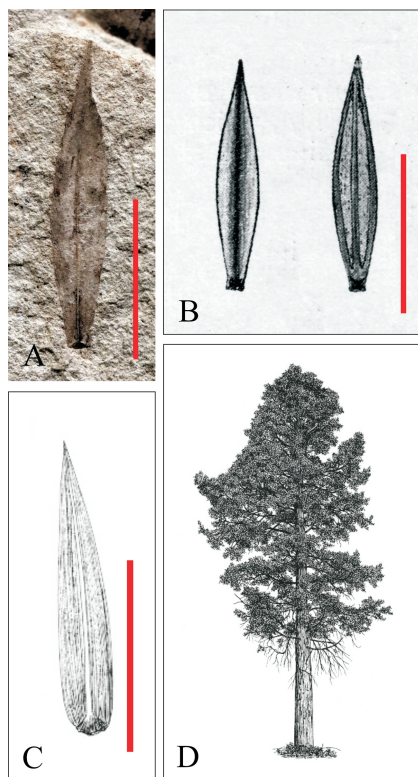


Fig. 2. A – *Juniperus* aff. *drupacea*, Sat-4618; B – *Juniperus* aff. *drupacea* (sub nom. *Arceuthos* aff. *A. drupacea* in [9]); C – *J. drupacea* (leaf) after [8]; D – *J. drupacea* (habitus) after [8]

Juniperus aff. *drupacea* is the only representative of the genus in the Bulgarian fossil flora, which was established during the Paleogene [2].

Location and stratigraphical range: Brezhani (Goreshtitsa Formation, Lower Oligocene); Satovcha (Sivik Formation, Middle Miocene); Podgumer (Novi Iskar Formation, Upper Pontian-Lower Dacian = Messinian-Lower Zanclean).

Discussion. Three of the *Juniperus* taxa listed in Table 1, are found on the territory of Bulgaria today as modern species. These are *J. communis* L., *J. excelsa* M. Bieb. and *J. oxycedrus* L. Two other taxa that are present in Table 1, have nearest living relatives that are distributed in the southern parts of the

T a b l e 1

Fossil Genus *Juniperus* taxa established in Bulgaria by leaf imprints, their geographical and stratigraphic distributions and references. (L – Lower, M – Middle, U – Upper)

Taxa	Locality	Stratigraphy	References
<i>Juniperus</i> aff. <i>drupacea</i>	Brezhani (Pirin Basin)	L Oligocene, Goreshtitsa Formation	Palamarev [18]
	Satovcha (Satovcha Graben)	M Miocene, Sivik Formation	<i>hoc loco</i>
	Podgumer (Sofia Basin)	U Miocene – L Pliocene (U Pontian – L Dacian = Messinian – L Zanclean), Novi Iskar Formation	Stefanoff, Jordanoff [9]
<i>Juniperus</i> sp. aff. <i>J. foetidissima</i>	Podgumer (Sofia Basin)	U Miocene – L Pliocene (U Pontian – L Dacian = Messinian – L Zanclean), Novi Iskar Formation	Stefanoff, Jordanoff [9]
<i>J. oxycedrus</i>	Podgumer (Sofia Basin)	U Miocene – L Pliocene (U Pontian – L Dacian = Messinian – L Zanclean), Novi Iskar Formation	Stefanoff, Jordanoff [9]
<i>J. brevifolia</i> foss.	Podgumer (Sofia Basin)	U Miocene – L Pliocene (U Pontian – L Dacian = Messinian – L Zanclean), Novi Iskar Formation	Kitanov [10]
<i>Juniperus</i> sp. aff. <i>J. communis</i>	Gaber (Beli Breg Basin)	U Miocene – L Pliocene (U Pontian – L Dacian = Messinian – L Zanclean), Kaisiynitsa Formation	Bozukov et al. [13]
	Lozenets (Sofia Basin)	U Pliocene (Romanian = Piachencian), Lozenets Formation	Kitanov, Nikolova [19]
<i>J. excelsa</i>	The Opera (Sofia Basin)	U Pliocene (Romanian = Piachencian), Lozenets Formation	Kitanov [20]

Balkan Peninsula. These are *J. drupacea* Labill. and *J. foetidissima* Willd., found in southern Greece, which is the northern limit of their range. Only *J. brevifolia* Antoine is a species that does not occur in continental Europe, as it is an Azores endemic. This species is of particular importance because it is restricted to humid subtropical conditions.

According to Farjon [8] the altitudinal range of *J. brevifolia* is 240–800 m a.s.l. and the prevailing SW winds in the Azores set the conditions for a moist but mild climate with abundant rain and fog. Accordingly, its fossil form *J. brevifolia* foss., which was established by KITANOV [10] in the Podgumer paleoflora, is of particular importance because it is an indicator of the presence of such climatic conditions and, accordingly, of subtropical elements in the paleoflora.

It is necessary to mention that in the paleofloras of the Late Miocene age from Garmen (Gotse Delchev Basin) (Pontian = Middle Tortonian – Messinian) [11] and Late Miocene – Early Pliocene (Late Pontian – Early Dacian = Messinian – Early Zanclean) from Podgumer [9,10], Kurilo (Sofia Basin) [12] and Gaber (Beli Breg Basin) [13] there are also other species attached to subtropical conditions, such as representatives of the families Lauraceae, Magnoliaceae, Myricaceae, etc. It can be argued that *J. brevifolia* foss. existed in communities similar to today's in the Azores, in which species of the genera *Laurus*, *Persea*, *Myrica*, *Ilex* participate [8], because such species are also recorded in the palaeofloras of Podgumer, Garmen and Gaber [9–11,13]. Due to the scarce amount of subtropical element fossils, compared with the abundance of arctotertiary elements in these paleofloras, it can be assumed that the paleotropical element increasingly lost its importance during the Miocene-Pliocene transition [14].

The taxon *Juniperus* aff. *drupacea* established here is new to the Middle Miocene flora from Satovcha. On the territory of Bulgaria, other relevant taxa have been registered in the Lower Oligocene and Upper Miocene-Lower Pliocene (Table 1). With the new finding of *Juniperus* aff. *drupacea*, the missing link of its stratigraphic distribution, namely the Middle Miocene, is established. Since the taxon was not recorded in a higher stratigraphic level on the territory of Bulgaria, and today *J. drupacea* is distributed in southern Greece, it can be assumed that after the Early Pliocene the taxon migrated to the south. There it exists today in a Mediterranean climate (Csa by [15]) similar to the subtropical one (Cfa by [15]), while in Bulgaria after the Early Pliocene, a continental climate (Dfb by [15]) was gradually established. These facts give an indication of migration of *Juniperus* species linked to climate change. So the modern species *J. drupacea* is distributed in the Eastern Mediterranean region from southern Greece, southern Turkey, western Syria, and Lebanon. The altitudinal range is from 600 m to 1800 m a.s.l. where the climate is Mediterranean, with winter rain, sometimes snow, and dry, hot summers [8].

In addition to the fact that the new find enriches the taxonomic composition of the Satovcha paleoflora, it also confirms the presence of subxerophytic forest

and shrub paleocenoses, which have left traces in the flora-bearing sediments in the area of the village of Satovcha [3]. These paleocenoses have a very limited distribution in the mentioned paleoflora, because they developed in the conditions of the middle Miocene climatic optimum and the existence of subxerophytic paleocenoses was possible with very rare combinations of relief and water regime. The presence of *Juniperus* aff. *drupacea* is an important fact confirming their existence and their relationship with some modern Mediterranean mesoxerophyte coastal communities [3].

According to Farjon [8] *J. drupacea* is a tree usually 10–15 m tall (Fig. 2-D), sometimes a shrub, and occurs in Eastern Mediterranean in mixed (low) montane conifer forest and woodland with *Pinus brutia* Ten., *P. nigra* J.F. Arnold, *Abies cephalonica* Loudon, *A. cilicica* Carr., *Cedrus libani* A. Rich., *Juniperus excelsa*, *J. foetidissima*, *J. oxycedrus*, *Quercus coccifera* L., *Q. Ilex* L., and more rarely with *Fagus orientalis* Lipsky. Although *Juniperus* aff. *drupacea* is not found in the Gaber, Garmen, and Kurilo palaeofloras [11–13], they are comparatively synchronous with the Podgumer palaeoflora, including parts of Pontian (= Middle Tortonian - Messinian) all of them. In general these palaeofloras include fossil taxa related to the recent *Fagus orientalis*, *Juniperus excelsa*, *J. foetidissima*, *J. oxycedrus*, *Pinus brutia*, *Quercus coccifera*, *Q. Ilex* [9–13], i.e. most of the species with which *Juniperus drupacea* is found with today in the above-mentioned eastern Mediterranean communities. This is another proof of the migration of species and types of phytocenoses under the influence of climate changes.

Today, four species of the genus *Juniperus* are found in the Bulgarian flora: *J. communis* (including *J. sibirica* Burgsd. and *J. pygmaea* C. Koch), *J. excelsa*, *J. oxycedrus*, and *J. sabina* L. Only *J. sabina* has not left fossil traces, which may mean that it appeared on the territory of Bulgaria after the Neogene. Today its range covers SW, Central & SE Europe, N Africa (Atlas Mts.), Ukraine: Crimea, Caucasus, Russia (Altai & Ural Mountains), Iran, Kazakhstan, Kyrgyzstan, Turkey, Mongolia, N & NW China [8]. In Bulgaria, *J. sabina* is found in Central Balkan Mountains and Central Rila Mountain about 1000 m a.s.l. [16]. This species is classified as endangered in Bulgaria [17] and probably again a change in climate is the reason for this. *J. communis* is found in the mountains all over Bulgaria from (250) 500 m to above 2 000 m, singly, in groups or in communities [16]. *J. oxycedrus* is distributed in S Bulgaria (400) 500–700 m in the composition of mixed shrubs of the southern type [16]. *J. excelsa* forms communities in the Kresna Gorge (SW Bulgaria) [16]. This species is classified as vulnerable on the territory of Bulgaria [17], due to its limited distribution and human activity near its range.

Conclusions. The first recording of the taxon *Juniperus* aff. *drupacea* in the Satovcha Middle Miocene flora is a contribution to its study, which increases its composition and confirms its diversity and specificity. Apart from the fact that the genus *Juniperus* was established for the first time in this paleoflora, this finding

confirms the presence of a subxerophytic forest and shrub paleocenosis in the vegetation, which left its traces in the Middle Miocene flora-bearing sediments in the area of the village of Satovcha. These paleocenoses have a very limited distribution and the presence of *Juniperus* aff. *drupacea* is an important fact confirming their connection with some modern Mediterranean mesoxerophytic coastal communities. The establishment of *Juniperus* aff. *drupacea* in Middle Miocene sediments on the territory of Bulgaria is the connecting link in the stratigraphic distribution of the taxon, which was missing until now. Thus, its stratigraphic range already includes the Lower Oligocene, Middle Miocene and reaches the Lower Pliocene inclusively.

The presence of *Juniperus* taxa, which are related to modern species restricted to subtropical conditions (or close to them) in Late Miocene – Early Pliocene sediments on the territory of Bulgaria is evidence of the presence of a transitional type of climate from subtropical to temperate. Over time, this climate strengthened its continental component and fossil taxa related to *J. drupacea*, *J. foetidissima* migrated south and disappeared from Bulgaria. At the same time, *J. brevifolia*, which requires higher humidity, disappeared from continental Europe. *J. sabina* probably appeared on the territory of Bulgaria after the Neogene, following the continentalization of the climate from the north-northeast (Altai & Ural Mountains) to SE Europe and the rest of its present-day range.

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