

Evidence of Holocene fossil *Aldrovanda vesiculosa* (*Droseraceae*) seeds at Lake Arkutino, southeastern Bulgaria

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Abstract. Information about the present and past distribution of *Aldrovanda vesiculosa* in Bulgaria is presented. The find of fossil seeds from Lake Arkutino dated to 760–570 cal. BC appears as the earliest Holocene record so far.

Key words: *Aldrovanda vesiculosa*, Bulgaria, fossil seeds, Holocene, Lake Arkutino

Introduction

The species *Aldrovanda vesiculosa* L. (*Droseraceae*) is a submerse and freely floating carnivorous plant. It is a rare plant which occurs in shallow lakes in the reed zone and in open water as well. There are a few scattered occurrences in Europe as in the Czech Republic, Poland, Germany, Switzerland, Hungary, Italy, Bulgaria, Romania and Russia (Heywood 1964). Outside Europe, *Aldrovanda* was found at very few sites in Turkey, Japan, India, southeast Asia and Australia. In Africa, however, *Aldrovanda* occurs in larger areas in the southeastern and southern parts of the continent (Meusel & al. 1987). From several occurrences which were known in the past, the species disappeared probably by human influence.

Recently, Galka & al. (2015) reported about the first fossil *Aldrovanda* seeds found in southeastern Poland (dated to after 1600 AD) and in southwestern Tanzania (ca. 440 AD). The authors suggest this to be first evidence of fossil *Aldrovanda* seeds ever found in Holocene sediments in the world. However, they did not mention the find of fossil *Aldrovanda* seeds presented in a macrofossil diagram from Lake Arkutino located in southeastern Bulgaria (Bozilova & Beug 1992).

This contribution attempts to provide additional information about the present and past distribution of *A. vesiculosa* in Bulgaria and the find of Holocene fossil seeds from Lake Arkutino.

Study area

Lake Arkutino (42°19'47" N, 27°43'28" E and 0 m a.s.l.) is a freshwater lake situated along the southern Bulgarian Black Sea coast about 10 km southeast of Sozopol (Figs 1 and 2). The lake is separated from the sea by ca. 450 m wide dune barrier. The lake covers an area of ca. 1,16 km² and has no outlet. The water depth is 0.5–1.0 m but the lake often falls dry in dry seasons. The part with open water is surrounded by a reed zone with much *Typha angustifolia* L. For details about the vegetation cover of the area and the lake itself see in Bozilova & Beug (1992).

Material and methods

Three sediment cores were obtained from different parts of Lake Arkutino in the period 1980–1984. They were analyzed for pollen and plant macrofos-



Fig. 1. Map of present (red circle) and past (black circle) distribution of *A. vesiculosa* in Bulgaria: 1) Dragomansko swamp; 2) Lake Srebana; 3) Lake Arkutino.



Fig. 2. Lake Arkutino and open water with *N. alba*. In the background the reed zone and the longoz (flooded) forest communities (photo taken by H.-J. Beug in 1982).

sils (seeds, fruits or fruitstones) as explained in Bozilova & Beug (1992). Photos of fossil *A. vesiculosa* seeds were taken with a special microscope for macro objects. The radiocarbon dates from sediment core Arkutino-2 closest to the *A. vesiculosa* seeds were calibrated to calendar years ($\pm 2\sigma$ range, mean value) with the computer program OxCal v4.3 (Bronk Ramsey 2009) using the relevant atmospheric data (Reimer & al. 2013). The calibrated ages in BC/AD are shown on Table 1.

Table 1. Radiocarbon dates closest to the fossil *A. vesiculosa* seeds.

Lab. code (Hv)	Sample depth (cm)	^{14}C age (BP)	^{14}C age (cal. AD/BC, 2σ)	Mean value
Hv 11762	152–162	1390 \pm 65	530–770 AD	650 AD
Hv 11763	255–267	3185 \pm 100	1730–1210 BC	1470 BC

Results and discussion

The distribution of *A. vesiculosa* in Bulgaria

The species *A. vesiculosa* was found for the first time in 1928 (herbar specimen SO-57104) in the deepest parts of Dragomansko swamp (Znepole floristic region) with buds, flowers and fruits (Fig. 1). The swamp is located 38 km northwest of Sofia at 42°55'58" N, 22° 57'43" E and 704 m a.s.l. Here the plant grew with other hydro- and hygrophytes such as *T. angustifolia*, *Spartanium natans* L., *Potamogeton natans* L., *P. lucens* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Schoenoplectus lacustris* (L.) Palla, *Nymphaea alba* L., *Myriophyllum verticillatum* L., *Ranunculus lingua* L., etc. (Jordanoff 1929). Later on, it disappeared from this locality as a result of draining. In 1988 the plant was found again in the northern and western parts of Lake Srebarna (northeastern Bulgaria) located along the Danube river at 44°06'26" N 27°04'19" E and 10 m a.s.l. (Fig. 1). The individuals collected (herbar specimens SO-94033, SO-93789, SOM-146974 and SOM-146977) were without flowers and fruits (Baeva 1988, 1992).

The current conservation status of *A. vesiculosa* is considered as "Critically Endangered" because of its low reproductive potential and of the possibility that it can be easily replaced by other widely distributed floating water plants. The populations have low number of individuals, up to several tens of plants. The localities of the species within the borders of Srebarna Managed Nature Reserve are included in the European ecological network Natura 2000 (Meshinev 2015).

The fossil record from Lake Arkutino

Three seeds of *A. vesiculosa* were found in the depth interval 216–225 cm of the sediment core Arkutino-2 collected from the central part in 1982 and a photo of the best preserved seed is shown for the first time (Fig. 3).

The fruits of *Aldrovanda* are capsules mostly with 10 seeds. The seeds are set free under water when the capsules are opened by decay. The seeds are black, with a length of 1.0–1.5 mm, with a ring-shaped hilum and a pointed umbilicus (Fig. 3).

Drawings of recent seeds of *Aldrovanda* were published by Bertsch (1941) and Katz & al. (1965).

The age of the fossil seeds was determined by taking into consideration the two closest radiocarbon dates (Table 1). By interpolation the age of the fossil seeds can be dated to the first half of the 1st millennium BC

(760–570 cal. BC). In European countries apparently no fossil seeds of *Aldrovanda* of Holocene age were found before the publication of Bozilova & Beug (1992).

It is also worth mentioning that fossil *Aldrovanda* seeds of Eocene age (*A. ovata* (Chandl.) Reid et Chandler) and of Pliocene age (*A. praevesiculosa* Kirchheimer – the ancestor of the present species) were described from coal basins in eastern and southwestern Bulgaria (Palamarev 1970, 1973).

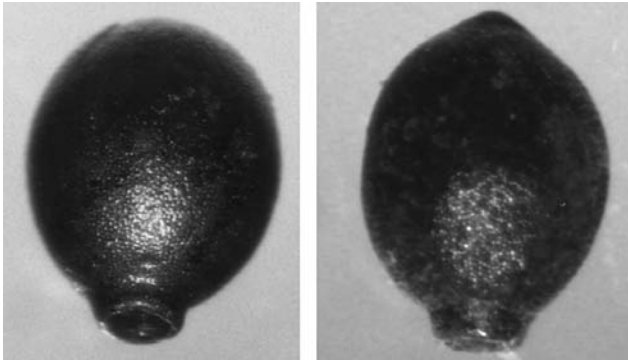


Fig. 2. Fossil seed of *A. vesiculosa* found in Lake Arkutino (length 1.1 mm) (photo taken by H.-J. Beug).

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