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Technical Report · September 2020

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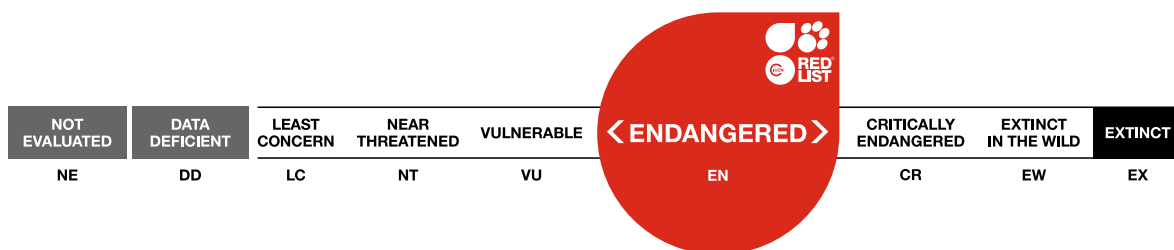
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## *Aldrovanda vesiculosa*, Waterwheel

Assessment by: Cross, A. & Adamec, L.



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## Taxonomy

Kingdom	Phylum	Class	Order	Family
Plantae	Tracheophyta	Magnoliopsida	Nepentales	Droseraceae

**Scientific Name:** *Aldrovanda vesiculosa* L.

### Synonym(s):

- *Aldrovanda generalis* E.H.L. Krause
- *Aldrovanda verticillata* Roxb.
- *Drosera Aldrovanda* F. Muell. [Illegitimate]

### Regional Assessments:

- Europe

### Common Name(s):

- English: Waterwheel, Common Aldrovanda
- French: Aldrovandie vésiculeuse, Aldrovandie à vessies
- Bulgarian: Алдрованда
- Croatian: Mjehurasta vodena stupica
- German: Wasserfalle
- Hungarian: Aldrovanda
- Italian: Aldrovanda
- Korean: Beol-le-meog-i-mal
- Macedonian: Воденичарче
- Russian: Алдрованда
- Serbian: Водена ступица

### Taxonomic Source(s):

Linn. 1753. *Sp. Pl.* 1: 223.

### Taxonomic Notes:

There are no significant taxonomic issues associated with this name.

## Assessment Information

**Red List Category & Criteria:** Endangered B2ab(iii,iv,v) [ver 3.1](#)

**Year Published:** 2020

**Date Assessed:** October 5, 2019

### Justification:

From 379 natural historical populations distributed throughout 124 regions in 43 countries, this species has declined over the last century to only 50 confirmed extant localities. Two thirds of these are, however, found in one region within Poland and the Ukraine, with the remaining 18 sites thinly spread across four continents. The species has been confirmed extinct in Austria, Slovakia, Czech Republic (although reintroduced), France, Germany, Italy, Bangladesh, India, Japan, Uzbekistan and East Timor,

and remains unverified in another 21 countries. The likelihood of persistence in many of these areas is slim due to extensive wetland degradation, and it is undeniable that this species faces a potentially severe outlook if attempts to mediate the species decline are not swiftly made. This species has an area of occupancy (AOO) of 244 km<sup>2</sup>, a severely fragmented population, and is facing continuing declines in habitat, number of subpopulations and its population size. It is therefore assessed as Endangered.

### Previously Published Red List Assessments

2012 – Endangered (EN)

<https://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T162346A901031.en>

## Geographic Range

### Range Description:

Historically, *Aldrovanda vesiculosa* occurred throughout western, central, southern, northern and eastern Europe, from coastal areas in western and southern France, throughout northern and central Italy, Austria and Germany to Poland, Belarus, Bulgaria, Croatia, the Czech Republic, Greece, Hungary, Lichtenstein, Lithuania, Montenegro, Northern Macedonia, Ukraine, Romania, the Caucasus, Volga, Ussuri, Amur, Lipetsk and St Petersburg areas of Russia, Serbia, Slovakia and Turkey; with several sites known throughout Asia in Bangladesh, India, the Manchuria region of China, Kazakhstan, Uzbekistan, North and South Korea, and Japan; extending down to East Timor and several coastal areas in southwest, northwest, north, east and southeast Australia. Populations have also been recorded from Botswana, Burundi, Cameroon, Chad, Ghana, Malawi, Mozambique, Rwanda, South Africa, South Sudan, Tanzania, Togo, Uganda and Zambia throughout Equatorial Africa. Presently, this species remains distributed scarcely throughout Europe in Bulgaria, Greece, Northern Macedonia, Hungary, Lithuania, Poland, Romania, the St Petersburg, Pskov and Lipetsk areas of Russia, Serbia and the Ukraine; persists on the Far East of Russia in the Primorje County; in northern and south-eastern Australia; and in China, Zambia, Botswana, Uganda and South Africa.

This species has been successfully introduced in Switzerland, The Netherlands and the USA (Adamec 2018) and reintroduced to the Czech Republic to several potential suitable sites in South Bohemia, Trebon basin, in 1995-2009 (Adamec 2018).

**Africa** Botswana: Five extant locations and two unverified locations in three regions.

- Five sites among the shallow swamps of the expansive Okavango Delta, among *Nymphaea caerulea*, *Caldesia reniformis*, *Nymphoides indica*, *Potamogeton thunbergii*, *Utricularia benjaminiana*, *U. foliosa*, *U. reflexa* and *U. stellaris*. The region is likely to harbour extensive suitable habitat, however is poorly surveyed and access to many areas is difficult. Extant, discovered in 1975, and confirmed in 1981 and 2004 (Adamec 2005b, Kaminski 2006, Pretoria Herbarium).
- In the Linyanti River, west of the Chobe floodplains, near the border with Namibia and Zambia. Unverified since 1930 (Flora Zambesiaca, Kew Gardens).
- Near Kasane, in the Chobe swamp, a large wetland-dominated area formerly the territory of Mozambique. Unverified since the early 1900s (Lloyd 1942).

Burundi: One unverified location in one region.

- One ambiguous and undated location, likely to originate from Lake Tanganyika near the southern border with Tanzania (Flora Zambesiaca).

Cameroon: Two unverified locations in two regions.

- On the shores of Lake Fianga, an inland oxbow fringed with swampland near the border with Chad in the Extreme North region. Unverified since 1963 (Lebrun 1968).
- In the vicinity of Lake Bamendjing, a large lake on the border between the rugged and mountainous West and Northwest regions. Unverified since 1974 (Cameroon National Herbarium).

Chad: Four unverified locations in one region.

- Four sites near Sarh, formerly Fort Archambault, in the Chari River delta. Unverified, observed between 1962 and 1968 (Lebrun 1969, 1968).
- With *A. vesiculosa* known from Lake Fianga's northern reaches in Cameroon, it is possible that the species' occurrence extends across the border into swampy areas fringing the lake in southwest Chad.

Ghana: Three unverified locations in two regions.

- Swampland near Kete Krachi, in the northern reaches of the expansive Lake Volta. Unverified since 1963 (Lebrun 1969).
- In swamps of the Volta River delta, east of Dabala, in the Keta Lagoon protected area. Unverified since 1963 (Lebrun 1969).
- A second ambiguous location in Lake Volta. As the wetlands surrounding this immense lake are numerous, it is possible that a number of populations may exist in the region. Unverified since 1965 (Lebrun 1969).

Malawi: One unverified location in one region.

- In scattered swampland near the southern extent of Lake Malawi, an area remaining somewhat in contention with Tanzania. Unverified and undated (Kaminski 2006).

Mozambique: One unverified location in one region.

- An ambiguous collection with no exact locality given. Unverified since 1928 (Flora Zambesiaca).
- The further occurrence of *A. vesiculosa* in Mozambique has been suggested by several authors in the past. This is based on observations of the species around Chobe swamp and the upper basin of the Limpopo river of South Africa, both of which border and extend into the country.
- Additionally, the occurrence of *A. vesiculosa* in the Malawi territory of Lake Malawi may suggest further suitable habitat exists in the north.

Rwanda: One unverified location in one region.

- An ambiguous collection with no location or date provided, most likely to originate from the east near Tanzania (Flora Zambesiaca).

South Africa: Two extant locations in two expansive regions.

- Throughout the swamps and rivers of the Northern Province, a rather ambiguous description in a large region encompassing the entire upper Limpopo river basin. Extant and recently confirmed, though with no exact locations or dates provided (Kaminski 2006).
- Near Mpumalanga in the vicinity of the upper Limpopo river basin. Extant and recently confirmed, though with no exact dates provided (Kaminski 2006).

South Sudan: Two unverified locations in two regions.

- Extensive swampland in the Sudd region, in the northern extent of the Shambe Nature Reserve in the White Nile Delta. Observed in 1902, unverified since 1959 (Berta 1961, Flora of Tropical East Africa, Kew Gardens).
- In the catchment of the Upper White Nile, near Bentiu. Unverified since 1869 (Berta 1961).

Tanzania: Four unverified locations in two regions.

- Two sites near Lake Rukwa, in the Lukwati Game Reserve. Unverified and undated (Kaminski 2006).

- Two sites on the western fringes of Lake Victoria, a huge lake extending into both Uganda and Kenya. Unverified and undated (Kaminski 2006). As Lake Victoria has experienced extreme recent eutrophication (L. Adamec pers. comm. 2012), these sites are now probably extinct.

Togo: One unverified location in one region.

- In the Koumongou River, near the town of Sansanné-Mango in the northeast. Unverified since 1984 (Herbarium Togoense).

Uganda: One unverified location in one region and recently verified three to four sites.

- During the 1970s, *Aldrovanda vesiculosa* was discovered at an undescribed location by Prof P. Denny (L. Adamec pers. comm. 2012). The location remains unverified since this date.
- On the north of Lake Victoria, three sites were described in 2016 (Kalema *et al.* 2016).
- In 2015, a German tourist photographed red *Aldrovanda* in a lake near the northern shore of Lake Victoria (A. Fleischmann and L. Adamec unpubl. data).

Zambia: Three unverified locations in three regions and one verified location.

- In the area of Luangwa valley, possibly in the Lusandwa Reserve. Unverified and undated (Kaminski 2006).
- Lake Lusiwasi in central Zambia, east of Kanona. Unverified since 1958 (Flora Zambesiaca).
- In the vicinity of Lake Bangweulu in the Isangano National Park, near the north-west border with the Democratic Republic of the Congo. Unverified since 1958 (Flora Zambesiaca).
- Recorded from Lake Wasa in 2012 where the species was present in 20% of the points sampled (K.J. Murphy pers. comm. 2012, see Bingham *et al.* 2019).

## Europe

Recent European and Asian sites are described in detail by Adamec (2018).

Austria: Four extinct locations in two regions.

- Two locations in the peaty floodplains of Lake Constance near Bregenz. Noted from 1834, 1861, 1863, and 1865, now extinct (Erlebnis Naturschau Dornbirn, Germany; Herbarium WU, Vienna; Kaminski 2006)
- Two locations in southern Tirol, east of Innsbruck, observed to flower and fruit in proliferation amongst reeds. Observed in 1851 and again in 1909, now extinct (Kaminski 2006; National Herbarium Nederland).

Belarus: Twenty-two unverified locations in three regions.

- Seven sites in the Vitebsk Province, throughout oxbow lakes, canals and river channels. Dating to 1862 and 1897, requiring verification (Kaminski 2006).
- Fourteen sites in swamps and tributaries of the Pripyat River basin, from near Mazyr in the east to Brest Province in the west. Discovered in 1897, confirmed in the 1950s and presently unverified (Berta 1961, Kaminski 2006, Shiyan and Andrienko 2011).
- In the vicinity of Grodno, near the northwest border with Poland and Lithuania (Herbarium WU).

Bulgaria: Two extant locations in two regions.

- In Dragoman Marsh, Zenpole. The population was discovered in 1928 and became extinct after draining in 1960, however was restored by reintroduction of nearby Romanian plants, undertaken by the Balkani Wildlife Society in the late 1990s. The Dragoman Marsh Karst complex has recently been announced as a Ramsar site of world heritage, and *Aldrovanda vesiculosa* has flourished at the site in recent years (Balkani Wildlife Society, Bulgarian Flora Online, Kaminski 2006, Ralev pers. comm. 2012).
- In Srebarna lake, within the Srebarna Managed Nature Reserve. Initial discovery unknown, but

confirmed in 2009 (Balkani Wildlife Society, Bulgarian Flora Online).

Croatia: One unverified location in one region.

- Along riverbanks near Slavonski Brod in the east, on the border with Bosnia and Herzegovina. Unverified since 1915 (Herbarium WU).

Czech Republic: One extinct location in one region plus reintroduced localities.

- Loucke fishponds in the Karvina district, near the northeast border with Poland in close proximity to populations in Polish Silesia. Last observed in 1952, now extinct after coal mining (Kaminski 2006, Adamec 1995a).
- Plants from E Polish and Hungarian were introduced to South Bohemia in 1995-2009 and two stable populations counting c. 2000-50,000 plants each occurred in the Trebon basin in 2018 (Adamec 2018).

France: Eighteen extinct locations in four large regions.

- Throughout the numerous swamps around Maillé, south of Fontenay le Comte. Recorded extensively throughout the 18th, 19th and 20th centuries in 1753, 1780, 1786, 1830, 1861, 1892, 1897, 1932, 1939, 1946, 1961, 1967 and 1969, however now extinct (Inventaire national du Patrimoine naturel).
- Wetlands on the eastern shore of Lake Leon, in the Reserve Naturelle du Courant d'Huchet, north of Leon. Observed in 1930, 1931 and 1934, now extinct (Inventaire national du Patrimoine naturel).
- Around the fringes of Lake Noir, south of Menacou. Undated and extinct (Inventaire national du Patrimoine naturel).
- Near Mouries, in the Mercantour National Park. Discovered in 1861, now extinct (Kaminski 2006).
- In swampland around Lacanau, Gironde, west of Bordeaux. Recorded from 1858, 1859, 1860 and 1958, before its extinction in 1969. Three further undescribed locations from the 1970s originate from this area however are also extinct. (Kaminski 2006, Adamec 1995a, Museum national d'histoire naturelle et Reseau des Herbiers de France).
- Near Hourtin, north of Lacanau. Discovered in 1811 and confirmed in 1958, now extinct (Kaminski 2006).
- Lake Hardy, in Landes. Discovered in 1892, and also collected in 1957, 1967 and 1969, now extinct (Museum national d'histoire naturelle et Reseau des Herbiers de France).
- Marshland and channels around Le Porge, south of Lacanau. Discovered in 1859, now extinct (Museum national d'histoire naturelle et Reseau des Herbiers de France).
- In the Bassin D'Archachon, south of Lacanau. Discovered in 1811 and confirmed in 1958, now extinct (Kaminski 2006).
- Near Mauranne, in Laurède, Aquitaine. Undated and extinct (Inventaire national du Patrimoine naturel).
- In the vicinity of Marseilles. Undated and extinct (Museum national d'histoire naturelle et Reseau des Herbiers de France).
- Near Languedoc-Roussillon in the south. Recorded in 1780, now extinct (Inventaire national du Patrimoine naturel).
- Near Orange, Vaucluse. Discovered in 1789 and recorded from 1830, now extinct (Museum national d'histoire naturelle et Reseau des Herbiers de France, Kaminski 2006).
- In the vicinity of Mont Ventoux, east of Orange. From 1874, now extinct (Museum national d'histoire naturelle et Reseau des Herbiers de France).
- In Bouches-du-rhone Departement, in the northern extent of the World Heritage listed Camargue wetlands, and numerous locations around Arles. Observed in 1861, 1862, 1865, 1869, 1874, 1875 and 1888, now extinct (Castagne 1862, Museum national d'histoire naturelle et Reseau des Herbiers de France).

- In Perpignan, near the border with Spain in the far south. Undated and extinct (Kaminski 2006).
- Narbonne on the east coast. Undated and extinct (Kaminski 2006).
- In canals near Montpellier. Undated and extinct (Kaminski 2006).

Germany: Twenty-one extinct sites in six regions.

- Two sites at Lake Constance, near Lindau. Observed first around 1852, then in 1885, 1902, 1908, 1914 and 1936, now extinct (Bundesamt für Naturschutz, Flora exsiccata Bavarica, Herbarium of Oskarshamn, Kaminski 2006, Leiner-Herbar Konstanz).
- Near Angermünde, northeast of Berlin near the Polish border. Collected in 1883, 1885 and 1886, now extinct (Kaminski 2006, Museum national d'histoire naturelle et Reseau des Herbiers de France, Nationaal Herbarium Nederland).
- Ziethen, southwest of Angermünde. Undated and extinct (Bundesamt für Naturschutz).
- In the vicinity of Hohenfinow, northeast of Berlin. Undated and extinct (Bundesamt für Naturschutz).
- Zeuthensee, east of Zeuthen, southeast of Berlin. Undated and Extinct (Kaminski 2006).
- Several sites in the vicinity of Rheinsberg. Observed between 1867 and 1906, now extinct (Bundesamt für Naturschutz, Herbarium WU, Kaminski 2006, Museum national d'histoire naturelle et Reseau des Herbiers de France).
- In Mühlweiher, northwest of Cham. Discovered in 1904, now extinct (Kaminski 2006).
- At least two sites near Brandenburg, west of Berlin. Observed between 1867 and 1906, now extinct (Bundesamt für Naturschutz, Herbarium WU, Kaminski 2006, Museum national d'histoire naturelle et Reseau des Herbiers de France).
- Near Ruhland, in the southeast. Undated and extinct (Kaminski 2006).
- In the vicinity of Schlenkenstrasse, between Grossegegen and Bulten. Discovered in 1867, and persisting until the early 1970s before becoming extinct (Kaminski 2006).
- Two sites at Parsteiner See and Grosser Plagesee, east of Brodowin in the Chorin region northeast of Berlin. Discovered in 1867, and persisting until the early 1970s before becoming extinct (Kaminski 2006).
- Lake Hegesee, near Mölln south of Lübeck. Known to have persisted into the late 1980s, now extinct. (Adamec 1995a, Weber 1995, Kaminski 2006, Bundesamt für Naturschutz).
- Along riverbanks near Worms, north of Mannheim. Undated and extinct (Bundesamt für Naturschutz).
- Near Nahe, in the north of the country. Undated and extinct (Kaminski 2006).
- In the vicinity of Bergedorf, near Hamburg. Undated and extinct (Bundesamt für Naturschutz).
- Near Langen, on the north coast. Undated and extinct (Bundesamt für Naturschutz)
- Lake Gehspitzweiher, in Neu-Isenburg south of Frankfurt. Undated and extinct (Bundesamt für Naturschutz).
- Along riverbanks near Schnackenburg. Undated and extinct (Bundesamt für Naturschutz).

Greece: One extant location in one region.

- In Lake Prespa, a large lake in northern Greece extending into both Albania and the Northern Macedonia. An initial collection is dated to around 1981, with the population recently rediscovered in 2011 and confirmed in 2017 (Flora of Greece Checklist, Kaminski 2006, Jovanovska *et al.* 2017).

Hungary: One extant, two unverified and four extinct populations in six regions.

- Two populations, at the northern and southern ends of Lake Balata-to, Somogy County. Discovered in 1924, these populations persisted at least until the late 1990s (Borhidi and Járαι-Komlódi 1959). In 1997 both were confirmed to be very large, consisting of tens or possibly over a hundred thousand plants, growing among *Salvinia natans*, *Potamogeton natans*, *Utricularia vulgaris*, *Lemna minor* and *Spirodela polyrhiza*. A survey in 2003 observed far fewer plants over a much lesser area however, and after significant drying of the lake between 2003–2009 the survival of these populations was questioned (Herbarium Musei Silesiensis, Kaminski 2006, Lájér 2006). In 2010, water levels in the lake were restored



and the population has recovered, probably from a limited soil seed bank (L. Adamec pers. comm. 2012). In 2019, a population counting a few thousands of plants was confirmed (Kasza and L. Adamec pers. comm. 2019).

- A long oxbow with *Menyanthes trifoliata*, *Cicuta virosa* and *Urtica kioviensis*, in an area of abandoned pastures near Pocsaj, on the eastern border with Romania. The site was discovered in 2002, however is in a region threatened by eutrophication and may no longer persist (Lájer 2006).
- Near Füzesgyarmat, in the east, close to the border with Romania. Observed in 1859 and 1881, however extinct by 1907 (Herbarium WU, Lájer 2006).
- Along riverbanks near Simonka Béla. Discovered in 1873, and extinct since 1924 (Lájer 2006).
- Near Békés in the southeast. Discovered in 1881, now extinct (Herbarium WU, Lájer 2006).
- A further undescribed site discovered in 1900 but extinct by 1907 (Lájer 2006).

Italy: Nineteen extinct locations in seven regions.

- Mantua Lakes and Ostiglia Wetlands, south of Verona. Now extinct (Herbarium records)
- Several collections from around Bolzano (Bozen), in the north. First observed in 1851, now extinct (Herbarium WU).
- In the Adige river near lake Reschensee, close to the border with Switzerland and Austria. Undated and extinct (Herbarium WU).
- Salorno (Salurn), southwest of Bolzano. Collected in 1854, 1862 and 1874, now extinct (Herbarium WU, Tiroler Landesmuseum Ferdinandeum).
- Along muddy riverbanks near Ivrea. Undated and extinct (Caspary 1858).
- In Lake Candia, east of Candia Canavese. Discovered in 1858 and known to persist until at least 1955, now extinct (Berta 1961, Caspary 1858).
- In a moat near Verona. Undated and extinct (Caspary 1859).
- In the vicinity of the Monts Euganéens, east of Verona. Undated and extinct (Caspary 1858).
- In swamps near Chioggia, south of Venice. Undated and extinct (Diels 1906).
- Near Padua, west of Venice, with *Azolla*, *Salvinia*, *Hydrocharis*, *Lemna minor*, *Utricularia vulgaris* and *U. minor*. Collected in 1858 and confirmed in 1914, now extinct (Beguinet 1914, Kaminski 2006).
- Near Pavia, south of Milan. Undated and extinct (Caspary 1862).
- Three sites, at Duliolo, Budrio and Gandazollo, in the Bologna region. These date as far back as 1747, and are the namesake collections for *A. vesiculosa*. The swamp at Duliolo is regarded by many as the type location for the species (McPherson 2010, Caspary 1859, Caspary 1858).
- Two sites at lake Gascina, near Bientina, east of Pisa on the west coast. Undated and extinct (Caspary 1859, Herbarium WU).
- At Sibolla, near Lucca, northeast of Pisa. First described in 1865, and known to have persisted until 1997 before becoming extinct (Adamec 1995a, Diels 1906, Anon. 1865, Tassara and L. Adamec pers. comm. 2012).
- Rare throughout Lake Lattanzi near Anticoli, east of Rome. With *Potamogeton lucens*, *P. pectinatus*, *Cyperus flavescens* and *Utricularia vulgaris*. No exact date provided, now extinct (Diels 1906, Anon 1900, Anon 1897).

Lithuania: One extant and two extinct locations in three regions.

- Throughout numerous bays and marshy shoreline, in the creek joining Lake Ruzas and Lake Zilmas near Birdeksniai near the northeast border with Belarus. The abundance of *A. vesiculosa* in several locations here is noted to have hindered the movement of a small wooden boat, with the species growing extensively among *Nuphar lutea*, *Potamogeton lucens*, *Myriophyllum spicatum*, *Potamogeton natans*, *Hydrocharis morsus-ranae* and *Utricularia vulgaris*. Discovered in 2001 and confirmed in 2002

(Vilkonis 2004).

- In the vicinity of Vilnius, in the southeast. Discovered in 1906, now extinct (Diels 1906, Kaminski 2006).

- In the large Lake Dysnai, on the border of the Ignalina District in the northeast. Discovered in 1955, now extinct (Vilkonis 2004).

- Although the observation bears no location, *A. vesiculosa* is recorded from Lithuania as early as 1821 (Nyman and Roth 1886).

Montenegro: One unverified location in one region.

- Unsubstantiated reports of an *A. vesiculosa* population persisting in the Skadar Lake National Park.

Poland: Twelve extant and seventy-five extinct locations in seven regions.

- Three sites in the Międzychodzko-Sierakowski Lake District, at lakes Obierznie, Czarne and Ostrowo Swiete. Only the last of these remains, after reintroduction efforts in 2005, the others becoming extinct throughout the latter part of the 20th century (Kaminski 2006, Kaminski 2010).

- Thirteen sites in the Augustowskie Lake District. One of the most ecologically intact regions remaining, harbouring four naturally extant populations at lakes Orle, Miklaszowek, Augustowskiego and Kruglak. Populations are no longer found at lakes Krzywe, Kolno and Paniewo (Kaminski 2006, Kaminski 2010).

- Forty-four sites in the Leszna-Wlodawa Lake District in the West Polesie Biosphere Reserve, near the region of the Pripyat River basin extending throughout Belarus and the Ukraine. Of these, eight have escaped extinction through agrarian development in the mid 20th century, with natural populations persisting only at lakes Moszne and Dlugie, and restored sites at lakes Lukie, Hanskie, Koseniec, Plotycze, Pereszpa and Orchowe (Kaminski 2006, Kaminski 2010).

- Thirteen sites in the upper Odra basin, including swampland near Opole, Rybnik, Raciborz, Cieszyn, Gmina Czarnkow, Krakow and Niemodlin, in Silesia. Collections for this area are numerous, with observations recorded from 1851, 1868, 1871, 1872, 1873, 1880, 1894, 1898, 1907, 1939, 1940 1941. All are now extinct due to industrialisation and agrarian development (Herbarium Musei Silesiensis, Herbarium WU, Kaminski 2006). The last occurrence of *A. vesiculosa* in the Odra basin was in the small peaty Nowa Kuznia fishpond near Opole, which was confirmed in 1983 but extinct by 1994 (L. Adamec pers. comm. 2012, Kaminski 1987a).

- Three populations in the Upper Vistula Valley. Observed infrequently between 1862 and 1967, now extinct (Kaminski 2006).

- Three ponds at the mouth of the San River, in the southeast. Recorded in the 1930s, now extinct (Kaminski 2006).

- Eight sites near Ostrowo and Slupca in central Poland, in lakes Powidzkie, Solomonowskie, Hutka, Klasztorne. Wieksze and Sende. Observed between 1882 and 1971, and all now extinct (Herbarium WU, Kaminski 2006).

Romania: One extant and sixteen unverified locations in five regions.

- Four sites around Tulcea, in the Danube Delta. Observed in 1923 and 1961, unverified since 1995 however believed to persist (Museum national d'histoire naturelle et Reseau des Herbiers de France, NSW Herbarium). Recent records exist for the Danube Delta from wetlands near the Sulina branch in 1998 and 2008 (Maldonado San Martin *et al.* 2003, Elansary *et al.* 2010), with plants collected here maintained in *ex situ* culture at the Institute of Botany, Trebon, Czech Republic (L. Adamec pers. comm. 2012). In the Danube Delta area, hundreds of microsites may exist.

- The lake north of Oltenita, near Mangalia, on the southern border with Bulgaria. Unverified since 1965 (Herbarium WU).

- Six sites in the swamps and river near Snagov. Unverified since 1906 (Kaminski 2006).

- Near Oradea, in the northwest. Unverified since 1906 (Kaminski 2006).

- Swamps in Kaplony, Szatmárnémeti, in the northwest near the border with Hungary. Unverified since 1859 (Herbarium WU).
- In swampland of the Koros-Maros National Park, south of Oradea on the Hungarian border. Unverified since 1906 (Kaminski 2006).
- South of Brasov, near the Carpathians. Unverified since 1961 (Kaminski 2006).
- In the vicinity of Craiova, in the south. Unverified since 1961 (Kaminski 2006).

Russia: Six extant and thirty-seven unverified locations in nine regions.

- A large population in a lake Mokhovo'e in the Galich'a Gora Nature Reserve near the village of Soshki, about 25 km south of Lipetsk, Lipeck county, SW Russia, numbering over a hundred thousand plants in the mid 1990s (Kaminski 2006). Confirmed in 2003, with plants maintained *ex situ* at the Institute of Botany, Trebon, Czech Republic (Slavgorodskii and L. Adamec pers. comm. 2012). Around in 2013, another site (Chystyi prud) was discovered in this area, but the site was dry and extinct in 2017 (Grigorov pers. comm. 2017). Four additional locations are recorded from the basin of the Voronezh River in the 1960s, also in the Lipetsk county, and remain unverified (Kaminski 2006, Anon 1968).

- Along the expansive shoreline of Lake Ladoga, east of St Petersburg. The site (shallow lake) near the estuary of the Sviri river on the SE bank of Lake Ladoga represents the largest and most stable extant site in the world, harbouring a population estimated to be in the millions. It is the only known location where *A. vesiculosa* is the dominant species, often for stretches of coastline kilometres in length (Afanas'ev 1953). Population fluctuations occur regularly however, and a number of threats to the lake ecosystem have developed (Degreef 1986, Adamec 1995a, Kaminski 2006). The abundant site was confirmed also in 2000-2005 (Muravnik pers. comm. 2012). Recently, a new abundant site was found near the S bank of Lake Ladoga, about 108 km southwest from the first one, in a shallow lake 3 km south of Kukorevo village (Doronina 2014).

- Several large populations in the Volga delta, in the Astrakhan nature reserve. Recorded from the 1960s, unverified since numerous surveys between 1990–1996 (Anon 1968, Caspian Environment Programme).

- In the Maly Orlovsky lake at Kletsko-Pochtovskiy, in Volgogradskaya oblast northwest of Volgograd. Unverified since 1993 (Aranzadi Zientzi Elkarte).

- Six sites on the shores of the large inland Khanka Lake, on the border with China in the east, and extending to the mouth of the Ussuri River near Vladivostok. Undated and unverified (Kaminski 2006). In the watershed of the Ussuri River, one site has recently been verified. Near the town of Khasan in the Primorsk county close to the Chinese and North Korean border, an abundant site with red plants was discovered in nymphaeid-dominated Lake Lotos and verified in 2018 (Volkova pers. obs. 2018). Another site inhabited with green plants was discovered in 2019 (Vozmishcheva pers. comm. 2019). It is located in a lake situated in a floodplain of a smaller river ca. 2 km from the sea in the Sikhote-Alinskii Nature Reserve near the town of Terney, ca. 390 km on the northeast of Nakhodka.

- Four sites in lakes and oxbows along the Amur River, north of Khabarovsk in the east. First described in a publication dated 1897, and not observed since the late 1950s (Berta 1961, Anon 1968, Kaminski 2006).

- At least nine populations in lakes and swampland throughout the expansive Caucasus region, from the Caspian Sea in the east to coastal areas near Krasnodar in the west. Mostly undated, and all requiring verification (Berta 1961, Anon 1968, Kaminski 2006).

- Two sites along riverbanks near Rostov, north of Moscow. Undated and unverified (Kaminski 2006).

- Seven sites in the west near Belarus, in swamplands extending across the border to Gomel. Undated and unverified (Kaminski 2006). Since 2005, two close-by sites have been found very close to the Latvian

and Belarusan border in the Pskov county in W Russia. In 2005, a site was found in the dystrophic Lake Berezvica (Ivanova pers. comm. 2012), while another site in Lake Dolgo'e (ca. 20 km from the latter) in the Sebez National Park was found in 2016 (Doronina pers. comm. 2016) and these plants are maintained *ex situ* at the Institute of Botany, Trebon, Czech Republic.

- Kronstadt Island, in the Gulf of Finland west of St Petersburg. Unverified since 1907 and likely extinct (Kaminski 2006).

Serbia: Nine extinct locations in five regions.

- Recently in the Zasavica Special Nature Reserve, in the Valjevac inundation zone. Discovered in 2005 and confirmed in 2008. However, P. Dencic visited the site in 2017 and reported the extinction (pers. comm. 2017). It is likely that the species was extinct as early as in 2009-2010 but its occurrence was mistakenly reported later on.

- Two locations in swampy habitat near Jurišić, in Veliko and Malo okno. Collected in 1889 and 1896, now extinct (Herbarium WU, Protection and Management of Zasavica Special Nature Reserve 2011)

- Near Kupinovo, in the Obedska bara Special Nature Reserve. Discovered in 1915 and last observed in 1977, now extinct (Herbarium WU, Museum national d'histoire naturelle et Reseau des Herbiers de France, Protection and Management of Zasavica Special Nature Reserve 2011)

- Along the Danube River, near Novi Sad. Last observed in 1982 (Adamec 1995a).

- Three locations near Obrenovac along the Sava River. Discovered in 1916, now extinct (Kaminski 2006, Protection and Management of Zasavica Special Nature Reserve 2011).

- In the Danube River near Makiš, Belgrade. First observed in 1884, now extinct (Kaminski 2006, Protection and Management of Zasavica Special Nature Reserve 2011).

Northern Macedonia: One extensive extant site in one region.

- Since 2016, rediscovered at four microsites (near Sit Han, Asamati, Nakolec) in the N and E part of Lake Prespa in shallow *Phragmites australis*-dominated littoral belt (Jovanovska *et al.* 2017). In 2018, five microsites were verified in large reed stands in Lake Prespa indicating an abundant *Aldrovanda* population of dozens of thousands of plants (Jovanovska and L. Adamec pers. obs. 2018). These plants are maintained *ex situ* at the Institute of Botany, Trebon, Czech Republic.

Slovakia: One extinct location in one region.

- Green (Zelene) Lake, near Vojka, on the southeastern border with Hungary. The population is known to have become extinct after drying and infilling in 1984 (Adamec 1995a, Kaminski 2006).

Turkey: One unverified location in one region.

- An ambiguous location in the north of the country. Undated and unverified (Kaminski 2006).

Ukraine: Eighteen extant, eight unverified and thirteen extinct locations in five regions.

- At least thirty sites throughout the expansive Pripjat River basin, along the northern border with Belarus. These range from the Kiev reservoir and lakes near Korma in the east, to Shats'k in the east. Thirteen locations are now extinct, with seventeen persisting in the far northwest throughout the Shatskyi Biosphere Reserve, confirmed since 2000 (Adamec 1995a, Kaminski 2006, Shiyani 2011).

- Two sites in the vicinity of Chernihiv, northeast of Kiev. Unverified since 1961 (Berta 1961, Kaminski 2006).

- Near Perejaslaw-Chmelnizkyj, southeast of Kiev. Unverified since 1961 (Kaminski 2006).

- In a lake near Kharkiv, in the east. Unverified since 1987 (Kaminski 2006).

- Three sites near the mouth of the Danube River, bordering Romania. Unverified since 1993 (Kaminski 2006).

- Throughout the Dnieper reservoir, in the southeast. Undated and unverified (Kaminski 2006).

- Kardashyns'kyi Lyman Lake, in the extensive Dnieper delta near Kherson in the far south. Recently discovered in 2001 (Kaminski 2006).
- Throughout the heavily vegetated Lake Rogozy, in the Olleshky sand dunes of the Dnieper Delta near Tsiuriupinsk, Kherson district. Unverified since 1976 (Herbarium Kiev, Ukraine).

## Asia

Bangladesh: Two extinct locations in two regions.

- Swampland near Dhaka. Extinct, last observed in 1937 (Zaman *et al.* 2011).
- East of Rajshadi in the extensive Chalan beel wetlands, in deep clear water amongst reeds and thickets of *Nymphaea*, *Ricciocarpus natans* and *Riccia fluitans*. Extinct, first recorded in 1974 and last observed in 1987 (Zaman *et al.* 2011).
- A non-specific Bangladeshi location mentioned by Cohn in 1850 is likely to originate from the Chalan beel area (Kaminski 2006).

China: One extant and at least two unverified locations in one expansive region.

- A wetland with red plants in the Qixinghe National Nature Reserve in Heilongjiang province, Manchuria. Discovered in 2017 (China Daily). In 2018, ca. 4,000 plants were estimated there (Yunlong pers. comm. 2018).

- Swamps in the Jiamusi Prefecture, Heilongjiang Province, Manchuria. Unverified, last observed in 2000 (Flora of China Checklist).

- Near Ulanhot, in the Manchuria region bordering Inner Mongolia. Unverified, last observed in 2000 (Flora of China Checklist).

India: Two extinct locations in two regions.

- Throughout the extensive salt marshes east of Calcutta. Extinct, first recorded in 1832, and last observed in 1903 (Zaman *et al.* 201).
- Swampland in Manipur state. Extinct, last recorded in 1961 (Zaman *et al.* 201)
- Two additional unspecified locations, including the first documented collection of *A. vesiculosa* by Plukenet in 1696 and another referenced by Cohn in 1850, are both likely to originate from the large Calcutta marshlands (Plukenet 1696, Kaminski 2006).

Japan: Twelve extinct locations in nine regions.

- Near Chiba City, Chiba Prefecture. Extinct and undated (Osaka Museum of Natural History).
- Among rushes in the Tatara-numa pond, Gunma Prefecture. Extinct and undated (Gunma Museum of Natural History).
- Near Ibaraki town, Ibaraki Prefecture. Extinct, collected in 1902 (Ibaraki Nature Museum, Makino 1905).
- At the edges of Ogura-Ike Lake, Kyoto Prefecture. Possibly collected in 1955 (L. Adamec pers. comm. 2012), now extinct (Osaka Museum of Natural History).
- In the Mie-Aich area, Kyoto Prefecture. Extinct and undated (Osaka Museum of Natural History, Kondo pers. comm. 2012).
- Houzouji Pond, in Hanyu City, Saitama Prefecture. The last remaining natural Japanese population, destroyed by flood in 1966 (Komiyama 1966, Kondo *et al.* 1997, Osaka Museum of Natural History).
- Near Ogasawara, Saitama Prefecture. Extinct and undated (Osaka Museum of Natural History, Flora of China Checklist).
- An undescribed location at Nara, Nara Prefecture. Extinct and undated (Osaka Museum of Natural History).

- A small pond in rice fields, at Yoda on the Yedo River near Koiwa, east of Tokyo. The population was noted to be rare when first discovered in 1890, and was observed to flower in 1891, however was last observed in 1909 and is now extinct (Makino 1905, Smithsonian National Museum of Natural History).

- Along the banks of the Arakawa river, near Tokyo. Extinct and undated (Kondo pers. comm. 2012).

- Near Yukimatsu, Fukui Prefecture. Extinct and undated (Osaka Museum of Natural History).

- In shallow ponds near Honshu in central Japan. Recorded as rare in 1965, now extinct (Ohwi 1965).

Kazakhstan: Three unverified locations and two extinct locations in four regions.

- In the Ural River, north of the Caspian Sea. Noted to be rare in the 1960s, and unverified since 1990–1996 (Caspian Sea Biodiversity Project, Caspian Environment Programme).

- At least two sites in lagoons along the northern shores of the Caspian Sea, in and between the deltas of the Volga and Ural rivers. The first of these is located near Peshnoy, south of Atyrau at the northernmost extent of the Caspian Sea on the Ural delta, and the second is south of Dzhabul in the expansive swampland of the Volga River delta. Both are noted as being rare in the 1960s, and remain unverified since 1990–1996 (Caspian Sea Biodiversity Project, Caspian Environment Programme).

- In the Syrdarya river delta near the Aral Sea. Probably extinct, with no date given (Kaminski 2006).

- Lake Balkhash in the Far East. Probably extinct, with no date given (Kaminski 2006).

Uzbekistan: One extinct location in one region.

- Reference is made to *A. vesiculosa* becoming extinct during the 1980s in the Amu River delta, after an initial observation here in the 1960s (Novikova 2001, Anon 1968).

North Korea: One unverified location in one region.

- No locality given, observation date recorded as 1935 (Korea National Arboretum).

South Korea: One unverified location in one region.

- No locality given, and no date provided (Flora of China Checklist, Kaminski 2006).

East Timor: One extinct location in one region.

- Among *Nymphoides* and *Eleocharis dulcis* in a small stream near Mehara, Lautém district, Timor-Leste. Unverified and probably extinct, from a single collection dated 1953 (Australian National Herbarium).

**Australia** Western Australia: One extant and three unverified locations in three regions.

- A small billabong on the Morgan River, North Kimberley. Discovered in 2019. (A.T. Cross pers. obs. 2019)

- Meelarrie swamp, a small oxbow billabong west of the Drysdale River. Unverified since 2002 (New South Wales [NSW] Herbarium).

- In a large billabong above Mertens Falls, Mitchell Plateau, with *Nymphaea*, *Utricularia australis* and *U. gibba*. The type locality for *A. vesiculosa* var. *rubescens*. Reportedly several sites exist around this billabong (L. Adamec pers. comm. 2012), however no collections of such material have been vouchered. Observed in 1993 when plants were in full flower, however unverified since this date (Australian National Herbarium, Western Australian [WA] Herbarium).

- Throughout a large *Melaleuca cuticularis* swamp in Cape le Grande, Esperance, among *Baumea articulata* and *Utricularia australis*. Several hundred individuals were observed in swampland to the west when the population was discovered in 2004, with similar numbers observed in 2008. The site was heavily degraded in 2007 after road development, leading to the extinction of the western population, however in 2009 around a hundred plants were discovered in a deeper wetland to the west. The entire site experienced particularly dry seasons in 2010 and 2011, and with numerous surveys since 2009 failing to locate even a single individual, the population is probably extinct (Cross 2012, Gibson 2004, WA Herbarium). However, a handful of plants were discovered in an ephemeral swamp about 10 km south of this site in 2017, and it is therefore listed as unverified until further survey is conducted.

Northern Territory: Two extant and thirteen unverified locations in eight regions.

- At least five locations in the *Hymenachne* grasslands of the Reynolds river floodplain. Unverified since 1990 (Cowie *et al.* 2000, Flora Atlas NT).
- Several locations in the Finniss River floodplain, among emergent grasses. Unverified since 1990 (Cowie *et al.* 2000, Flora Atlas NT).
- A swamp on Pukitarmarloo Point, among *Melaleuca viridiflora*, *M. leucodendra* and *Eleocharis sphacelata*, at the western end of Bathurst Island (often mistaken for Melville Island). Unverified since 2001 (Cowie *et al.* 2000, WA Herbarium).
- Throughout Girraween Lagoon, in Darwin. Collected in 1976 and 1978, however not observed since development near the site in 2005 (Cowie *et al.* 2000, Flora Atlas NT).
- Among emergent vegetation on the fringes of Leach Lagoon, southeast of Katherine. Discovered in 1980 and confirmed in 2010 (Flora Atlas NT, Cowie *et al.* 2000, NSW Herbarium).
- Among emergent sedges near the boardwalk at Fogg Dam, in the Fogg Dam Conservation Reserve, Humpty Doo. Initial discovery unknown, confirmed in 2004 (Cowie *et al.* 2000, Gibson pers. comm. 2012).
- On the shallow margins of permanent swampland dominated by *Eleocharis sphacelata* and *Oryza rufipogon*, in the Ramingining area. Unverified since 1998 (Australian National Herbarium, Cowie *et al.* 2000, Flora Atlas Northern Territory [NT]).
- In the vicinity of Milingimbi, north of Ramingining. Unverified since 1998 (NSW Herbarium).
- McMinns Lagoon, just south of Girraween Lagoon. Discovered in 1976, and unverified since 1978 (Australian National Herbarium, Cowie *et al.* 2000).
- In *Eleocharis sphacelata* sedgeland near Arafura homestead, Arafura. Unverified since 1990 (Cowie *et al.* 2000, Flora Atlas NT).
- Amongst reeds in *Melaleuca viridiflora* swampland near Dog mountain, Arafura. Unverified since 1998 (Cowie *et al.* 2000, Flora Atlas NT).

Queensland: Two unverified locations in two regions.

- In extensive swampland with *Ricciocarpus natans*, *Lemna trisulca*, *Utricularia australis*, *Nelumbo nucifera* and *Leersia hexandra*, near Toomba, northwest of Charters Towers in North Kennedy. Unverified since 2001, and extensively flooded in 2010 (NSW Herbarium)
- Numerous unconfirmed reports of a population near Bundaberg, on the east coast. This area also experienced extensive flooding in 2010.

New South Wales: Three extant and four unverified locations in three regions.

- Longvale Swamp, northwest of Broulee, with *Utricularia australis*, *Myriophyllum* sp., *Marsilea mutica*, *Paspalum* sp. and *Eleocharis sphacelata*. Discovered in 1997, and confirmed in 2007 (Clayton pers. comm. 2012, NSW Herbarium).
- Waldron's Swamp, between Mogo and Moruya, scarcely distributed in shallow water among *Eleocharis sphacelata* and *Azolla pinnata*. Discovered in 2000, and confirmed in 2011 (Bourke pers. comm. 2012, NSW Herbarium).
- Billybung Lagoon, near Armidale in the NSW highlands at 1370 m a.s.l. Scarcely distributed among *Myriophyllum varifolium*, *Nymphoides montana*, *Eleocharis dietrichiana*, *E. sphacelata* and *Utricularia australis*. A turion was discovered in sediment samples in 1994, with the species formally discovered in 1998 and a small population of around a dozen plants confirmed in 2006 (Bell pers. comm. 2012, Gibson pers. comm. 2006, NSW Herbarium).
- Wiliija Swamp, in coastal lowlands near Moruya. Several hundred plants growing sparsely among *Typha orientalis*, *Baumea articulata*, *Eleocharis sphacelata*, *Utricularia australis* and *Azolla pinnata*.

Unconfirmed since 1999 (Australian National Herbarium; NSW Herbarium).

- Y-swamp, near Moruya airport, with *Eleocharis sphacelata*, *Baumea articulata*, *Marsilea mutica*, *Triglochin* sp., *Chara* sp. and *Myriophyllum* sp. Unconfirmed since 1995 (NSW Herbarium).
- Ghosties Lagoon, near Evans Head in an RAAF bombing range. Discovered in 1978, unverified since 1985 (NSW Herbarium).
- Pinch Lagoon, near Black Mountain in the NSW highlands. Very scarcely distributed throughout sedgelands with *Eleocharis sphacelata*, *Isolepis fluitans* and *Myriophyllum varifolium*. Unverified since 1999 (Bell pers. comm. 2012, NSW Herbarium).

### Country Occurrence:

**Native, Extant (resident):** Australia (New South Wales, Northern Territory, Queensland, Western Australia); Botswana; Bulgaria; China (Heilongjiang); Greece (Greece (mainland)); Hungary; Lithuania; North Macedonia; Poland; Romania; Russian Federation; Serbia; South Africa (Limpopo Province, Mpumalanga); Uganda; Ukraine; Zambia

**Native, Extinct:** Austria; Bangladesh; Belarus; Burundi; Cameroon; Chad; China (Nei Mongol); Croatia; France (France (mainland)); Germany; Ghana; India (Manipur, West Bengal); Italy (Italy (mainland)); Japan (Honshu); Kazakhstan; Korea, Democratic People's Republic of; Korea, Republic of; Malawi; Montenegro; Mozambique; Rwanda; Slovakia; South Sudan; Tanzania, United Republic of; Timor-Leste; Togo; Turkey (Turkey-in-Europe); Uzbekistan

**Extant & Reintroduced (resident):** Czechia

**Extant & Introduced (resident):** Netherlands; Switzerland; United States



## Population

*Aldrovanda vesiculosa* possesses one of the greatest disjunctions known for any angiosperm species, with populations frequently isolated by around 800-1,500 km and sometimes over 2,000 km. As such, the species' distribution is highly fragmented, with suitable habitat now rare and still declining in availability and quality. The species occupies a very specific and restricted ecological niche within suitable habitats, and declines rapidly following even small changes to habitat quality. It possesses a low dispersive ability and experiences large population fluctuations annually throughout its range. In general, populations number in the hundreds of plants or fewer and may experience up to 70-80% losses due to poor overwintering success throughout Europe (Adamec 1999a). Exceptions are large and relatively stable populations persisting in a handful of sites in Poland, Lithuania, north-west Russia and the Ukraine, though each is extremely disjunct and possesses limited dispersive potential. Only 49 populations have been recently confirmed extant, of which 31 were located within a single region (the Pripyat River region of Ukraine, an area increasingly under pressure from anthropogenic activity as exclusion around the Chernobyl nuclear disaster site recedes) and 18 distributed sparsely between four continents. 184 populations have been sought and confirmed extinct, with a further 146 remaining unverified despite numerous survey attempts of many regions and most generally regarded as extinct.

**Current Population Trend:** Decreasing

## Habitat and Ecology (see Appendix for additional information)

This species is a perennial, free-floating, rootless aquatic herbaceous plant, with a simple or sparsely branched stem possessing successive whorls of bristled, prey-catching leaves. The leaves are arranged in whorls of 4–9, measuring up to 23 mm in diameter, and are basally fused with a swollen, dorsally flattened petiole that broadens upwards before dividing into 3–8 terminal, filiform bristles of 4–8 mm length. Stem length is dependent upon water quality, prey abundance and irradiance, but is commonly between 6–20 cm. The compact, whorled structure of the species provides the plant with an almost cylindrical appearance, and gives rise to the species' common name of the "Waterwheel Plant". The growth season for this species extends from early–mid spring into early autumn, with flowers produced throughout summer under favourable conditions. As day length decreases and water temperature begins to drop in mid–late autumn, apical growth becomes increasingly compact and temperate (and some tropical) populations produce dormant overwintering buds called turions (Adamec 2018). Any remaining stem and vegetative material senesces and breaks away from the mature turion, which slowly sinks to the bottom of the water where temperatures are stable and warmer during winter. Overwintering often leads to considerable population losses, with survival frequently only 20–30 per cent (Adamec 1999, Adamec and Lev 1999), particularly as turions failing to sink are generally washed ashore, grazed on by waterfowl, or killed by the onset of frost. In spring, when water temperatures begin to rise once again, the surviving turions float to the surface and recommence growth. In latitudes experiencing very mild winters, it may grow year-round with no overwintering period. Flowering in *A. vesiculosa* is rare and poorly successful, highly variable between season and populations, and yields exceedingly low numbers of viable seed even under optimum conditions (Cross 2012). While plants from warmer climates are known to bloom with greater profusion and regularity, particularly throughout tropical and sub-tropical Australia, these flowers open only for brief periods and also often fail to develop fruit. Under even the most optimal of conditions plants produce scant numbers of viable seeds, and these are thought to originate almost entirely from self-pollination. The primary dispersive agent in it is likely to be vegetative propagules such as stem fragments or turions, transported externally

by birds between suitable habitat. This species occurs in a wide variety of habitats, from small fens, peat-bog pools and billabongs to lakes, lagoons and river deltas. While it has been infrequently observed in mesotrophic lakes and eutrophic habitats such as fishponds and rice paddies (Breckpot 1997, Adamec 1999a), it is native to nutrient impoverished oligo-mesotrophic and dystrophic (humic) systems (Adamec 1995b, 2018). The stenotopic nature and reliance upon carnivory of this species yield little competitive ability, and limits the species' distribution to specific microhabitats dominated by loose and species-poor plant communities (Adamec 1995a, 1999a, 2005, 2018; Degreef 1986; Kaminski 1987a). These are generally shallow backwaters or the littoral zone of larger lakes, where competition with other aquatic species forming dense stands is reduced or absent (Kaminski *et al.* 1996; Kaminski 1987a,b; Studnicka 1984), and are typically areas experiencing little variation in water level throughout the growing season. This species is extremely intolerant of habitat degradation, and even slight changes to water chemistry can result in local extinction (Kaminski 1987a). *A. vesiculosa* possesses virtually all the characteristic traits of a genetically uniform aquatic plant. The species is highly clonal, known to propagate strictly by vegetative means throughout most of its range, and is capable of extremely rapid growth under optimal conditions. It inhabits a restricted ecological niche, with very specific habitat requirements and facing further reductions to the abundance of suitable habitat. *A. vesiculosa* exhibits strongly repressed sexual function dominated by obligate autogamy, and further limits the chance of recombination with the presence of a non-successful floral morph under suboptimal conditions. It is likely to disperse vegetatively over both short and long distances, and persists through unsuitable periods of winter primarily in the form of dormant or non-dormant winter buds rather than seed. The species is contemporary in geological origin, unlikely to have persisted in any given location for long enough to experience significant genetic drift, and has experienced numerous severe bottlenecks in its recent evolutionary history.

**Systems:** Freshwater (=Inland waters)

## Use and Trade

There is limited trade in this species, mainly in Europe.

## Threats (see Appendix for additional information)

According to a review of conservation threats to carnivorous plants presented by Jennings and Rohr (2011) and revised by Clarke *et al.* (2018), this species is threatened primarily by residential and commercial development, agriculture and aquaculture, natural systems modifications and pollution. The Commission of the European Union (2009) also lists acidification, canalization, desilting, drainage, eutrophication, forestry clearance, gravel extraction, mining, pollution, hydrological modification and limited dispersal as threats to the species throughout Europe. Eutrophication and water level decline due to warming climate and drought are the main recent threats to the most European sites (Adamec 2018). Additionally, though its extent and effects on natural populations are unknown, it is believed that some illegal trade also occurs in *A. vesiculosa*. Habitat degradation is common throughout the species' entire range and very few sites, including those within conservation reserves, remain pristine.

## Conservation Actions (see Appendix for additional information)

As the true extent of the species' decline has become clearer, legislative protection has been provided to this species in virtually all countries of its distribution. Though a deficiency of data relating to its distribution has hindered an appraisal of conservation status throughout much of Africa, Asia and

Australia, *A. vesiculosa* has been regarded as Critically Endangered throughout most of Europe since 1982 (IUCN Threatened Plants Unit 1982), and is included in Appendix I of the Bern Convention (Council of Europe 2001) as a species requiring specific habitat conservation measures. However, in light of the continuing habitat eutrophication and global climate changing (higher temperatures, drought), conservation measures do not help much. Therefore, as based on the pieces of experience in successful introductions to Switzerland, The Netherlands and the USA (see Adamec 2018), introductions of related populations to potentially suitable sites remain the most effective measures of conservation for this species.

#### Australia

- Priority Two Flora in Western Australia (Department of Environment and Conservation 2009), indicating the species to be a poorly known taxon requiring further survey and study.
- Least Concern in the Northern Territory, on the basis that large areas of potential habitat remain unsurveyed.
- Endangered in New South Wales (NSW Threatened Species Conservation Act 1995 in NSW Scientific Committee 1995), requiring the provision of recovery and threat abatement plans, as well as the declaration and mapping of habitats critical to the species survival. To date these have not been conducted for this species.
- Least Concern in Queensland (Nature Conservation Act 1992 in Queensland Government 1992), despite the presence of only a single unverified location in this state.
- At a national level it has not been included under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999 (Commonwealth of Australia 1999), the Australian Government's principle piece of environmental legislation. However, the extant population at Billybung Lagoon, NSW, falls within the Upland Wetlands of the New England Tablelands Endangered Ecological Community.

#### Africa

- Not included in the Malawi Red List of Flora (Dombo *et al.* 2002a).
- Not included in the Botswana Red List of Flora (Dombo *et al.* 2002b).
- It is not protected by legislation in any other African nation, and is not included in any regional conservation initiatives.

#### Asia

- Protected as a National Natural Monument in Japan under the Cultural Properties Protection Law #214 (Culture Agency of the Ministry of Education, Science, Sports and Culture, Japan 1966).
- Included within the North Korean Red Book of Flora, though without further details provided.
- Though considered extinct in Bangladesh, the species remains listed as Critically Endangered in the Red Data Book of Vascular Plants of Bangladesh (Arshad Ali and Matiur Rahman 2001).
- It does not appear to be protected in China, and is not included in any regional conservation initiatives.

#### Europe

- Critically Endangered and protected in Bulgaria under the Biological Diversity Act (Ministry of Environment and Water, Bulgaria 2007) involving the provision of activities for the maintenance and recuperation of populations.
- Critically Endangered in Poland, and included in the Polish Red Book of Plants (Institute of Botany and the Institute of Environmental Protection of the Polish Academy of Sciences 2006). Described as threatened with extinction if risk factors are not addressed.
- Critically Endangered in Romania, and included in the national Red Book habitat directive (Dihoru and Negrean 2009).
- Critically Endangered and strictly protected in Serbia and Montenegro, under the Preliminary Red List

of Flora of Serbia and Montenegro (Stevanović 2002).

- Critically Endangered and officially protected in the Ukraine (Diduch 2009).
- Critically Endangered and included in the Red Data Book of Russia (Krasnoborov 1988).
- Critically Endangered and included in the Red Data Book of Slovakia (Maglocký and Feráková 1993).
- Included in the Red Data Book of Lithuania under the zero category as an extinct species, pending revision to Critically Endangered (Rašomavičius 2007).
- It is declared as an extinct species of the Czech, German, French and Italian flora.
- It is included in Annex 2 of the European Union Habitats Directive (EEC 1992), requiring the establishment of designated protected areas.
- It is a keystone species in the Caspian Sea Biodiversity Project under the Caspian Sea Environment Program (Aladin *et al.* 2017), and is noted in the management plans for various threatened wetlands throughout Europe.

A number of populations, though many of them remaining unverified, are located within the borders of lands reserved for conservation purposes. The degree of protection afforded by these areas varies from unfenced game and nature reserves to carefully monitored and well-maintained national parklands and biosphere reserves, however all provide a degree of crucial habitat security. Managed and protected lands known to harbour extant *A. vesiculosa* populations include the Srebarna Managed Nature Reserve and the recently Ramsar listed Dragoman Marsh Complex (Bulgaria), the Zasavica Special Nature Reserve (Serbia), although it is extinct here, the Astrakhan Reserve (Kazakhstan), and the New England Tablelands Endangered Ecological Community (Australia). The effectiveness of conserving only small areas such as these is however limited by landscape-scale changes to hydrology and the intrinsic biotic linkages characteristic of wetland habitats, exemplified by the recent extinction of populations in the Obedska bara Special Nature Reserve (Serbia). One conservation area, formed by two large adjacent reserves, harbours over 50% of the entire global distribution of *A. vesiculosa* and clearly supports both the need for transboundary conservation and the management of larger scale ecological processes. Encompassing much of the expansive Pripjat River basin, the 48,977 hectare Shatskyi Biosphere Reserve in northwest Ukraine was designated in 2002 and provides some of the most ecologically intact freshwater habitat remaining in Europe, including the Ramsar listed Shatsk Lakes. Seventeen extant *A. vesiculosa* populations are known from the reserve, which is carefully monitored for a number of biotic and abiotic factors under the authority of the Scientific-Technical Council of the Shatskyi National Nature Park. Bordering Shatskyi to the west is the West Polesie Biosphere Reserve in East Poland, a similarly protected 139,917 hectare area maintained by the Forum of the International Biosphere Reserve "Polesie Zachodnie". Though patches of the Polish reserve are designated for extensive economic use, the lowland area is characterised by a mosaic of swamps, moors, lakes and rivers and eight populations persist in the region. It must be noted however that despite the protections afforded to even large landscapes such as these, widespread habitat degradation is not entirely avoided: historically the two regions harboured between them at least 74 populations which have been gradually lost due to agricultural development and continued wetland eutrophication.

## Credits

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## Appendix

### Habitats

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Habitat	Season	Suitability	Major Importance?
5. Wetlands (inland) -> 5.1. Wetlands (inland) - Permanent Rivers/Streams/Creeks (includes waterfalls)	-	Suitable	Yes
5. Wetlands (inland) -> 5.4. Wetlands (inland) - Bogs, Marshes, Swamps, Fens, Peatlands	-	Suitable	Yes
5. Wetlands (inland) -> 5.5. Wetlands (inland) - Permanent Freshwater Lakes (over 8ha)	-	Suitable	Yes
5. Wetlands (inland) -> 5.6. Wetlands (inland) - Seasonal/Intermittent Freshwater Lakes (over 8ha)	-	Marginal	-
5. Wetlands (inland) -> 5.7. Wetlands (inland) - Permanent Freshwater Marshes/Pools (under 8ha)	-	Suitable	No
5. Wetlands (inland) -> 5.8. Wetlands (inland) - Seasonal/Intermittent Freshwater Marshes/Pools (under 8ha)	-	Marginal	-
5. Wetlands (inland) -> 5.9. Wetlands (inland) - Freshwater Springs and Oases	-	Suitable	No
15. Artificial/Aquatic & Marine -> 15.2. Artificial/Aquatic - Ponds (below 8ha)	-	Suitable	No
15. Artificial/Aquatic & Marine -> 15.9. Artificial/Aquatic - Canals and Drainage Channels, Ditches	-	Suitable	No

### Plant Growth Forms

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Plant Growth Form
H. Hydrophyte

### Use and Trade

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

End Use	Local	National	International
Pets/display animals, horticulture	Yes	Yes	No

### Threats

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

Threat	Timing	Scope	Severity	Impact Score
1. Residential & commercial development -> 1.1. Housing & urban areas	Ongoing	Unknown	Unknown	Unknown
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
1. Residential & commercial development -> 1.2. Commercial & industrial areas	Ongoing	Unknown	-	Unknown
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
1. Residential & commercial development -> 1.3. Tourism & recreation areas	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.3. Agro-industry grazing, ranching or farming	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.4. Marine & freshwater aquaculture -> 2.4.3. Scale Unknown/Unrecorded	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
3. Energy production & mining -> 3.2. Mining & quarrying	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.1. Intentional use: (subsistence/small scale) [harvest]	Ongoing	Unknown	Unknown	Unknown
	Stresses:	2. Species Stresses -> 2.1. Species mortality		
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.1. Abstraction of surface water (domestic use)	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.2. Abstraction of surface water (commercial use)	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.3. Abstraction of surface water (agricultural use)	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.4. Abstraction of surface water (unknown use)	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
7. Natural system modifications -> 7.3. Other ecosystem modifications	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion		

				1. Ecosystem stresses -> 1.2. Ecosystem degradation
9. Pollution -> 9.1. Domestic & urban waste water -> 9.1.1. Sewage	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.1. Domestic & urban waste water -> 9.1.2. Run-off	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.1. Domestic & urban waste water -> 9.1.3. Type Unknown/Unrecorded	Ongoing	Unknown	Unknown	Unknown
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.2. Industrial & military effluents -> 9.2.2. Seepage from mining	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.2. Industrial & military effluents -> 9.2.3. Type Unknown/Unrecorded	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.3. Agricultural & forestry effluents -> 9.3.1. Nutrient loads	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.3. Agricultural & forestry effluents -> 9.3.2. Soil erosion, sedimentation	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
9. Pollution -> 9.3. Agricultural & forestry effluents -> 9.3.3. Herbicides and pesticides	Ongoing	-	-	Low impact: 3
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		

## Conservation Actions in Place

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

<b>Conservation Action in Place</b>
In-place land/water protection
Conservation sites identified: Yes, over part of range
Occurs in at least one protected area: Yes
In-place species management
Successfully reintroduced or introduced benignly: Yes
In-place education
Included in international legislation: Yes

## Conservation Actions Needed

(<http://www.iucnredlist.org/technical-documents/classification-schemes>)

<b>Conservation Action Needed</b>
1. Land/water protection -> 1.2. Resource & habitat protection

## Additional Data Fields

<b>Distribution</b>
Estimated area of occupancy (AOO) (km <sup>2</sup> ): 244
Estimated extent of occurrence (EOO) (km <sup>2</sup> ): 114232825
Lower elevation limit (m): 0
Upper elevation limit (m): 1,580
<b>Population</b>
Continuing decline of mature individuals: Yes
Population severely fragmented: Yes
Continuing decline in subpopulations: Yes
All individuals in one subpopulation: No
<b>Habitats and Ecology</b>
Continuing decline in area, extent and/or quality of habitat: Yes

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