Mexican Mosquitofern (*Azolla mexicana*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, March 2015
Revised, February 2017, October 2017, February 2021, March 2021
Web Version, 7/16/2021

Organism Type: Plant
Overall Risk Assessment Category: Uncertain

Photo: Richard Droker. Licensed under Creative Commons BY-NC-ND 2.0. Available: https://www.flickr.com/photos/29750062@N06/23480759593/ (February 2021).

1 Native Range and Status in the United States

Native Range

From Washington State Department of Ecology (2015):

"Western North America and northern South America."

From Gill (2005):

"In Canada, the Mosquito-fern [*Azolla mexicana*] occurs only in British Columbia."

Status in the United States

From eFloras (2008):

"In the eastern United States, *A. mexicana* may have been occasionally introduced."

From Environment and Climate Change Canada (2017):

"In the United States, it is found in several western and mid-western states […]: Arizona, Arkansas, California, Colorado, Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington, and Wisconsin."

No records of *Azolla mexicana* in trade in the United States were found.

Azolla mexicana is on the 'Aquatic life approved species list' of Illinois (Illinois DNR 2015). "The following aquatic life categories will be considered approved for aquaculture, transportation, stocking, importation and/or possession in the State of Illinois."

Means of Introductions in the United States

No information on means of introduction for *A. mexicana* was found.

Remarks

The taxonomic authority used for plants by this screening process considers *Azolla mexicana* a valid species (WFO 2021). This screening was conducted using the taxonomic structure set for the *Azolla* genus in WFO (2021). In some resources *Azolla mexicana* is considered a junior synonym to two different accepted species *A. cristata* (ITIS 2015) and *A. microphylla* (Roskov et al. 2015). *A. cristata* and *A. microphylla* are considered separate, valid species (WFO 2021). Every effort has been made to only consider information pertaining to *A. mexicana* and not another valid *Azolla* species in this screening.

From Washington State Department of Ecology (2015):

"A compound microscope is required to positively distinguish species of Azolla."

Azolla mexicana is listed as a Threatened species in Canada (Environment and Climate Change Canada 2017).

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From WFO (2021):

"*Azolla Mexicana* C. Presl […]
This name is reported by Salviniaceae as an accepted name in the genus *Azolla* (family Salviniaceae)."

From CABI (2015):

"Domain Eukaryota
Kingdom Plantae
Phylum Pteridophyta
Class Filicopsida
Family Azollaceae
Genus *Azolla*
Species *Azolla mexicana*"

See Remarks section, above, regarding taxonomic issues with this genus.

Size, Weight, and Age Range

From eFloras (2008):

"Stems prostrate, 1--1.5 cm"

Environment

From Environment and Climate Change Canada (2017):

"[water] Depth: typically, but not exclusively, 50 cm or less; where the roots can touch the substrate in summer drawdown"

"Chemistry: above pH 3.5, below pH 10 (optimal at pH 6.5-8.1); low salinity (≤1.3% salt); iron and phosphorous-rich, but otherwise nutrient-poor"

"[water] Temperature: optimal at 18–28°C (cold tolerance dependent on pH)"

Climate

From eFloras (2008):

"*Azolla mexicana* is generally less cold tolerant and has a narrower environmental range than *A. caroliniana*."

From Gill (2005):

"The Mosquito Fern prefers moderately dry climates, but where saline soils are not widespread (so that salt does not rise to intolerable levels during the water-level reduction which seems necessary for its development)."

Distribution Outside the United States

Native

From Washington State Department of Ecology (2015):

"Western North America and northern South America."

From Gill (2005):

"In Canada, the Mosquito-fern [*Azolla mexicana*] occurs only in British Columbia."

Introduced

Azolla mexicana was first found in France in 1901 (Thiébaut 2007). Thiébaut (2007) classified it as 'potentially invasive' but restricted in distribution in the Atlantic and Continental zones of France.

From Puky et al. (2008):

"Lately, *Azolla mexicana* was also found in the backwater of the Solti-Danube in the Gemenc floodplain [Hungary] (Steták 2006)."

From NOBANIS (2017):

"*Azolla mexicana* in Sweden
[…]
Time of introduction: 1935
Year of first report: 1935
Type of introduction: Unintentional
Status: Not established
[…]"

Additionally, CABI (2015) reports *Azolla mexicana* as present in Kerala (India), Bulgaria, Germany, Greece, and the Netherlands, all of which are outside the native range of the species.

Means of Introduction Outside the United States

Azolla mexicana was introduced into France as an escapee from aquaria (Thiébaut 2007).

Short Description

From eFloras (2008):

"Plants green or often blue-green to dark red, some red-fringed leaves usually present in nature, free-floating or forming a multilayer mat to 4 cm thick in early summer; plants frequently fertile. Stems prostrate, 1--1.5 cm. Largest hairs on upper leaf lobe near stem 2(--3)-celled; broad pedicel cell often 1/2 or more height of hair, apical cell curved, with tip nearly parallel to leaf surface. Megaspores not covered with raised angular bumps, pitted and sparsely covered with a few long filaments extending over surface."

From Washington State Department of Ecology (2015):

"A single root is on the underside of the plant."

Biology

From Gill (2005):

"Vegetative reproduction is the primary vehicle for plant growth; the production of fertile material is proportionately rare. Populations completely disappear each fall/winter and do not show any evidence of survival until conditions are suitable for growth, then, the population expands quickly [Environment Canada no date; Royal BC Museum no date].

Different from most other pteridophytes, the Mexican Mosquito Fern produces two kinds of spores: microspores and megaspores. These function as reproductive packages for the species. Having overwintered at the bottom of the pond, they eventually float to the surface again, where they initiate sexual reproduction and so produce a new generation of mosquito ferns. Though microspores (sometimes referred to as the "male" spores) are said to occur commonly in this species, megaspores (the "female" spores) are rather rare, and have apparently not been reported from Canadian collections. In this connection, it is noteworthy that the North Thompson collections bear both types of spores [Environment Canada no date; Royal BC Museum no date].

A dramatically reduced water-level is apparently essential for the development of the Mosquito Fern. The water must be somewhat acidic for optimum *Azolla* growth and nitrogen-fixation. As well, the blue-green algae which the fern has a symbiotic relationship with cannot fix nitrogen without the proper levels of manganese [Environment Canada no date; Royal BC Museum no date]."

"Small ponds surrounded by wet meadows, still-water, fresh ox-bow lakes over sandy floodplain deposits and edges of slow streams are where the Mosquito Ferns are found. These locations are usually surrounded by young hardwood and/or mixed forests but can be in the open amongst grasses and shrubs. The plants are both free-floating and on logs and rotting vegetation [Environment Canada no date; Royal BC Museum no date]."

From Washington State Department of Ecology (2015):

"Sheltered water. Occasionally found stranded on wet soil when water levels drop."

Human Uses

From Washington State Department of Ecology (2015):

"Water-fern [*Azolla mexicana*] is used as green fertilizer in rice paddies because of its nitrogen fixing ability."

Diseases

No information on pathogens of *Azolla mexicana* was found.

Threat to Humans

No information on threats to humans of *Azolla mexicana* was found.

3 Impacts of Introductions

Azolla mexicana has been introduced to areas in Europe and India, and possibly in the eastern United States. No information on impacts of introductions of *A. mexicana* was found.

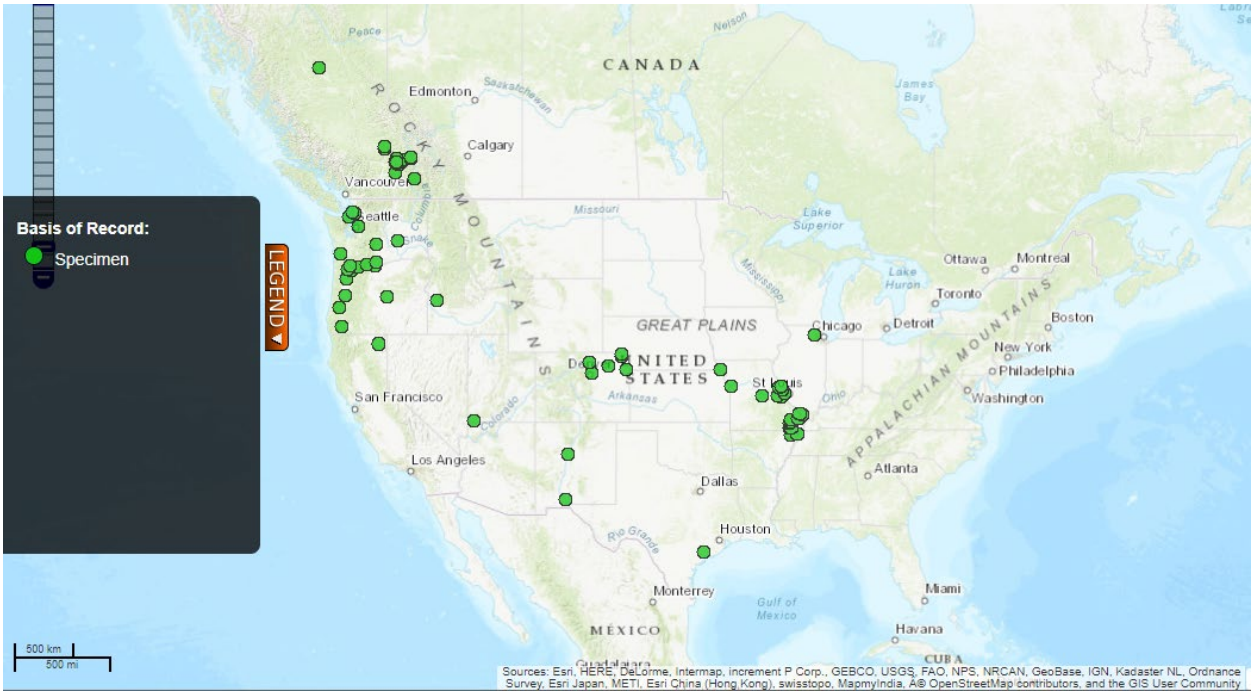
4 History of Invasiveness

There are known introductions of nonnative populations of *Azolla mexicana* in Europe and India, and possible introductions in the eastern United States. The species was introduced to France in 1901 and is still present in the Atlantic and Continental zones. *A. mexicana* is also listed as currently present outside its native range in India, Bulgaria, Germany, Greece, and the Netherlands. However, no information was found regarding impacts of introduction. The history of invasiveness is classified as Data Deficient.

5 Global Distribution

Georeferenced observations representing populations in Bulgaria, Greece, Hungary, and India were not found.

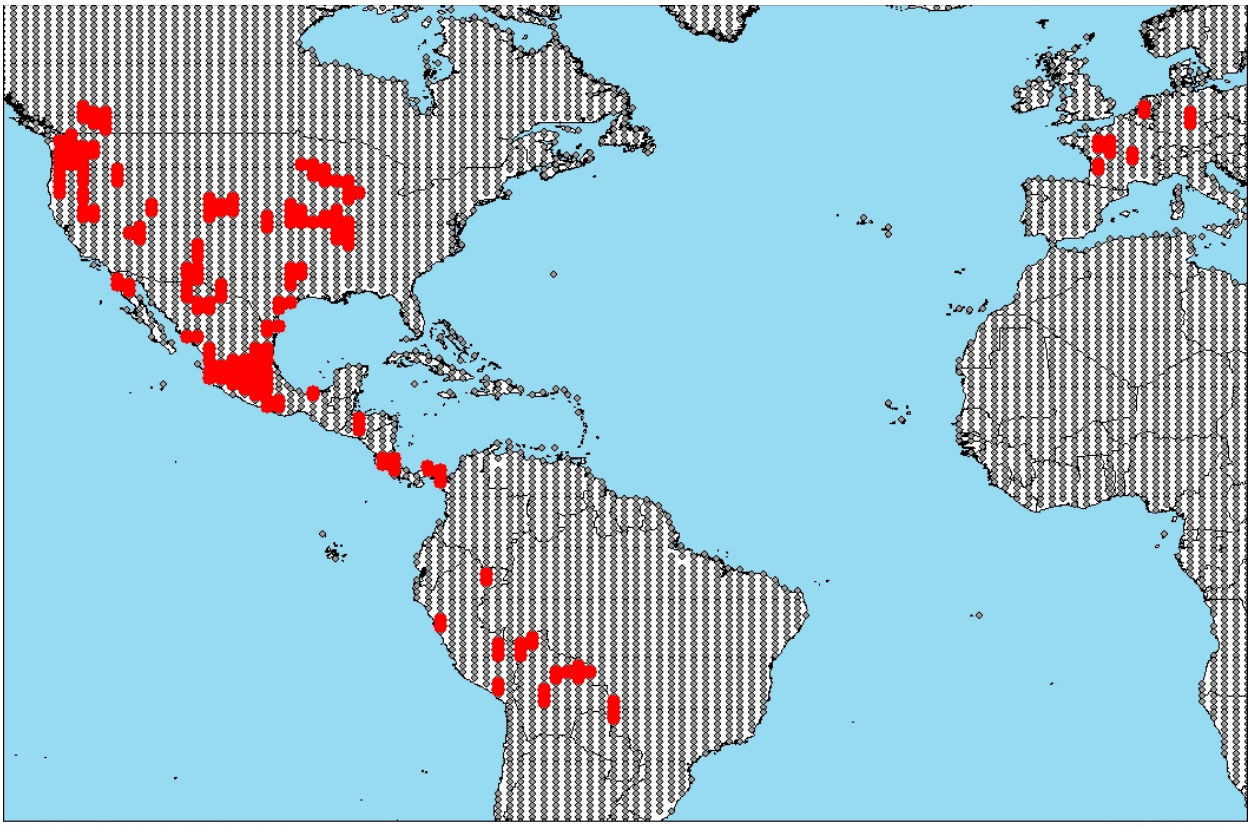
6 Distribution Within the United States

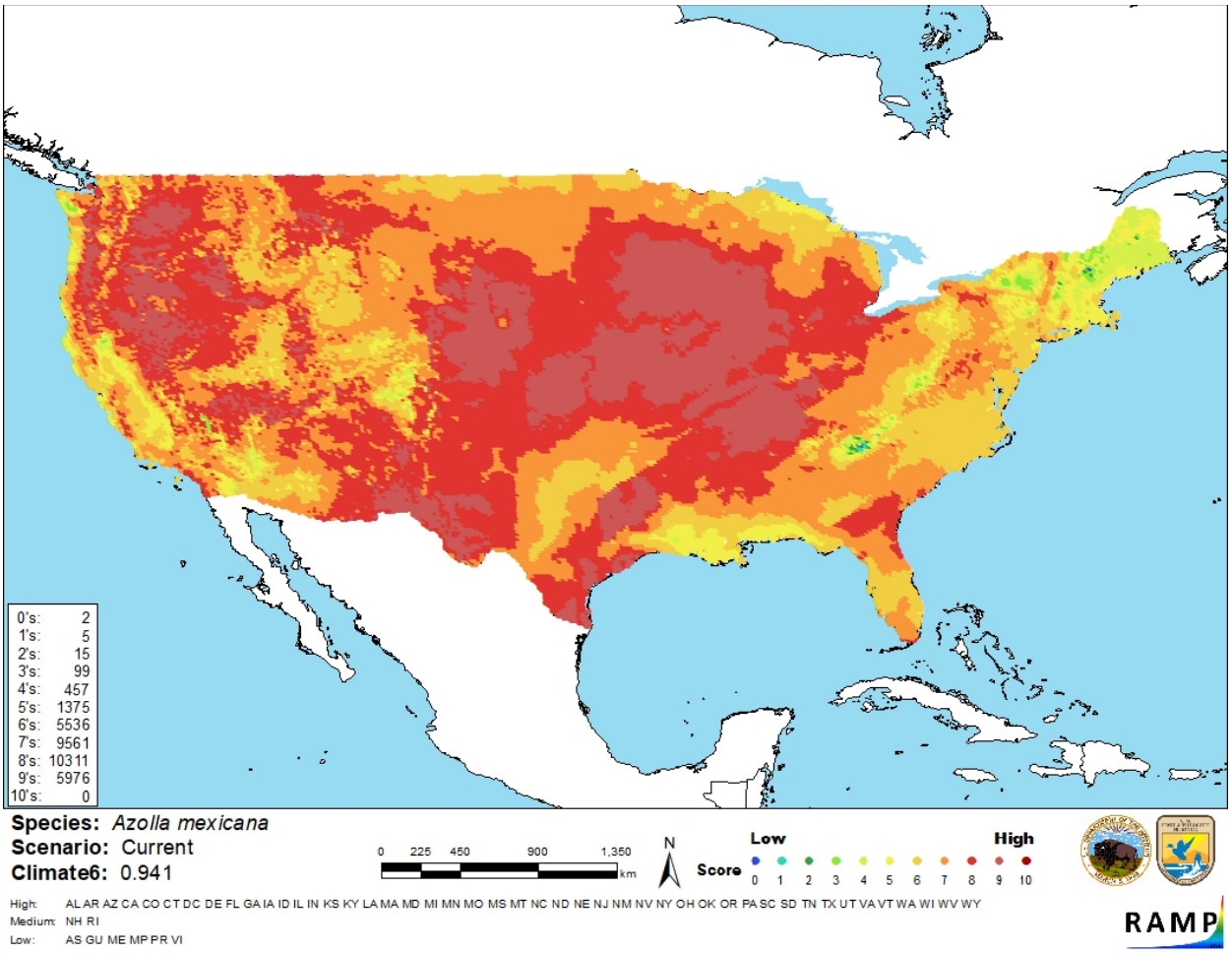


7 Climate Matching

Summary of Climate Matching Analysis

Most of the contiguous United States had a high climate match for *Azolla mexicana*. Areas of low to medium climate match were found in the Northeast, the southern Appalachian Range, and the Olympic Peninsula. There were other areas of medium match along the central Gulf Coast and in small areas in the Southwest and California. Everywhere else had a high match. Climate match was performed for the entire contiguous United States, which includes portions of the native range of *Azolla mexicana*. As expected, those areas had high climate matches. However, the eastern United States and upper Plains States, where *Azolla mexicana* is not native, still have areas of high matches. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.941, high (scores 0.103 and greater are classified as high). Rhode Island and New Hampshire had medium individual Climate 6 scores and Maine had a low individual climate score. All other States had high individual climate scores.


Species: Azolla mexicana
Selected Climate Stations
0 500 1,000 2,000 3,000
km
N
Selected
RAMP



The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Count of Climate Scores 6-10) / (Count of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

The certainty of this assessment is low. There was an adequate amount of biological and ecological information available for *Azolla mexicana*. Records of introductions were found but no records of impacts of those introductions. Uncertainty in the taxonomy of this genus reduces the overall certainty of the assessment.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Mexican mosquitofern (*Azolla mexicana*) is a small floating aquatic fern native to much of western North and South America, including the western and mid-western United States. It may have been introduced occasionally in the eastern United States. This fern is a nitrogen fixer and as such has been used as a green manure in agriculture, particularly in rice production. The history of invasiveness is classified as Data Deficient. There were records of introduction found for *Azolla mexicana*, with some resulting in established populations in Europe and India. No records of any impacts from those introductions were found. The overall climate match is high. *Azolla mexicana* is native to the western portions of North America, including the western United States. Many areas east of the Mississippi and upper Plains States, which are not in the native range, still have a high climate match. The certainty of assessment is low due to a lack of information regarding the introductions and impacts from introductions. The uncertainty in the taxonomy of the *Azolla* genus further reduces the certainty of assessment. The overall risk assessment category is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 3): Data Deficient**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Low**
- **Remarks/Important additional information:** The taxonomy of the *Azolla* genus is unresolved.
- **Overall Risk Assessment Category: Uncertain**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

BISON. 2021. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. Available: https://bison.usgs.gov (March 2021).

CABI. 2015. *Azolla mexicana*. In Invasive Species Compendium. Wallingford, UK: CAB International. Available: http://www.cabi.org/isc/datasheet/112634 (March 2015).

eFloras. 2008. *Azolla mexicana*. St. Louis: Missouri Botanical Garden; Cambridge, Massachusetts: Harvard University Herbaria. Available: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=233500221 (March 2015).

Environment and Climate Change Canada. 2017. Recovery Strategy for the Mexican Mosquito-fern (*Azolla mexicana*) in Canada. *Species at Risk Act* Recovery Strategy Series. Ottawa: Environment and Climate Change Canada.

GBIF Secretariat. 2021. GBIF backbone taxonomy: *Azolla mexicana* C. Presl. Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/11073901 (March 2021).

Gill C. 2005. Mexican mosquito fern, *Azolla mexicana*. Canada: Forsite.

Illinois [DNR] Department of Natural Resources. 2015. Aquatic life approved species list. Springfield: Illinois Department of Natural Resources. Available: https://www.ifishillinois.org/programs/aquaculture/aquatic_approved_species.pdf (November 2020).

[ITIS] Integrated Taxonomic Information System. 2015. *Azolla cristata* Kaulf. Reston, Virginia: Integrated Taxonomic Information System. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=898983 (March 2015).

NOBANIS. 2017. *Azolla mexicana*. In European Network on Invasive Alien Species. Available: https://www.nobanis.org/species-info/?taxaId=3393 (February 2017).

Peck JH. 2011. New and noteworthy additions to the Arkansas fern flora. Phytoneuron 30:1–33.

Puky M, Ács É, Bódis E, Borza P, Kiss KT, Tóth A. 2008. Invasive algae, plant, bivalve and crustacean species along the Hungarian Danube section: arrival time, colonisation characteristics, relative importance. Chisinau, Moldova: Proceedings of the 37th IAD Conference.

Roskov Y, Kunze T, Orrell T, Abucay L, Paglinawan L, Culham A, Bailly N, Kirk P, Bourgoin T, Baillargeon G, Decock W, De Wever A, Didžiulis V, editors. 2015. Leiden, the Netherlands: Species 2000 and ITIS Catalouge of Life, 2015 Annual Checklist. Species 2000: Naturalis. Available: http://www.catalogueoflife.org/col/details/species/id/8f46f6546e2dfc70dc94e86e26f398c9/synonym/2a41fcb14a3666fb108040f13275c7b3 (March 2015).

Sanders S, Castiglione C, Hoff M. 2018. Risk assessment mapping program: RAMP. Version 3.1. U.S. Fish and Wildlife Service.

Thiébaut G. 2007. Non-indigenous aquatic and semiaquatic plant species in France. Pages 209–229 in Gherardi F, editor. Biological invaders in inland waters: profiles, distribution, and threats. Netherlands: Springer.

Washington State Department of Ecology. 2015. *Azolla mexicana* C. Presl, Mexican water-fern. Aquatic Plants, Algae and Lakes. Available: http://www.ecy.wa.gov/programs/wq/plants/plantid2/descriptions/azomex.html (March 2015).

[WFO] World Flora Online. 2021. *Azolla mexicana* C. Presl. World Flora Online – a project of the World Flora Online Consortium. Available: http://www.worldfloraonline.org/taxon/wfo-0001110223 (March 2021).

11 Literature Cited in Quoted Material

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Environment Canada. No date. Species at Risk. Available: http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=223 (November 2005).

Royal [BC] British Columbia Museum. No date. Mexican mosquito fern. Available: https://www.royalbcmuseum.bc.ca/end_species/species/mfern.html (November 2005).

Steták D. 2006. Moszatpáfrányok *(Azolla mexicana* Presl, *Azolla filiculoides* Lam.). Pages 9–16 in Botta-Dukát Z, Mihály B, editors. Biológiai inváziók Magyarországon. Özönnövények II. Budapest: Környezetvédelmi és Vízügyi Minisztérium Természetvédelmi Hivatala.