

Recent Detection and Spread of a new type of *Trapa*, an Invasive Aquatic Plant, in the Potomac River Watershed

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For the first time in decades, the invasive nonnative species, water chestnut (genus *Trapa*) was found in the tidal Potomac River in Pohick Bay, 2014 (reported by Odenkirk, VGIF).



At first it was identified as *Trapa natans*



Research presented is collaborative among USGS, Lynde Dodd (ERDC) and Ryan A Thum (MSU)

Problematic in the northeastern United States since the latter half of the 19th century

Aggressive growth negatively influences aquatic ecosystem biodiversity and function, and impedes hydroelectric, irrigation, and recreation

PROTECT YOUR POTOMAC RIVER

Stop the spread of aquatic invasives



WATER CHESTNUT HAS BEEN FOUND ON THE VIRGINIA SIDE OF THE POTOMAC RIVER IN POHICK BAY. IT FLOATS AT THE SURFACE DURING LOW TIDES AND TYPICALLY OCCURS IN SMALLER COVES.

Water chestnut (*Trapa natans*) is a floating aquatic plant native to Asia. It is an invasive species that spreads quickly, wipes out native bay grasses, prevents water access and recreation where it occurs and creates breeding grounds for mosquitoes. The seeds have four hard, half-inch spines that are sharp enough to penetrate shoe leather.

REPORT FINDINGS TO

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dnr.maryland.gov/invasives



This signage was placed at Potomac River boat ramps

PRICE 15¢

SCIENCE NEWS LETTER

THE WEEKLY SUMMARY OF CURRENT SCIENCE •



September 20, 1941

River Pest

See Page 182

A S C I E N C E S E R V I C E P U B L I C A T I O N

Background: *Trapa natans* was discovered in the Potomac in 1920s, and quickly spread 5 miles up and 35 miles down the freshwater portion of the river. It spread from Washington DC to Quantico, VA by 1941 where it obstructed navigation (Photo).

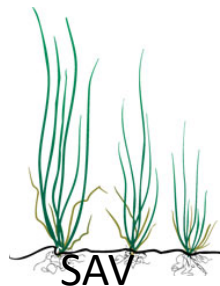
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The 2 inch long, hard and spiny seed pods pierced the feet of river beachcombers.

Through shading it competed with native submerged aquatic vegetation (SAV) that was considered preferable fish and waterfowl habitat.

Between 1939 and 1945, the US Army Corp of Engineers brought Water chestnut under control with mechanical harvesters (3.7 million dollars (converted to current dollars)).

For decades afterwards the fresh- tidal Potomac River was devoid of SAV.



Source: <https://www.sciencenews.org/sn-magazine/september-20-1941>; Martin and Uhler 1939; Naylor, 2004

In September 2014, after discovering the colony, Virginia Game and Inland Fisheries coordinated a harvest



A
Hand pulled, each bushel basket counted



B
Harvested plants moved to upland site

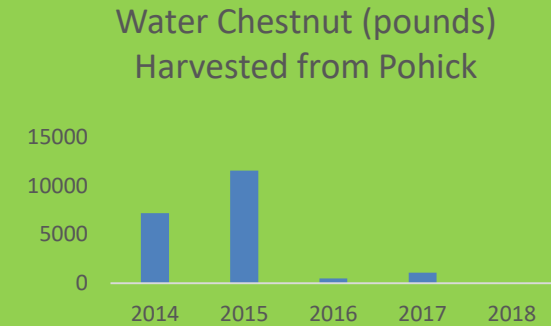


C



D

E



Source: John Odenkirk, (Virginia Game and Inland Fisheries Program)

Photos A, B, C, D are of 2014 water chestnut harvest at Pohick Bay, Lorton, Virginia on the Potomac River (VGIF, Northern Virginia Regional Park Authority, NVRPA, and numerous volunteers).

Plot E, Pounds harvested has diminished especially after 2015 when the harvesting period was adjusted to July, before the plants initiated fruit production.

In 2014, USGS began a study at Pohick Bay and collected specimens and measured productivity

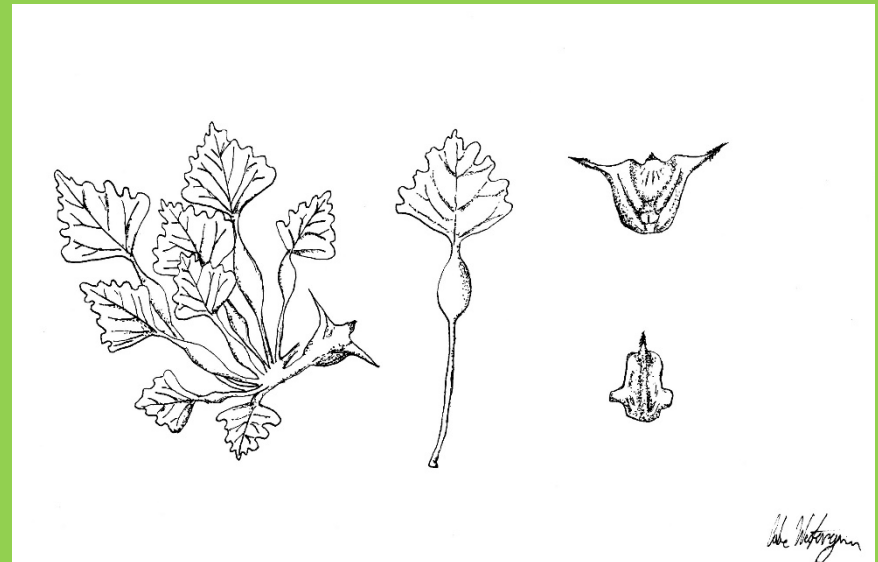
US *Trapa natans* has four horned fruit, but we discovered this Pohick Bay colony was a two horned type!

Water chestnut at Pohick Bay was equally as productive as NE US *Trapa natans* but the fruit and flower were different in appearance.

This information lead to a new study to determine the distribution, name and ecology of this different type of water chestnut plant, first steps in developing a early detection and eradication program.



Sept 5 2014, measuring *Trapa* sp. plant biomass (889 g dry weight m⁻²)

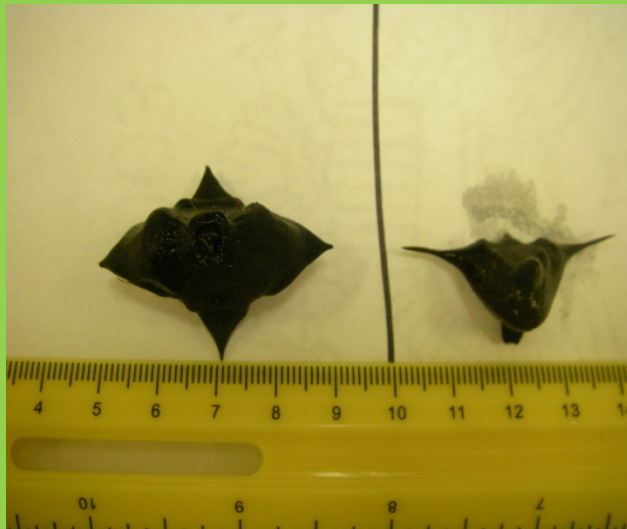


Line drawing of the new *Trapa* sp, by Gabe Westergren

Trapa (water chestnut) can be difficult to identify:

Many species of *Trapa* are described in Eurasia.

A key characteristic in differentiating species in this genus is the number of barbed spines (0, 2, 3, or 4) projecting from the fruit. Because of morphological variations there is little agreement about the number of species in the *Trapa* genus. Problem: the naming convention of *Trapa* species vary by country and within a country.



The photograph shows a comparison of the fruits of *Trapa natans* in Maryland (left) and *Trapa* sp. in Virginia (right).

Background:

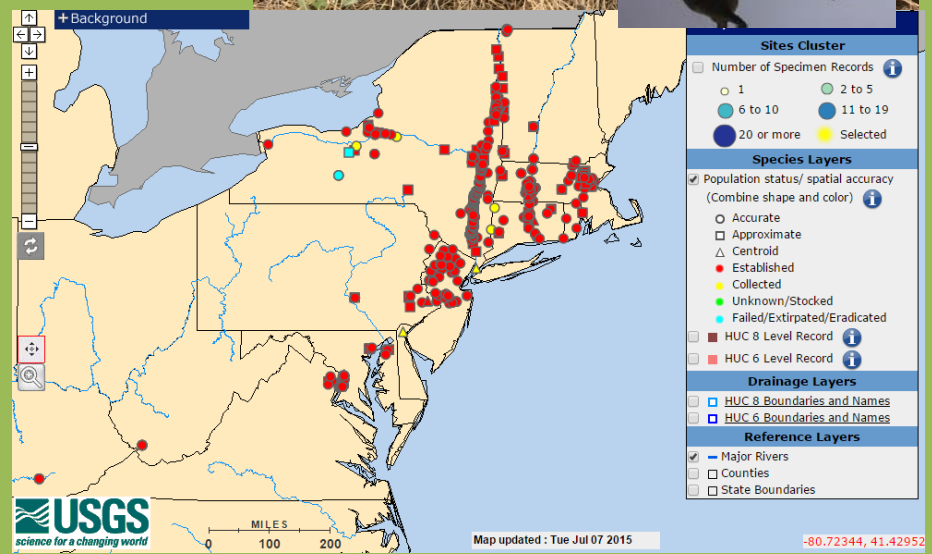
Water chestnut (*Trapa*) is an aquatic annual herb. It has edible fruit with medicinal qualities. It sprouts from seeds in spring and plants die off after a hard frost. Seeds can be found along the shoreline of waterbodies, even in winter. Some seeds are dormant in the sediment for years. Its tolerant of freshwater only.

Trapa seed cases (hollow) washed up on shoreline of a golf course pond



Water chestnut is native to Europe, Asia and tropical Africa. Its US distribution is limited to the NE US.

Map of current extent of observed *T. natans* in the United States (USGS, 2015)



Study Objectives in 2014 and 2015-

- Provide natural resource managers information about this previously unreported taxon in the Northeast United States.
- Investigate its local distribution and mode of dispersal.
- Compare characteristics of the two-horn *Trapa* sp. in Virginia with *T. natans* in other parts of the US and with other species described in the worldwide literature on *Trapa* spp



Fruit and reddish underside of leaf,
Trapa sp.



Pale pink flower and fruit,
Trapa sp. (ruler, cm scale)



A



B



C



D



E



F

Dispersal 2015-

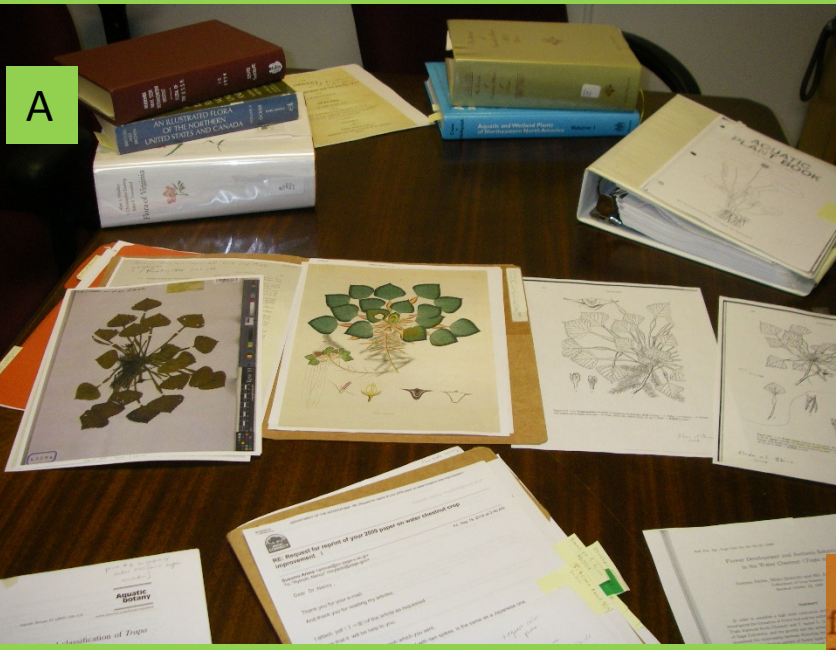
Photographs taken at Nutley Pond in Vienna, Virginia show the potential transport mechanisms for *Trapa* sp. A) Nutley Pond had a spillway that flowed into a tributary that is located 24 km upstream of Pohick Bay. Floating rosettes and seeds of *Trapa* sp. litter the spillway and are swept downstream during high flow events; B) Resident Canada geese (*Branta canadensis*) foraged in *Trapa* sp. beds in the pond; C to F) Barbed seeds of *Trapa* sp. cling onto geese plumage and seeds may be transported short distances by geese in flight. (Photo credit Libby Spence and other volunteers)



Characteristics:

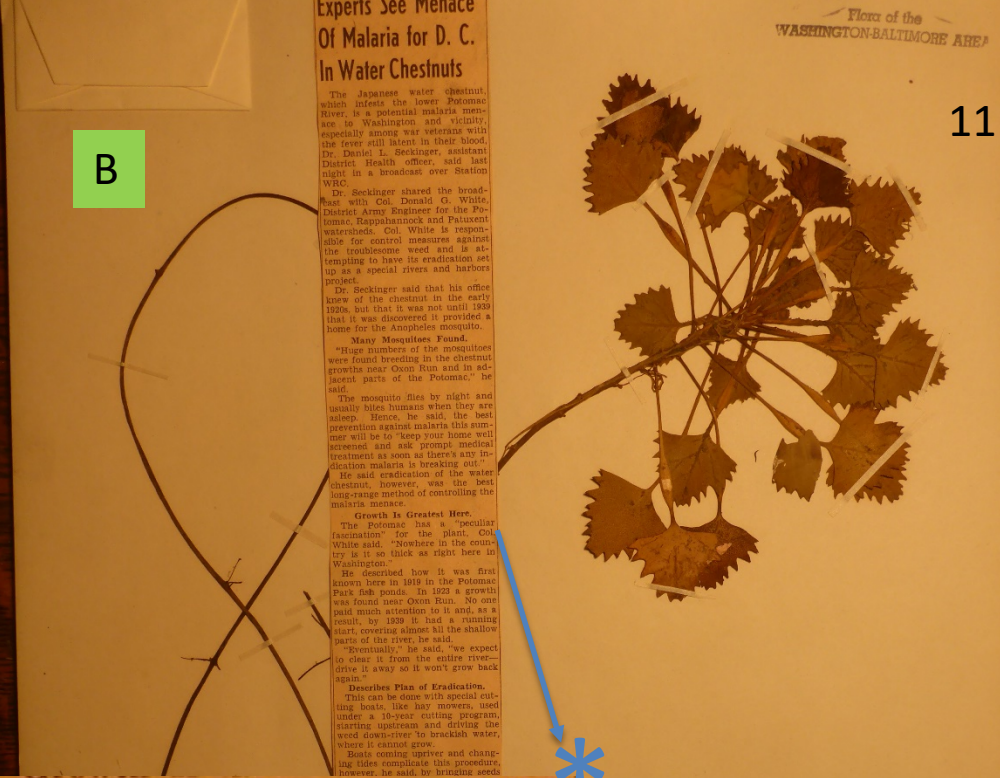
***Trapa* sp. 2-spine fruit 30 to 50 mm wide (left) and pink flower (right) collected from the Potomac River September 2016, Virginia.**

I reviewed the literature and I corresponded with *Trapa* specialists around the world to determine where the 2 horn *Trapa* may have originated (A).



I also reviewed the local Smithsonian and National Arboretum herbariums and saw no evidence of 2 horn *Trapa* in the US before now (B).

Attached to a *T. natans* specimen at the Smithsonian, I found a newspaper article “Experts see menace of malaria in DC in Water Chestnut” 1946, Evening Star *



The Potomac has a “peculiar fascination” for the plant, Col. White said. “Nowhere in the country is it so thick as right here in Washington.”

He described how it was first known here in 1919 in the Potomac Park fish ponds. In 1923 a growth was found near Oxon Run. No one paid much attention to it and, as a result, by 1939 it had a running start, covering almost all the shallow parts of the river, he said.

“Eventually,” he said, “we expect to clear it from the entire river—drive it away so it won’t grow back again.”



Review of over 25 journal articles and numerous Flora books written in English was used to create a list of all names and characteristics, then reduced to these best candidates for the potential name of the *Trapa* spreading, un-noticed until recently, in Virginia

Literature review : List of *Trapa* species with 2 horns and 30 to 50 mm wide..

Species name	Country of origin	Number of spines on fruit	Fruit Width (mm)	Fruit weight (g)	Flower color	Citation
<i>T. japonica</i> Flerov	Japan	2	ND	1.41	ND	Hoque et al. 2005
<i>T. natans</i> L.	Korea	2	ND	1.83	ND	Hoque et al. 2005
<i>T. bispinosa</i> Roxb. var. <i>iinumai</i>	Taiwan	2	30-50 [^]	ND	white/rose	Hsieh 1994
<i>T. japonica</i> sensu Ohwi (1965)	Japan	2	30-50	ND	ND	Kadono 1987
<i>T. japonica</i> Flerov	Japan	2	ND	ND	ND	Kadono 1994
<i>T. japonica</i> Flerov	Japan	2	30-40 [^]	ND	white/rose	Ohwi 1953
<i>T. japonica</i> Flerov	Japan	2 ^{**}	ND	ND	ND	Otaki 1980
<i>T. japonica</i> Flerov	Korea	2	30-40	ND	ND	Park 2007
<i>T. komarovii</i> V. Vassil.	Russia, Japan, China	2 (3)	36-40 [*]	ND	ND	Shishkin 1949
<i>T. korshinsky</i> f. <i>ambigua</i> V. Vassil.	Russia	2 (3)	25-35 [*]	ND	ND	Shishkin 1949
<i>T. korshinsky</i> V. Vassil.	Russia, Japan, China, Korea	2	30-40 [*]	ND	ND	Shishkin 1949
<i>T. litwinowii</i> V. Vassil.	Russia, Japan, China	2	36-46 [*]	ND	ND	Shishkin 1949
<i>T. bicornis</i> var. <i>iinumai</i> (= <i>T. japonica</i>)	Japan	2	30-50	ND	ND	Takano and Kadono 2005
<i>T. bicornis</i> var. <i>makinoa</i>	Japan	2	30-50	ND	ND	Takano and Kadono 2005

Next steps (2016-2018)

- collaborate with Greg Chorak, Lynde Dodd, Kadiera Ingram, Murat Buyukyoruk, Yasuro Kadono, Yuan Yuan Chen and Ryan Thum:

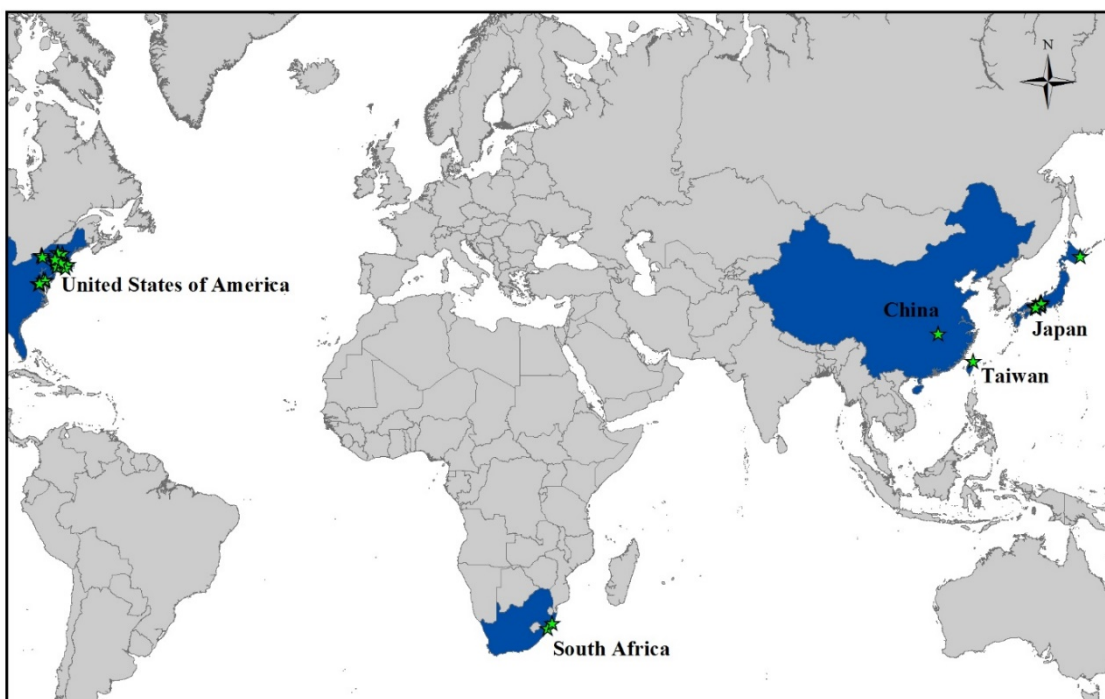
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Determine if *Trapa* sp is morphologically and genetically distinct from other water chestnut populations

Collect *Trapa* samples from populations in VA, the NE US outside VA, S. Africa, China and Japan

Describe the morphology of the leaf and fruits for each of 22 population

Conduct molecular analysis using amplified fragment length polymorphism (AFLP) markers (method from Li et al. 2017)



Map of 22 populations (Chorak, et al. 2019, Aquatic Botany)

Columns show the dry fruit specimens of some of the *Trapa* in our study:

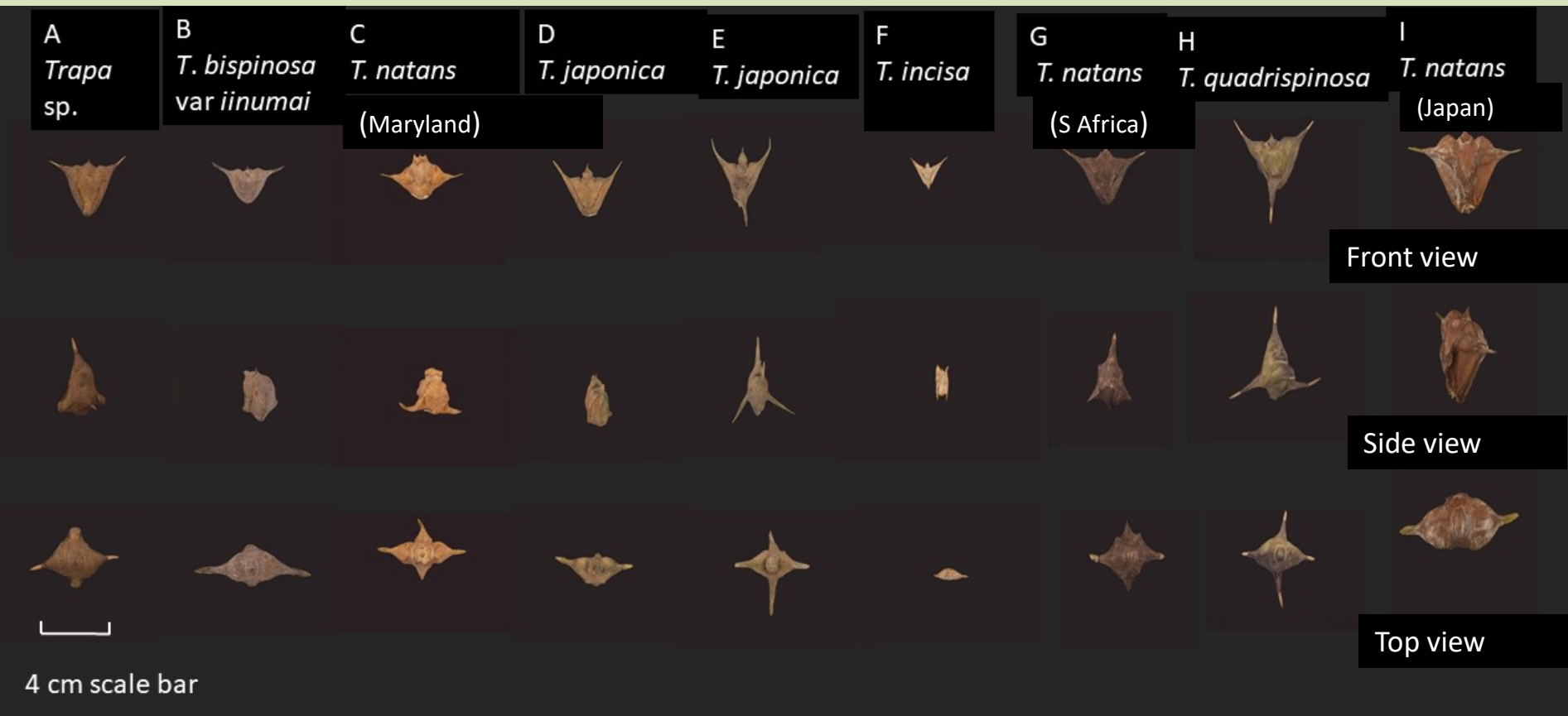
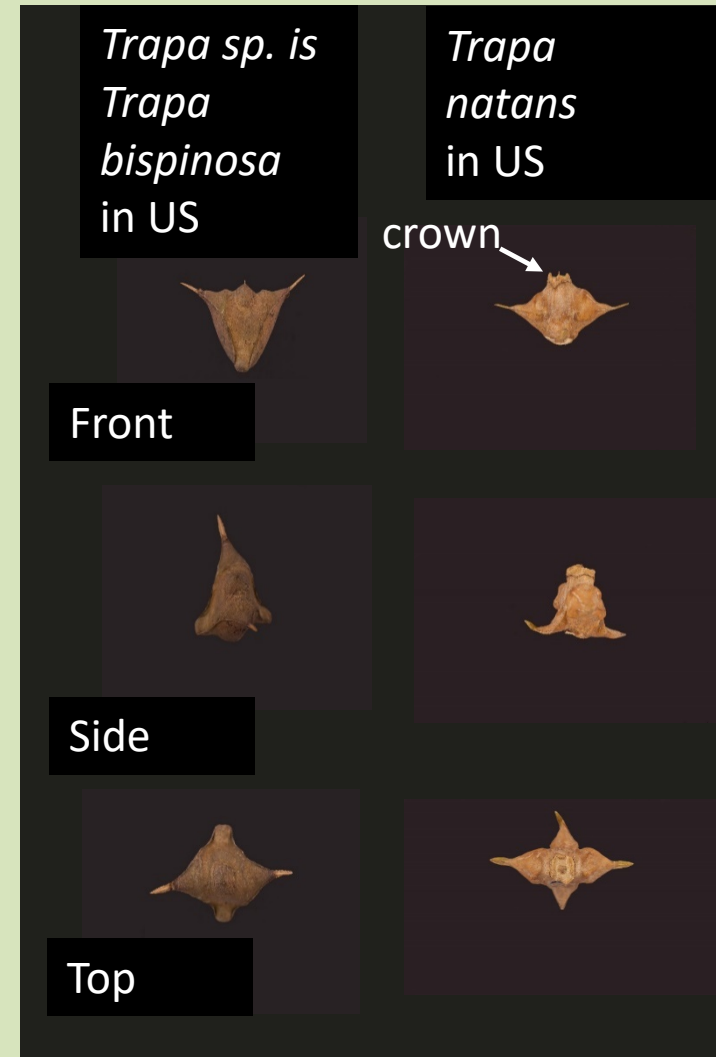


Figure 1 -Photographs of dry fruit specimens of *Trapa* in our study. Species (location) and specimen number: *Trapa* sp. (US), WP-VA_1 (Column A); *T. bispinosa* var *iinumai* (Taiwan), SLR-TW_11 (Column B); *T. natans* (US), BR-MD_1 (Column C); *T. japonica* (Japan), ONO-J_1 (Column D); *T. japonica* (Japan), ONO-J_6 (Column E); *T. incisa* (Japan), NAK-J_18 (Column F); *T. natans* (S. Africa), EM-KZN_13 (Column G); *T. quadrispinosa* (China), HB-C_12 (Column H); *T. natans* (Japan), TEM-J_1 (Column I). Top, middle and bottom row are front, side and top view. (See Appendix B for list of specimens and their morphological attributes)

Source “Cryptic introduction of water chestnut (*Trapa*) in the northeastern United States”
 Chorak, G. M., Dodd, L. L., N. Rybicki, K. Ingram, M. Buyukyoruk, Y. Kadono, Y. Y. Chen, and R. A. Thum. (*Aquatic Botany*, 2019).

- US *Trapa natans* has four horned fruits, but a two horned type of *Trapa* was discovered recently
- DNA and morphological data reveal this as a cryptic invasion of a distinct *Trapa*
- The newly discovered US *Trapa* is identified as *T. bispinosa* Roxb. var. *iinumai* in Taiwan
- Distinguishing these two US *Trapa* taxa will be important for documenting spread and identifying new populations
- Need for a world wide review to clarify the taxonomy of *Trapa*

In the US, the newly-recognized *Trapa* has pink flowers, the fruit has two sharp horns and lacks a crown and the underside of its leaf is reddish. *T. natans* has white flowers, four horns and a prominent crown and the underside of the leaf is green.



Phenology Study Method- Four sites, Waples Pond (WP-VA), Myrtle Leaf Pond (ML-VA), Pohick Bay (PB-VA) and Industrial Pond (IR-VA) were observed at 2-week intervals, 8 rosettes collected each date.

Results-In 2017 *Trapa* sp initiated flowers and fruits in early to mid July, in contrast to *T. natans* that flowers in mid June in MD.

Percentage of Sampled Rosettes that are Reproductive (Flowering and/or Fruiting) n=8					
Days Since Summer Solstice (6/21/2017)	Date	WP-VA	ML-VA	PB-VA	IR-VA
-11	6/10/2017				0
-3	6/18/2017			0	
-1	6/20/2017	0	0		
12	7/3/2017		62.5		
14	7/5/2017	100		0	0
27	7/18/2017	100	100	50	100
41	8/1/2017		100		100
42	8/2/2017	100			

Phenology varies by year and site.

GMU phenology study 2019, seven sites: At least 1 of 7 sites flowered before the solstice. On 6/3, 6/11, and 6/21 flowers on 25%, 88%, and 88% of the plants and the pond was 70% covered with *Trapa bispinosa*.

Waples Mill Rd Pond July 2017
(jurisdiction, Fairfax Park Authority)



Pohick Bay early July 2017 (jurisdiction, tidal water and NVRPA) 17



Myrtle Leaf Road Pond August 2017,
(jurisdiction, Fairfax county)



Industrial Road Pond August 2017 (private pond)

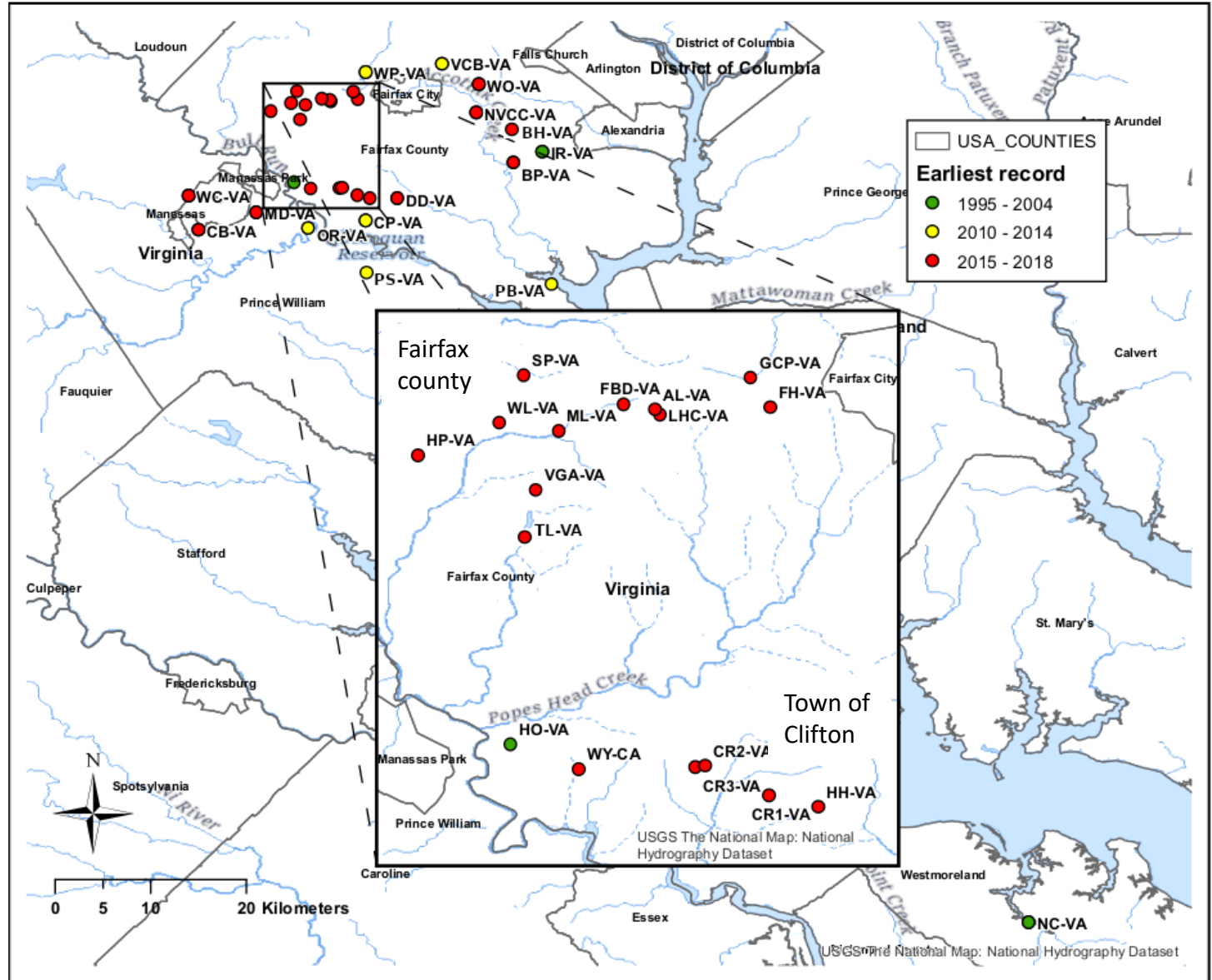




In 2017, the Industrial Pond *Trapa* 18
sp. bed was the largest colony
(26,000 square meters).
First documented in 2000 (GMU
herbarium specimen, mis-
identified as *T. natans*), and
covers 50% of the pond. The
company was unaware of *Trapa*
until I contacted them. **In 2018**
they reported that they had a
contract with a local pond
management company to treat
the pond.

The next largest colony (8600
square meters) was Wellington
Road, a federal facility, was first
noticed in 2016 by the property
maintenance contractor and
reported to VGIF in fall 2017 who
informed me. **In 2018 they have**
no treatment plan.

We have verified *Trapa* sp. in Virginia in about 8, 18, and 33 sites in 2016, 2017, and 2018, respectively. 3 sites in Prince William county, 9 sites in the Clifton city limits. Many of these ponds and lakes are not well monitored or managed. **No EDRR plan. No funding for further investigations on pace of spread.**



2018 Acres of Trapa	Site Code	Jurisdiction	Treatment	Site name	Initial year	N
0	BP-VA	FFX SW	Herbicide	Brookfield Pond	2017	1
0	FBD-VA	FFX SW	Herbicide	Fairfax County Bus Depot	2017	2
0	GCP-VA	FFX SW	Herbicide	Fairfax Government Cent	2012	3
0	LHC-VA	FFX SW	Herbicide	Lee Highway Costco	2017	4
0	ML-VA	FFX SW	Herbicide	Myrtle Leaf Pond	2018	5
0	PB-VA	NVRP	Mechanical	Pohick Bay	2013	6
0	PS-VA	Prince William	Herbicide	Pfizer Stadium (PW) Pri	2014	7
0	CP-VA	Private	Mechanical	Clifton Pond	2010	8
0	DD-VA	Private	Herbicide	Fairfax Station, pond on D	2014	9
0	HH-VA	Private	Mechanical	Fairfax Station, 11309 Hu	2018	10
0	IR-VA	Private	Herbicide	Industrial Pond	2000	11
0	NVCC-VA	Private	Mechanical	Annandale, NVCC Annan	2016	12
0	VCB-VA	Private	died out	Nutley Pond, 2721 Baront	2010	13
0	MD-VA	Private	H and M	Miller Drive Pond (PW) (8	2014	14
0	BH-VA	Private	H and M	Brook Hill Dr. Pond, 4913	2014	15
0	OR-VA	Tributary	Mechanical	Occoquan Reservoir (PW)	2010	16
?	NC-VA	unknown		Pond Mt Holly, Near Nom	1995	17
0.01	FH-VA	Private	H and M	Forest Hills Community, p	2010	18
0.03	AL-VA	Private	none	4890 ALLIANCE DR, Fai	2017	19
0.04	SP-VA	Private	none	Stringfellow Park n Ride (2017	20
0.08	HP-VA	Private	none	H-mart Retention Pond, C	2017	21
0.10	WY-CA	Private	none	12900 Wyckland Dr, Cliftc	2010	22
0.16	WP-VA	FCPA	none	Waples Pond	2010	23
0.17	WO-VA	Private	none	Willow Oak Corporate Dri	2015	24
0.17	WL-VA	FFX SW	treat if persists	13431 WOOD LILLY LN,	2018	25
0.22	HO-VA	NVRP	none	Hemlock Overlook 13220	2014	26
0.29	CR3-VA	Private	none	7398 Clifton Road, Clifton	?	27
0.34	CR2-VA	Private	none	7401 Clifton Road, Clifton	?	28
0.48	CR1-VA	Private	none	7518 Clifton Rd, clifton, V.	?	29
0.99	CB-VA	Private	none	10552 Coral Berry Drive,	2018	30
2.14	WC-VA	Federal	none	Wellington Road Contract	2016	31
2.70	VGA-VA	Private	none	Virginia Golf Academy, 58	?	32
6.74	TL-VA	FCPA	partial treatment	Twin Lakes Golf Ponds (6	2000	33

Table shows acres of *Trapa* at the end of 2018. 33 sites were verified by USGS in 2018 (30 in Fairfax). Six are Fairfax county storm water ponds (FFX SW). The initial year colonized varies from 1995 to 2018.

16 sites were treated and had no *Trapa* reported at end of 2018.

Pohick Bay was harvested since 2014 and Occoquan reservoir was harvested in 2010 by VGIF.

Treatment began in 2017 or 2018 for most other sites.

Most colonies were < 1 acres except, Twin Lakes (2 lakes), Virginia Golf Academy (6 ponds), and Wellington Road Federal facility (1 lake) totaled 6.7, 2.7 and 2.1 acres of *Trapa bispinosa*, respectively

Management of *Trapa*:

Invasive *Trapa* populations in the US are typically managed with hand-pulling or treatment with herbicides.

In both cases, the ideal timing of control is before seed set in order to reduce the number of seeds available for recolonization the following growing season.

For two-horn *Trapa* in Virginia management by mid-July is best.

If *Trapa* is pulled up before it fruits it can be composted in a corral in the water but if seeds have formed the pulled plants should be composted in an upland site



B

21

Long handled throw rake and line used to pull up plants



C

Simple single wire fence to deter geese from entering pond. Goose dispersal can be inhibited if ponds are fenced or geese populations are controlled.



A

Photo courtesy of Mike Naylor

Urgent need for *Trapa* early detection and rapid response (EDRR):

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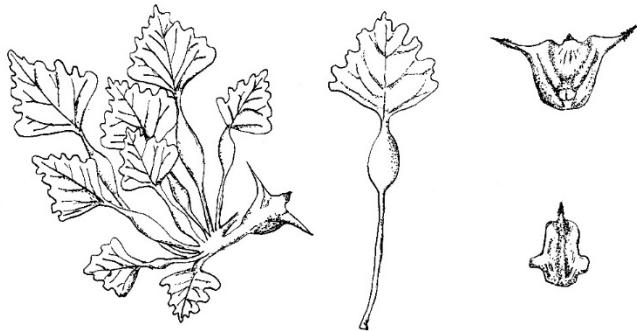
If water chestnut is allowed to establish itself in ponds it could spread back into tidal waters, we could face an epic control challenge that would both undo past decades of successful eradication effort and undermine more recent estuarine water quality improvements that have resulted in restoration of an increasingly diverse and abundant population of submersed aquatic vegetation.



Help Stop the Spread of *Trapa bispinosa*, a New Invasive Aquatic Species of Water Chestnut in the Potomac River Watershed:

Report this or other invasive aquatic species to the US Geological Survey's Nonindigenous aquatic species web site

(<https://nas.er.usgs.gov/SightingReport.aspx>), iNaturalist, or University of Georgia Center for Invasive Species and Ecosystem Health's Early Detection and Distribution Mapping System (EDDMapS)



John W. Hartman

Trapa bispinosa leaves and seed

Literature review and current data suggest that early detection and rapid response could help manage the distribution and spread of *Trapa bispinosa*.

Management by early to mid July is very successful in eradicating the plants but it may take several years of effort, if some seeds fall before harvested.

More information:

Distribution map (*Trapa*

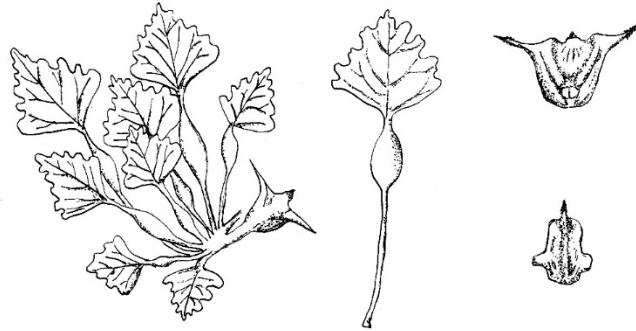
bispinosa): <https://nas.er.usgs.gov/viewer/omap.aspx?id=f3a647f4-6906-4928-b5b4-1421cd95a211>

Identification and reporting *Trapa bispinosa*: <http://mdinvasives.org/iotm/june-2018/>

Scientific article (available

from Nrybicki@usgs.gov): <https://doi.org/10.1016/j.aquabot.2019.02.006>

Technical Report: <https://erdc-library.erdcdren.mil/xmlui/handle/11681/32506>



Trapa bispinosa leaves and seed

Lynde Dodd

More information herbicide studies:

[Lynde Dodd](#), lynedodd@laerf.org, Research Biologist, USACE | ERDC | EL | 972-436-2215 x 221 o | 769-666-8777 c

More information DNA studies:

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Acknowledgments

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Many additional acknowledgements are included in Chorak et al, 2019.

THE END