Phenology of *Trapa bispinosa* in Northern Virginia Ponds

Sujata Poudel, R. C. Jones & NB. Rybicki
George Mason University, Fairfax, VA

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Abstract

Eurasian water chestnut (*Trapa natans)*, have plagued the northeastern US, including the tidal Potomac for over 100 years. In 2014, a new species of invasive water chestnut identified as two-horned water chestnut (*Trapa bispinosa* Roxb. var *iinumai Nakano*) was discovered in the Potomac River and in subsequent years it has spread to more than 80 waterbodies in VA.
The purpose of this study is to describe the phenology of *T. bispinosa*. Structured observational studies were conducted at two ponds in northern Virginia in 2019 and 2020. *T. bispinosa* initiated growth in late April, increasing rapidly to a maximum in June. Rosette diameters increased gradually from late April to a maximum in August and September. This increase in rosette size was strongly correlated with degree days and calendar days and is consistent among ponds and between years. Flower and fruit counts were zero from April through June, then increased rapidly to maximum in the fall. Since the species is annual and dependent on sexual reproduction, control efforts for *T. bispinosa* should be initiated before fruits are produced. Based upon our data, in the mid-Atlantic region, May would be an ideal time to begin the treatment for its control as rosettes should be observable, but flowers and fruit should not appear until late June. These studies indicate aquatic managers may have a four to six week window in the late spring to prevent seed production and should focus resources on management during that time period.

Introduction

Trapa bispinosa was introduced at some undetermined time and place and remained cryptic for a number of years until a large enough outbreak occurred to merit notice. *Trapa* bears pink flowers and forms two-horned fruits with two small pseudo-spines with no prominent crown (Figures 4 and 5). The vast majority of *Trapa* rosettes have leaves with pink to dark red undersides. The long anchoring stems can reach up to 4 m deep. Like other *Trapa* species, in addition to the floating leaf rosette, it has feathery underwater leaves at each node of the submersed stem. Adventitious roots grow down into the substrate from the lower nodes. Most of the ecological data available for this genus has been derived from studies of *T. natans* which has spread throughout the northeastern U.S (Naylor 2003).
Water chestnut creates a canopy that interrupts the passage of light through the water (Groth et al. 1996) thereby inhibiting photosynthesis by submersed aquatic vegetation trying to grow below it. Light levels were reduced by over 95% below a *T. natans* bed in the tidal Hudson River as compared with a nearby *Vallisneria americana* bed (Caraco and Cole 2002).
The dispersal of water chestnut is facilitated by both natural and human-mediated vector. Its barbed seeds can attach to fish nets, boats, birds and other animals . A probable mode of dispersal is resident Canada geese (*Branta canadensis*); *Trapa* spp. seeds cling to goose plumage and may be transported locally by geese. Managers in Virginia and Maryland are concerned that if *T. bispinosa* in the Potomac River watershed is allowed to establish in ponds, it could soon spread back to tidal waters. This would create a management challenge that would undo past decades of successful eradication and undermine more recent estuarine water quality improvements. Thus, continuous monitoring and early detection and rapid response (EDRR) are needed to control its rapid spread.

Study Area

The study was conducted in two ponds, Virginia Golf Academy (VGA) and H-mart Pond (HP) in 2019 and 2020 (Figure 1). These ponds are located in the Bull Run subwatershed of the Potomac River about 2.5 km apart. VGA had an area of 0.38 ha with inputs consisting mostly of golf course runoff while HP had a smaller area of 0.12 ha and received inputs mainly from a shopping center parking lot.

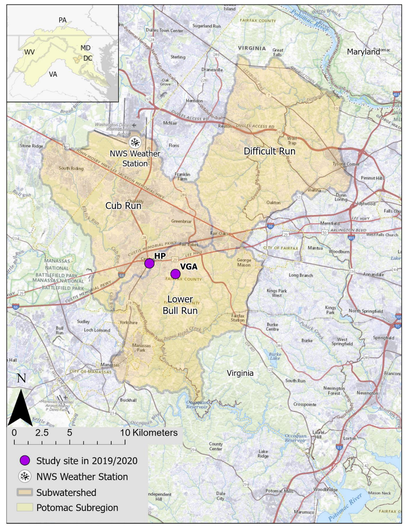


Fig. 1. *T. bispinosa* study ponds and weather station in Fairfax County, Virginia.

Materials and Methods

- VGA - sampled weekly; HP-sampled bi-weekly; in 2019 & 2020.
- The whole pond maximum coverage was estimated by visual observation.
- Three locations ~ ten meters apart, were chosen along a consistent stretch of the vegetated shoreline and three replicate quadrats sampled at each location.
- Quadrat coverage of *Trapa* was assessed by using 1 m^2 quadrat divided into 100 (10 by 10) cells (Figure 2).
- Cells with any *T. bispinosa* leaves present were noted and tallied to get a number from 0 to 100 (the total number of cells) for each quadrat.
- Water temperature was measured in each pond on each date using a YSI ProDDS minisonde.
- For the phenology, 3 representative plants were chosen randomly from each of the three quadrats at each of the three sampling locations in each pond. Nine plants were sampled from each pond whenever possible. Debris on the rosette was rinsed and the plants were placed in plastic bags and processed within 24-48 hours of collection (Figure 3).
- Mean and standard error of RD was calculated for each site visit and flower numbers (FL) and fruit numbers (FR) were recorded. Mean and standard error of RD, FL, and FR were calculated.
- Air degree days (ADD) and Water Degree Days (WDD) were calculated, and statistical analysis was done.

Fig. 2. Quadrat used for sampling *T. bispinosa* coverage (QC). Whole quadrat is 1 m x 1 m and is divided into 100 squares each 0.1 m x 0.1 m.

Fig. 3. *T. bispinosa* Rosette Measurement

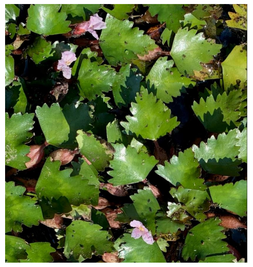


Fig. 4. *T. bispinosa* with pink flowers

Fig. 5. *T. bispinosa* with different stages of fruits

Results and Conclusion

Trapa Coverage

For *T. bispinosa* quadrat coverage, a consistent seasonal pattern was observed with a rapid increase from the first appearance of rosettes in late April to a maxima of 85-100% by mid-June in 2020 (Table 1).

Pond Name	VGA	HP
Latitude (°)	38.82867	38.83673
Longitude (°)	-77.40161	-77.42897
Pond Area (ha)	0.38	0.12
Frequency of Observation	Weekly	Bi-weekly
Max. Pond Coverage (%)	85	100
Initial Year of Colonization	2016	2015

Flowers were absent during the early growth period of the rosettes and were first observed in mid- to late June in both years and both ponds (Table 2).

Pond Name	VGA	HP
Rosettes First Observed in 2020	23-Apr	30-Apr
Quadrat Coverage Reaches 100% in 2020	12-Jun	19-Jun
First Flower Observed in 2019	11-Jun	21-Jun
First Fruit Observed in 2019	21-Jun	12-Jul
First Flower Observed in 2020	26-Jun	3-Jul
First Fruit Observed in 2020	10-Jul	16-Jul

Once flowers were present, FL increased rapidly within two to four weeks and reaching a maximum of approximately 2 to 3 flowers plant^{-1} in August with substantial variability. Subsequent values declined to approximately 1 to 1.5 flowers plant^{-1} (Figure 6).

Results and Conclusions (cont'd)

Correlation analysis was conducted on phenological variables, air and water temperature, CD, ADD, and WDD for the 2020 data from both ponds . A highly significant correlation was observed between RD and FL and between RD and FR (Table 3).

Pearson Correlation Matrix	Rosette Diameter (RD)	Flowers Plant^{-1} (FL)	Fruits Plant^{-1} (FR)	Cal. Days (CD)	Air Temp (°C)	Water Temp (°C)	Air Degree Days (ADD)	Water Degree Days (WDD)
Rosette Diameter (RD)	1							
Flowers Plant^{-1} (FL)	0.797	1						
Fruits Plant^{-1} (FR)	0.788	0.574	1					
Calendar Days (CD)	0.937	0.762	0.799	1				
Air Temp (°C)	0.532	0.470	0.224	0.415	1			
Water Temp (°C)	0.389	0.351	0.031	0.244	0.951	1		
Air Degree Days (ADD)	0.901	0.782	0.808	0.977	0.355	0.179	1	
Water Degree Days (WDD)	0.92	0.779	0.816	0.995	0.393	0.217	0.983	1

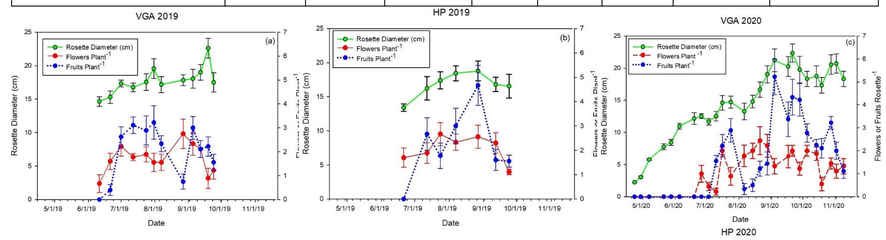
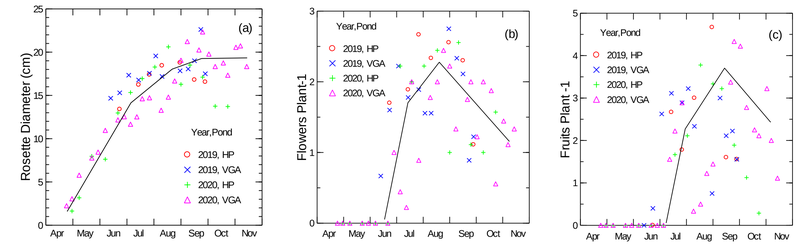


Fig. 6. Seasonal progression of Rosette Diameter (RD), Flowers Plant^{-1} (FL), and Fruits Plant^{-1} (FR) at each pond in each year. (a) VGA 2019 (b) HP 2019 (c) VGA 2020 (d) HP 2020. Mean with standard error.

Fig. 7. Seasonal progression of Rosette Diameter (RD), Flowers Plant^{-1} (FL), and Fruits Plant^{-1} (FR) with individual means from each pond and year. (a) RD (b) FL (c) FR. Trend line was added manually.



Based upon our data, May would be an ideal time to begin treatment and/or removal in the mid-Atlantic region as rosettes should be observable, but flowers and fruit should not appear until late June. Dire research is needed to understand the retreatment methods and intervals in order to prevent the seed production and control this species successfully.

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Literature Cited:

Caraco NF, Cole JJ. 2002. Contrasting impacts of a native and alien macrophyte on dissolved oxygen in a large river. Ecol. Appl. 12(5): 1496-1509.

Groth AT, Lovett-Doust L, Lovett-Doust J. 1996. Population Density and Module Demography in *Trapa natans* (Trapaceae), an annual, clonal aquatic macrophyte. Aquat. Bot. 83 (11): 1406-1415.

Naylor M. 2003.Water Chestnut (*Trapa natans*) in the Chesapeake Bay Watershed: A Regional Management Plan. Maryland Department of Natural Resources.