

PHRAGMITES AUSTRALIS LITTER AS FOOD VERSUS HABITAT FOR FRESHWATER MARSH MACROINVERTEBRATE POPULATIONS

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Abstract. *Phragmites australis* is native to freshwater tidal marshes and has become invasive in the last ten to forty years, affecting avian and emergent vegetation diversity and reducing ecosystem heterogeneity. Thus far, its effect on aquatic and semi-aquatic macroinvertebrates is not understood. This study investigates Tivoli North Bay (Tivoli, New York, USA) to establish the importance of *Phragmites australis* as a food source versus cover for semi-aquatic macroinvertebrates by examining macroinvertebrate colonization of artificial versus natural plant litter. The macroinvertebrate colonization rates observed indicate a preference for *Phragmites* leaves as a food source and stems as a means of protection. Both are important characteristics of microhabitat selection. Since the composition of ambient litter is 80% stems and 20% leaves, *Phragmites australis* may be able to maintain the existing semi-aquatic macroinvertebrate community as it continues to spread through the high marsh.

INTRODUCTION

Phragmites australis, the common reed, has existed in marshes for over 3,000 years (Niering et al. 1977, Orson 1999). It is only in the last 10 to 40 years that it has expanded rapidly (Roman et al. 1984, Marks et al. 1994), reaching radial expansion rates between 0.0062 and 0.209/yr (Angradi et al. 2001). There are several possible reasons for its expansion, including the restriction of tidal flow (Harrison and Bloom 1997, Roman et al. 1984), nutrient loading, physical disturbance (Phillips 1987, Marks et al. 1994, Windham and Lathrop 1999, Meyerson et al. 2000), and hybridization with a European strain (Galatowich 1999, Saltonstall et al 2002). Each theory has received some experimental support, but the high variability in expansion patterns and rates leaves much more to be understood (Meyerson et al. 2000). The rapid *P. australis* invasion rate has prompted efforts to eradicate it from marshes. Understanding the ecology of the plant and its interactions with other features of marshes will help determine whether or not eradication is ecologically and economically worthwhile.

Ecology of P. australis

P. australis is an extremely adaptable plant and thrives in salt and fresh water systems. It performs best in freshwater tidal marshes, where germination is not impeded by high salinity and it benefits from the nutrient loading associated with tidal inundation (Meyerson et al. 2000). *P. australis* stalks grow up to 3m tall and attain an aboveground biomass between 980-2642 g dw m⁻² compared to 152-900 g dw m⁻² as observed in stands of *Typha latifolia*, one of the dominant freshwater tidal marsh species (Meyerson et al. 2000). The biomass is increased further by the presence of dead stems that stand for up to two years (Roman and Daiber 1984, Meyerson et al. 2000). The stems in the litter layer take longer to break down than do the stems of *Typha latifolia* due to high lignin concentrations (Warren et al. 2001). The leaves, which consist of a quarter of the total biomass, break down faster than those of *Typha latifolia* (Warren et al. 2001).

Despite the differences observed in the decomposition of *Typha latifolia* and *P. australis* (USACOE 1998, Fell et al. 1998, Warren et al. 2001), previous studies by Fell et al. (1998), Rilling et al. (1999), and Warren et al. (2001), focused on the Connecticut River, found that the semi-aquatic macroinvertebrate community of marshes did not vary significantly between areas dominated by *P. australis* and those dominated by *Typha latifolia* and other emergent vegetation. Fell et al (1998) attribute invertebrate stability to their ability to eat the detritus and algae

associated with the *P. australis*. Warren et al. (2001) hypothesize that *P. australis* does not provide macroinvertebrates with adequate food sources, but may serve as better protection from predation.

This study aims to determine whether *Phragmites australis* is providing an adequate food source to litter macroinvertebrates or is primarily selected for protection from predators. Understanding macroinvertebrate use of *Phragmites australis* litter will provide insight into the sustainability of these communities as the stands expand.

METHODS

Study Site

Tivoli North Bay, Tivoli, Dutchess County, NY, USA (42.058°N, 73.910°W.) is over 100 miles upstream of the mouth of the Hudson River. The North Bay has an area of 149 ha. Less than 1% of its perimeter is open to tidal flow. Tivoli North Bay is a tidal freshwater marsh. Its typical emergent vegetation community is dominated by *Typha angustifolia* but also includes *Lythrum salicaria* (purple loosestrife), *Sagittaria latifolia* (broad leaf arrowhead), and *Peltandra virginica* (arrow arum) (USACOE, 1998). There are three significant patches of *P. australis* (See Figure 1).

T. angustifolia vs. P. australis

Five 0.10 m² plots were randomly selected in *T. angustifolia* and *P. australis* patches. Vegetation was removed and stored using the method outlined in Fell et al.(1997).

To remove macroinvertebrates from the litter, individual vegetation samples were placed in a one-quart plastic bag that was then filled with water and shaken for two minutes. After shaking, the effluent was poured through a 500µm sieve. This was repeated 5 times per sample. The debris collected in the sieve was examined under a dissecting microscope at 7.5X with overhead lighting within 3 days of collection. All macroinvertebrates were counted and identified to the family. To determine additional differences in litter characteristics, nitrogen and fungal biomass analyses were done (Findlay et al. 2002).

Manipulated Litter

P. australis litter was manipulated to separate its use as food versus cover by macroinvertebrates. Natural and artificial standing dead stem, litter stem and leaf material were tried separately to determine their relative importance to macroinvertebrates. Standing stem colonization was measured by placing cleaned *P. australis* stems and PVC piping of similar diameter and texture in the marsh for 25 days. At this time, stems were removed from the marsh and analyzed as outlined above.

Cleaned organic and synthetic litter stems and leaves equivalent to densities found in 30 cm² plots were placed in litter bags and left in the *P. australis* stand for 30 days. Synthetic litter stems were constructed of the same material as standing stems. False leaves were created out of strips of plastic, similar in length and thickness to *P. australis* leaves. Five replicates were done for each treatment. Upon collection, macroinvertebrate density and diversity was recorded as described earlier.

Statistics

A t-test was used to determine the significance of treatment effects on invertebrate numbers per 100g dwm⁻¹ and per m². A one-way ANOVA was used to determine differences in organism use of artificial vs. ambient stems and leaves.

RESULTS

Initial comparisons of *Typha* and *Phragmites* litter macroinvertebrates revealed similar macroinvertebrate community composition (Table 1). Nitrogen content percent dry mass and fungal biomass (g ergosterol/gDW) were both significantly greater for *T. angustifolia* than for *P. australis*. Macroinvertebrate density ($p < 0.05$ and $p \leq 0.05$, respectively, Figure 2) of ambient *Phragmites* and *Typha* litter was not significantly different per m^2 ($F = 0.881$ $P = 0.3754$, Figure 3), but there were significantly more macroinvertebrate organisms per 100 g dry weight mass ($F = 6.03$, $P = 0.0395$, Figure 4) in the *Typha* stand.

Analysis of standing stems revealed a total of 2, 4, and 3 individuals on 10 each of ambient, scrubbed, and synthetic standing stems samples with no significant difference among types. Comparison of real and synthetic leaf litter found significantly more organisms on the scrubbed natural leaves vs. the synthetic ones ($F = 13.30$, $P = 0.0065$, Figure 5) per 100 g dw. There was no significant difference between scrubbed-natural and artificial stems as compared per m^2 of surface area ($F = 0.05$ $P = 0.824$, Figure 6).

DISCUSSION

Previous studies done by Warren et al. (2001) and Fell et al. (1998), found similar densities of macroinvertebrates in areas dominated by *Typha* and those dominated by *Phragmites*, so this finding in Tivoli North Bay is not surprising. In their studies, diversity and species composition of macroinvertebrates was not compromised in *Phragmites* stands and densities either remained the same or increased slightly. Here, we find macroinvertebrates to be less dense in *Phragmites* stands when we consider grams of litter occupying a given area. This difference may be largely due to differences in the higher Nitrogen content of *Typha* litter as well as its ability to support a higher fungal biomass (Findlay, unpublished). However, *Phragmites* produces a higher mass of litter per unit area, counteracting this difference.

Macroinvertebrate communities in this study were comprised of the taxa identified in a broader survey of tidal marsh invertebrates USACOE (1998). Tubificid oligochaetes, dipterans, bivalves, gastropods, and ostracods were identified in both studies. Most surprising is the absence of amphipods in the surveys of the macroinvertebrate communities of each of these stands, as well as in the experimental plots, cited as among the most common of all intertidal macroinvertebrates in previous studies (Fell et al. 1998, Warren et al. 2001). Its absence from these samples is puzzling, but may be due to their mobility, enabling them to escape collection.

Since *Typha* may be a higher quality food source, we must examine whether or not some other habitat element occurs in *Phragmites* stands. Upon doing so, we find that protection seems to be influencing individuals' preference for *Phragmites* stems as nutrition seems to be guiding organisms toward the leaves. We would expect the leaves to be a preferred food source over the stems because of their lower lignin content (Warren et al. 2001, USACOE 1998), making them more palatable. Stems, however provide more substantial protection, as any organism able to get in and among a pile of them would be saved from insectivorous fish arriving as the litter is submerged with the rising tide (Fell et al. 1998). The composition of actual litter, about 25% nutritious, quickly decomposing leaves, may allow the invertebrate community to persist with just enough nutrition and protection despite the decreasing diversity of the emergent aquatic vegetation resulting from the *Phragmites* invasion (USACOE 1998).

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LITERATURE CITED

- Angradi T. R., S. M. Hagan, K. W. Able. 2001. Vegetation type and the intertidal macroinvertebrate fauna of a brackish marsh *Phragmites* vs. *Spartina*. *Wetlands* **21**(1): 75-92.
- Benoti L. K. R. A. Askins. 1999. Impact of the spread of *Phragmites* on the distribution of birds in Connecticut tidal marshes. *Wetlands*. **19**: 194-208.
- Chambers R. M., L. A. Meyerson, K. Staltonall. 1999. Effects of salinity and sulfid on distribution of *Phragmites australis* and *Spartina alterniflora* in a tidal saltmarsh. *Aquatic Botany*. **62**: 561-578.
- Fell P. E., S. J. Weissbach, D. A. Jones, M. A. Fallon, J. A. Zeppieri, E. K. Faison, K. A. Lennon, K. J. Newberry, L. K. Reddington. 1998. Does invasion of oligohaline tidal marshes by reed grass, *Phragmites australis* (Cav.) Trin ex Steud., affect the availability of prey resources for the mummichog, *Fundulus heteroclitus* L.? *Journal of Experimental Marine Biology and Ecology*. **222**: 59-77.
- Findlay, Stuart E.G., S. Dye, and K. A. Kuehn. (in press) Microbial growth and nitrogen retention in litter of *Phragmites australis* compared to *Typha angustifolia*. *Wetlands*.
- Galatowitsch S.M., N. O. Anderson, P. D. Ascher. 1999. Invasiveness in wetlands plants in temperate North America. *Wetlands* **19**: 733-755.
- Harrison, E. Z., A. L. Bloom. 1977. Sedimentation rates on tidal salt marshes in Connecticut. *Journal of Sedimentary Petrology* **47**: 1484-1490.
- Marks M. B. Layan, J. Randall. 1994. *Phragmites australis* (*P. communis*): Threats, management, and monitoring. *Natural Areas Journal* **14**: 285-294.
- Meyerson L. A., K. Staltonstall, L. Windham, E. Kiviat, S. Findlay. 2000. A comparison of *Phragmites australis* in freshwater and brackish marsh environments in North America. *Wetlands Ecology and Management*. **8**: 89-103.
- Mitsch W. J. and Gosselink J. G. 1993. *Wetlands*. 2nd ed. Van Nostrand Reinhold, New York. 722 pp.
- Niering W. A., R. S. Warren, C. Weymouth. 1977. Our Dynamic Tidal Marshes: Vegetation changes as revealed by peat analysis. Connecticut College Arboretum Bulletin No. 22. New London, CT.
- Odum W. E. 1988. Comparative Ecology of Tidal Freshwater and Saltwater Marshes. *Annual Review of Ecology and Systematics*.
- Orson R. A. 1999. A paleological assessment of *Phragmites australis* in New England tidal marshes: Changes in plant community structure during the last few millennia. *Biological Invasion* **1**: 149-158.
- Phillips J. D. 1987. Shoreline processes and establishment of *Phragmites australis* in a coastal plain estuary. *Vegetation*. **71**: 139-144.
- Rilling G. C., P. E. Fel, R. S. Warren, 1999. Fish use of brackish tidal wetlands on the lower Connecticut River: a comparison of *Phragmites australis* dominated vs. restored high marsh. Final Report to the Connecticut Department of Environmental Protection, Hartford, CT.
- Roman C.T., F. C. Daiber. 1984. Above ground and below ground primary production dynamics of two Delaware Bay tidal marshes. *Bulletin of the Tony Botanical Club*. **3**: 31-41.
- Roman C. T., W. A. Niering, R. S. Warren. 1984. Salt marsh vegetation changes in response to tidal restrictions. *Environmental Management*. **8**: 141-50.
- Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the common reed, *Phragmites australis*, into North America. *Proceedings of the National Academy of Sciences of the United States of America* **99**: 2445-2449.
- Stahler R. J., and Badner J. 1994. A twenty year comparison of vegetation of three abandoned rice fields, Georgetown County, South Carolina. *Castanea* **59**: 69-77.
- [USACOE]. US Army Core of Engineers. New York District. 1998. Hudson River Habitat Restoration Study: Final Report. Kingston, NY: Barry A Vittor & Associates Inc. 133 pp.

- Warren R. S., P. E. Fell, J. L. Grisby, E. L. Buck, G. C. Rilling, R. T. Fertik. 2001. Rates, Patterns, and Impacts of *Phragmites australis* Expansion and Effects of Experimental *Phragmites* Control on Vegetation, Macroinvertebrates, and Fish within Tidelands of the Lower Connecticut River. *Estuaries*. **24**: 90-107.
- Wetzel R. A., and G. E. Likens. 1991. *Limnological Analyses*. 2nd ed. New York: Springer-Verlag. 391 pp.
- Windham L. Lathrop R. G. 1999. Effects of *Phragmites australis* (common reed) invasion on above ground biomass and soil properties in brackish tidal marsh of the Millica River, New Jersey. *Estuaries* **22**: 927-935.

APPENDIX

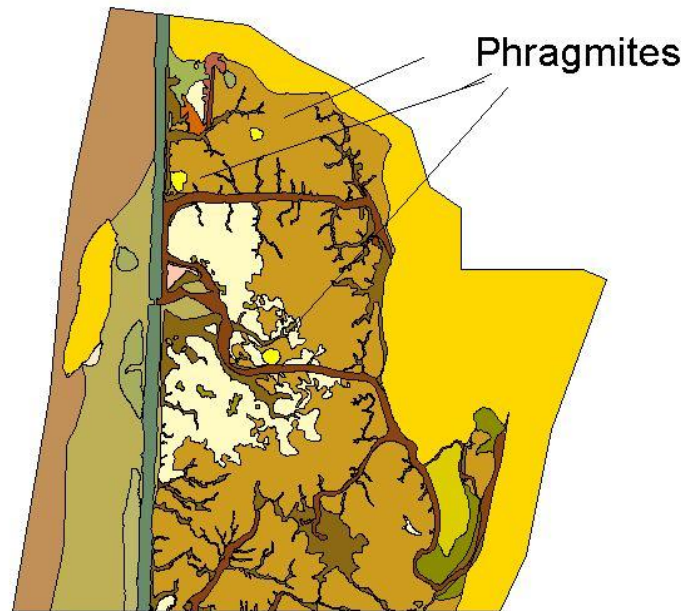


FIGURE 1. Tivoli North Bay, Tivoli, NY. *Phragmites australis* patches (yellow) in intertidal marsh vegetation.

TABLE 1. Semi-aquatic macroinvertebrate community composition for a stand of *Typha angustifolia*, *Phragmites australis*, scrubbed-natural(sc) and artificial(f) stems, and scrubbed(sc) and false(f) leaves. Data in each column is summed across five 30cm² samples for each treatment.

	<i>Typha</i>	<i>Phragmites</i>	Stems (sc)	Stems (f)	Leaves (sc)	Leaves (f)
Bivalve	42	56	5	11	27	2
Dipteran						
<i>Chironomid</i>	19	14	8	6	17	5
<i>Other</i>	42	36	0	0	4	1
Nematode	21	49	0	2	4	0
Oligochaete	0	0	4	5	31	2
<i>Tubificidae</i>						
Gastropod	7	29	8	14	12	21
Other	12	11	6	5	8	7
Total	150	203	46	63	104	38

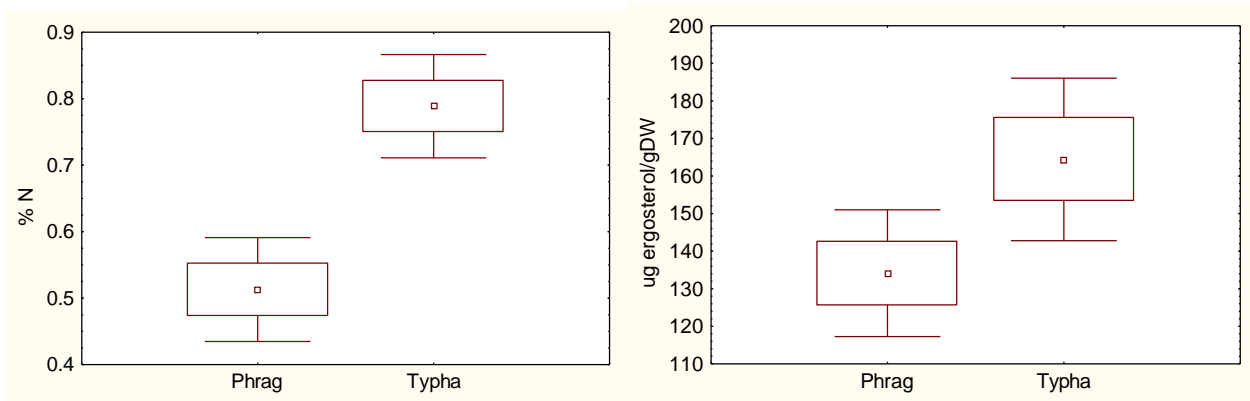


FIGURE 2. Nitrogen content and fungal biomass in *Phragmites* v. *Typha* litter.

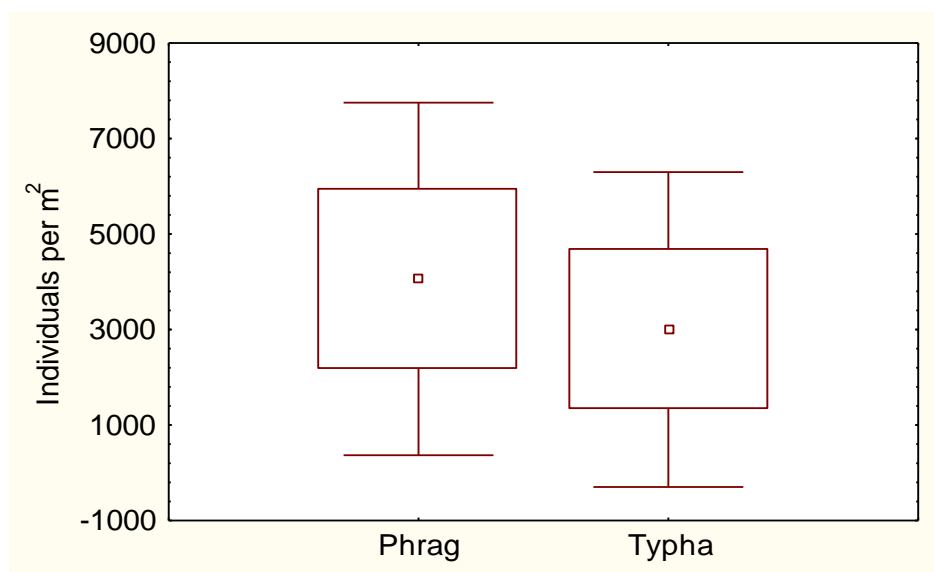


FIGURE 3. Macroinvertebrate organism density per square meter. Tivoli North Bay, Tivoli, NY.

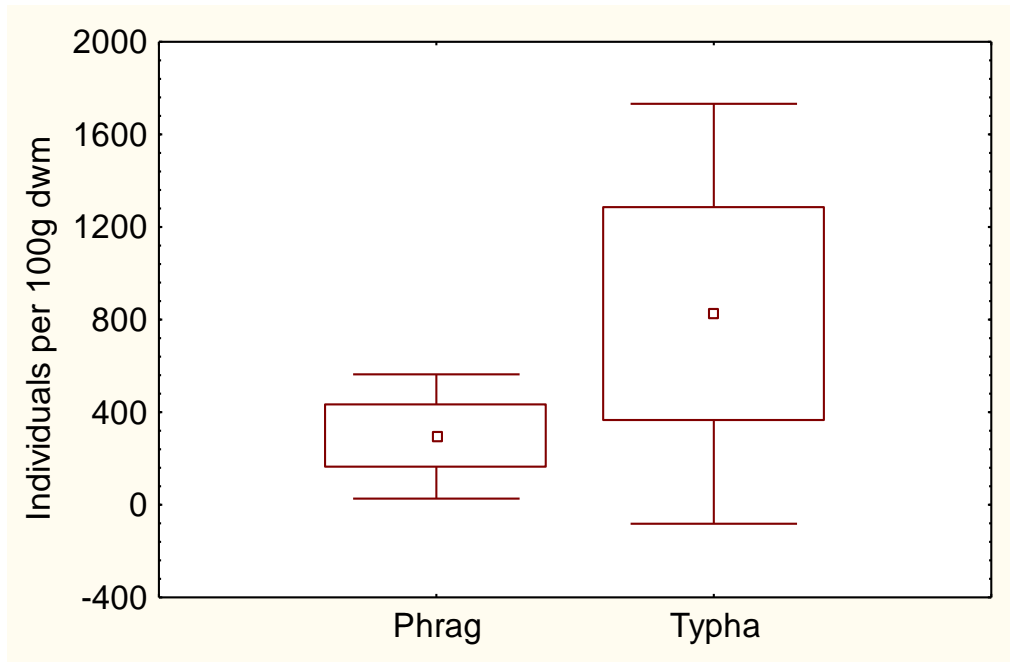


FIGURE 4. Macroinvertebrate organism density per 100 g dry mass. Tivoli North Bay, Tivoli, NY.

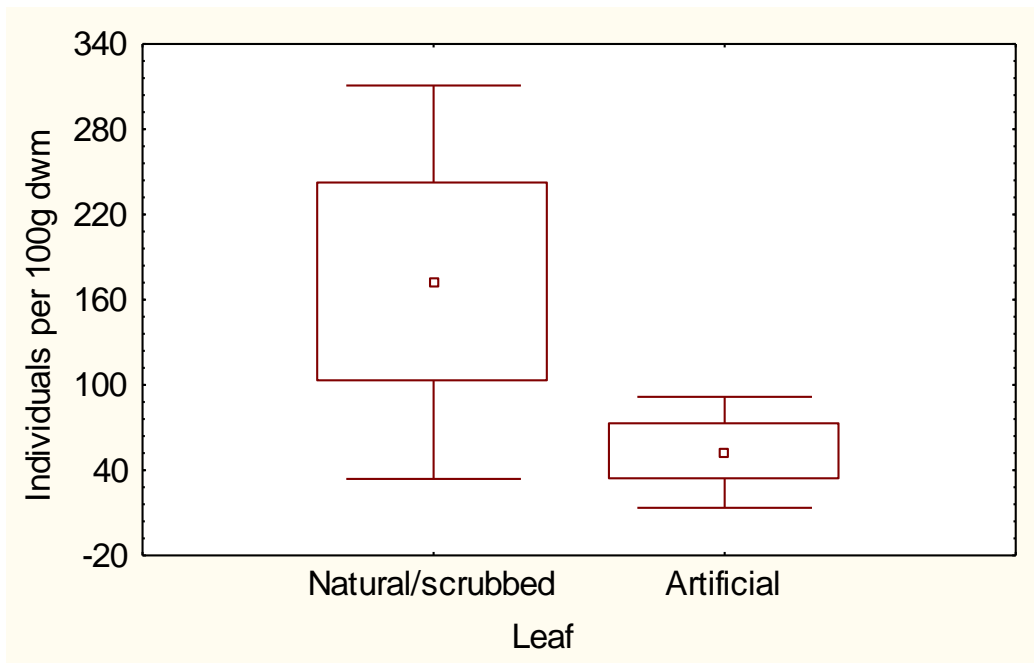


FIGURE 5. Macroinvertebrate organism density per 100g dwm natural/scrubbed vs. artificial leaves. Tivoli North Bay, Tivoli, NY.

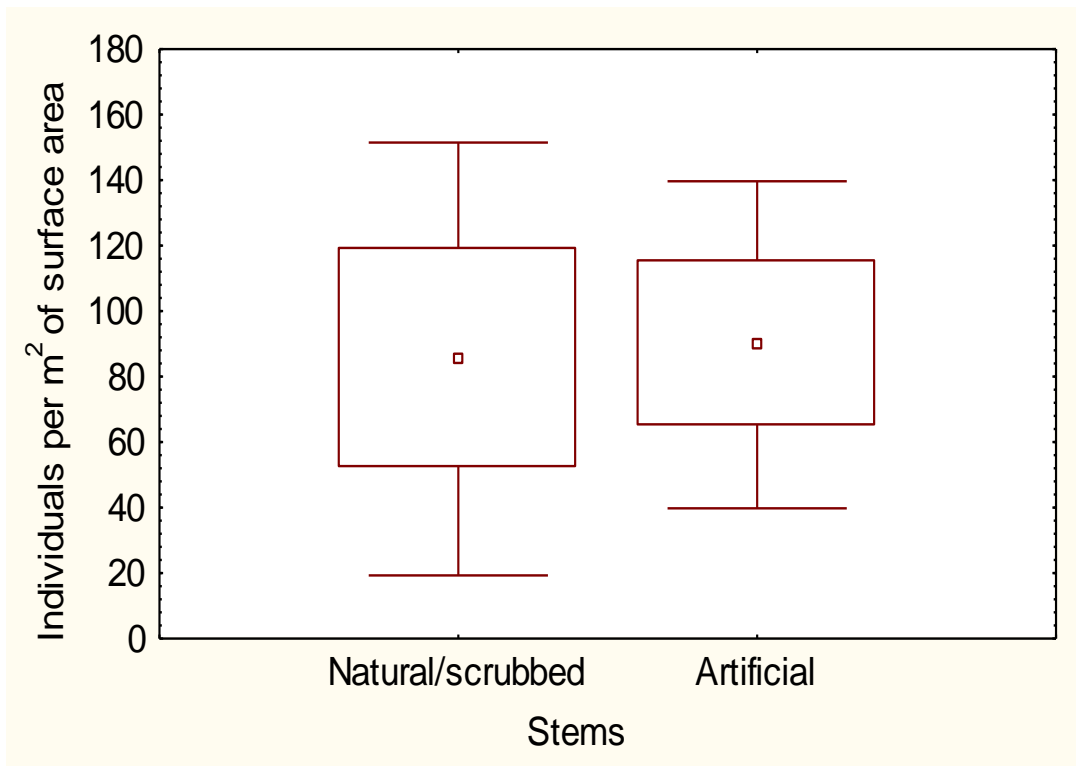


FIGURE 6. Macroinvertebrate organism density per square meter of surface area natural vs. artificial stems. Tivoli North Bay, Tivoli, NY.