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Factors Influencing the Distribution of *Wolffia columbiana* and *Wolffia punctata* (Lemnaceae)

Abstract

In the Mission Valley of western Montana, prairie potholes containing *Wolffia punctata* Griseb. and *W. columbiana* Karst. were compared to nearby potholes lacking these species. Potholes without *Wolffia* had a significantly higher conductivity and pH and a lower maximum depth than those with *Wolffia*. *Elodea* spp. and *Lemna minor* L. were positively associated with *Wolffia*. The dependence of *Wolffia*'s distribution on environmental conditions suggests that local dispersal limitations are less important than environmental limitations in controlling the distribution of *Wolffia*.

Introduction

Wolffia species (Lemnaceae) are globose, rootless, floating aquatic plants that when abundant can completely cover the water's surface. They are tiny (0.5 to 1.5 mm long), the smallest of flowering plants (Hutchinson 1975). Several species of Lemnaceae usually occur intermixed (Fassett 1957). *Wolffia punctata* and *W. columbiana* can often be found together (Clark and Thieret 1968, Schuyler 1983; nomenclature follows Hitchcock and Cronquist 1973).

In some of the potholes near Ronan, Montana, mixed populations of *W. columbiana* and *W. punctata* are present; in others, *Wolffia* is absent. The purpose of this study was to determine whether the pattern of occurrence reflected environmental difference or chance.

Study Area

The potholes are in a cluster immediately southeast of Ninepipe Reservoir in the Mission Valley, Montana, 8 km north of St. Ignatius (Fig. 1). The potholes studied are on or adjacent to Ninepipe National Wildlife Refuge. At an elevation of 915 m, the area receives an average annual precipitation of 38 cm. The topography is a rolling and pitted morainal surface covered by dry prairies (some now plowed or mown) with pockets of wetlands and standing water.

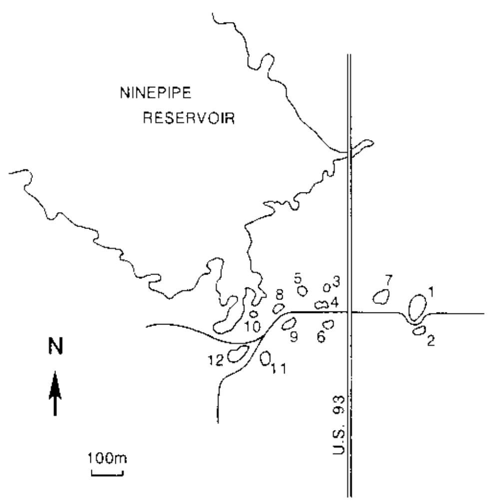

Figure 1. Locations of the twelve study potholes.

Methods

Twelve potholes were chosen for their varying amounts of *Wolffia*, close proximity to each other, and accessibility (Fig. 1). Six contained *W. columbiana* and *W. punctata* and six lacked *Wolffia*. Presence-absence of *Wolffia* was the focus of the analysis. Other Lemnaceae and common macrophytes were also noted.

The observed environmental factors were pH, conductivity, maximum depth of pothole, and

TABLE 1. Environmental characteristics (mean ± standard error, range) of potholes with and without *Wolffia*.

	Wolffia absent		*Wolffia* present	
	Mean ± s.e.	Range	Mean ± s.e.	Range
Conductivity (μmhos/cm)*	1793 ± 442	681-2825	133 ± 54	105-438
pH*	9.7 ± 0.1	9.1-10.0	9.0 ± 0.4	7.4-10.5
Maximum depth (m)*	2.0 ± 0.5	0.6-3.5	2.6 ± 0.4	1.2-3.4
Secchi disk (m)	1.1 ± 0.2	0.6-1.8	1.6 ± 0.3	0.8-2.8

*Means are significantly different at $p < 0.05$.

Secchi disk transparency. Conductivity was measured in the field at the water's surface, using a conductivity meter with thermometer. Conductivities (K) were corrected to standard temperature (25°C) using $K_c = K_{measured}/(1+0.0191(T-25))$ where T was the measured temperature. Secchi disk transparency readings were taken at midday. Maximum depth of water was obtained using a weighted rope. Water samples were collected at midday in 1 l bottles and transported to the lab in a cooler. pH was measured with a meter at 25°C.

Average conductivity, pH, depth, and transparency data were compared between potholes with and without *Wolffia* using two-tailed t-tests. Associations between *Wolffia* and other aquatic macrophytes were detected with chi-square tests on 2 *x* 2 contingency tables.

Results

Significant differences were found between potholes with and without *Wolffia* in three of the four physical and chemical parameters tested (Table 1). Both conductivity and pH were higher ($p < 0.001$ for both) in potholes lacking *Wolffia.* Potholes 3, 4, and 5 (Fig. 1) had the highest conductivities and had no surface water outlets. Maximum depth was lower ($p < 0.01$). Transparency was not significantly different between the two groups of potholes ($p = 0.2$).

Wolffia was positively associated with *Elodea* and *Lemna minor* ($p < 0.05$). The distribution of *Elodea* exactly matched that of *Wolffia* in these twelve potholes. *Lemna trisulca, Spirodela polyrhiza,* and *Potamogeton pectinatus* had borderline positive associations with *Wolffia;* a larger sample size is needed to resolve these borderline cases.

Discussion

Does the absence of *Wolffia* from some potholes represent a dispersal limitation or differential survival in different environments? Chance dispersal has often been implicated in explaining the spotty distribution of *Wolffia* and other Lemnaceae (Godwin 1923, Keddy 1976, Wolek 1983).

Due to their small size, whole plants could be easily transported by birds and muskrats from pothole to pothole (Jacobs 1947, Hutchinson 1975). Given the abundance of waterfowl in our study area, this short-range mobility seemed likely. However, long-distance transport of Lemnaceae by waterfowl is thought to be improbable by some because most truly aquatic plants die rapidly when dried (Jacobs 1947, Looman 1983). In our study area, potholes with no *Wolffia* were close (within 50 m) to those with abundant *Wolffia.* We suggest that these short distances between potholes are not effective barriers to its dispersal, and that environmental factors are primarily responsible for the patchy distribution of *Wolffia* in the Mission Valley.

Potholes with *Wolffia* had lower conductivities than those without it. Because the distribution of *Wolffia* was more strongly related to conductivity than pH ($t = 11.3$, $t = 5.2$, respectively), it seems likely that the absence of *Wolffia* from potholes with high conductivities reflects an intolerance to high salinity, rather than intolerance to free carbonates. For example, in pothole 10, where pH was very high (10.5) and conductivity relatively low (127 μmhos/cm), *Wolffia* was present, though rare. (Note that all Lemnaceae found in this study were present in some potholes exceeding the 8.0-8.5 pH limit reported by Hicks [1932] and Hillman [1961].)

The potholes with *Wolffia* were also deeper than those without it. Deeper potholes are more buffered against fluctuations in temperature and changes in salinity brought about by seasonal evaporation. It is possible that the shallower potholes may even lose all standing water during droughts.

Lemna minor was also absent from the three potholes with the highest conductivities, and *L. trisulca* from two of these three. These Lemnaceae also seem to be sensitive to salinity, although less so than *Wolffia*. *Lemna trisulca* at pothole 4 tolerated higher ion concentrations than *L. minor*.

Spirodela polyrhiza was present in only two potholes (8 and 11), both with relatively low conductivity and pH, but comparable to others in which it was absent. Because it is larger than the other Lemnaceae, it is perhaps less easily disseminated by birds than *Wolffia*. Therefore, *Spirodela* may be more dispersal-limited and perhaps less likely than *Wolffia* to show a tight relationship with environmental factors.

The importance of dispersal limitations to the distribution of the Lemnaceae depends on resistance to desiccation (Keddy 1976), propagule size, and the distance between patches of suitable habitat. In the Ninepipe Potholes, patches of suitable habitat are close to each other and environmental differences between potholes are related to the distribution of *Wolffia*. In this case, therefore, dispersal limitations are apparently less important than environmental limitations in controlling the distribution of *Wolffia*.

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