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DISTRIBUTION, HABITATS, AND TAXONOMY OF *RUPPIA MARITIMA* L. AND *R. OCCIDENTALIS* S. WATSON IN NEBRASKA

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ABSTRACT

Specimens of *Ruppia* from all eleven Nebraska counties in which it is known fall into two groups: *R. occidentalis* in alkaline Sandhills waters and *R. maritima* in saline waters of the Platte River Valley and Lancaster County. *Ruppia occidentalis* is distinguished by its more robust size; red-spotted leaves and stems; terete, entire, obtuse leaves; 4–8(9) carpels; and by two elliptic white spots on its endocarp, among other characteristics. *Ruppia maritima* is more delicate and unspotted; the leaves are oblate in section, sub-apically denticulate, and acute-acuminate; the carpels are 3 or 4, and the endocarp spots are nearly circular. Both species grow in waters of low species-richness of submersed macrophytes; *Potamogeton pectinatus* often grows with them in Nebraska, and *Chara* sp., *Myriophyllum* sp., *Utricularia vulgaris*, and *Zannichellia palustris* are sometimes present. Water qualities of some lakes having *Ruppia* are summarized.

† † †

More than a century ago, Bessey (1886) first reported the submersed halophyte *Ruppia maritima* L. in Nebraska, from "a pond near one of the many salt springs which occur in the vicinity of Lincoln [Lancaster County]." He noted that no species of *Ruppia* were reported in published floras of the nearby states of Iowa, Minnesota, Missouri, and Kansas. Early Nebraska collections of *Ruppia occidentalis* S. Wats. were from Box Butte County in 1889, Sheridan County in 1892, and Cherry County in 1936. However, neither Rydberg (1895) nor Pool (1914) noted *Ruppia* for the Sandhills, nor did Winter (1936) list any species of it for the State, and Petersen (1923) cited *R. occidentalis* only for Box Butte and Sheridan counties but did not mention *R. maritima*. Early regional floristic works cited *Ruppia* for Nebraska (e.g., Britton and Brown, 1896), as did all subsequent such floras. Larson (1972) reported it from seven Nebraska counties and today it is known from eleven. *Ruppia maritima* is locally abundant in quiet waters in the North Platte and central Platte river valleys and in Lancaster County in southeastern Nebraska, and *R. occidentalis* is common in some western and northern Sandhills lakes.

Ruppia is today known from all states adjacent to Nebraska except Iowa, as well as from North Dakota, Minnesota, and Oklahoma, among nearby states (Brooks and Hauser, 1978; Great Plains Flora Association, 1977, 1986; Harrington, 1964; Larson, 1979; Matsumura and Harrington, 1955; Ownbey and Morley, 1991; Weber, 1990). It grows in brackish Atlantic, Gulf, and Pacific coastal waters of North America, and in the interior it is commonest in the western half. *Ruppia* is essentially cosmopolitan, except for the coldest areas, and occurs mostly in brackish to hypersaline waters on six continents.

The ecological and biological attributes of *Ruppia* have been studied in detail; Kantrud (1991) extensively reviewed the literature. The considerable value of the plant as waterfowl food has produced the common names wigeon-grass and duck-grass and has stimulated much of the ecological research.

MATERIALS AND METHODS

I studied living specimens from five counties and herbarium specimens from all eleven counties in which it grows. I grew *Ruppia maritima* and *R. occidentalis* in the laboratory, where August-collected plants grew and flowered until early October, when they became moribund.

Figure 1 shows the eleven counties where specimens were collected from 1886 through 1992. The specimens are deposited in the herbaria of Chadron State College (standard herbarium code CSCN), the

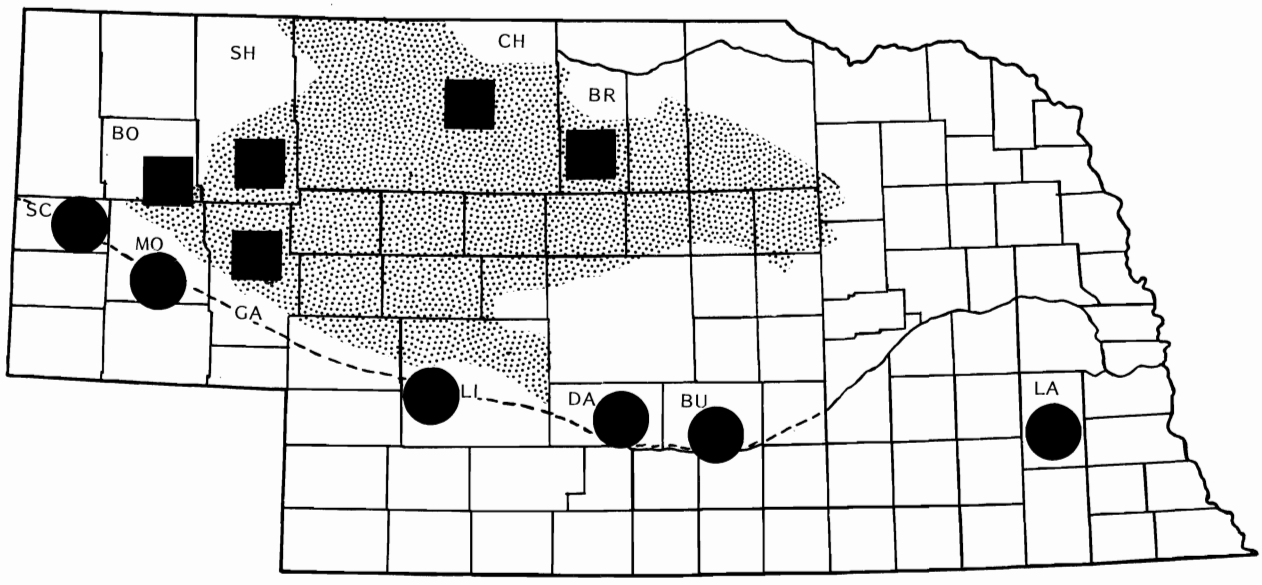


Figure 1. County-outline map of Nebraska showing counties from which *Ruppia maritima* (dots) and *R. occidentalis* (squares) have been collected from 1886 through 1992. County names are indicated by their first two letters: Box Butte, Brown, Buffalo, Cherry, Dawson, Garden, Lancaster, Lincoln, Morrill, Scotts Bluff, and Sheridan. The main area of Sandhills is stippled, and the Platte and North Platte rivers are shown by a dashed line.

University of Nebraska–Lincoln (NEB), the University of Nebraska at Kearney and at Omaha (OMA), and the University of Kansas (KANU).

RESULTS AND DISCUSSION

Current status of *Ruppia* in Nebraska

Although locally abundant today, *Ruppia* in Nebraska is probably less common than in pre-agrarian times, particularly *R. maritima*. Early collections of *R. maritima* in Lancaster County were from Little Salt Creek and a small saline pond near Middle Creek, but it is unknown there now. Those creeks today are turbid with silt and lack submersed vegetation, and the shallow ponds on saline soils near Middle Creek have been disturbed and drained. The species grew in Arbor Lake until the early 1970s, when the lake dried. Only Oak Lake has *R. maritima* now, but it is not in the numerous Lancaster County lakes of the Salt Valley watershed that were constructed in the mid-Twentieth Century, and it is unlikely to appear in them given their declining pH and other changing attributes as reported by Hergenrader (1980).

In the North Platte River Valley, the dramatic biological and hydrological changes effected by dams and water-diversion (see McDonald and Sidle, 1992, and references therein) have surely altered and probably reduced habitats for *Ruppia maritima*.

Most Sandhills lakes with *Ruppia occidentalis* are relatively undisturbed and the plants are often abundant. However, Bronco Lake in Box Butte County, from which robust specimens were collected in 1889 and 1951, dried about thirty years ago and is now cropland.

The number of counties from which *Ruppia* is known is unlikely to increase much because it is restricted to highly alkaline/saline waters and it is already known from most counties with such habitats. However, *R. occidentalis* probably will be discovered in others of the 2,400 lakes and large ponds in the Sandhills, especially those in Cherry, Garden, and Sheridan counties.

Water chemistry of *Ruppia*-inhabited lakes

The water chemistry of lakes having *Ruppia occidentalis* has been reported in some detail and is summarized in Table I. The plants grow on sandy soils in clear, quiet waters of pH generally above 9.0 and of various but high total alkalinity and hardness. Many alkali lakes of Garden and Sheridan counties in the Sandhills have *R. occidentalis*. They are in a closed-basin area of poor drainage and are possibly fed by subsurface waters, which would account for their high levels of potassium and dissolved solids, and their shorelines are often whitened by precipitated calcium carbonate.

The saline ponds of the North Platte River Valley and the saline lakes and ponds of Lancaster County

Table I. Water qualities of some *Ruppia*-inhabited lakes.*

Species County Lake	pH	Total alkalinity ($CO_3^{--} + HCO_3^-$)	$Na^+ + K^+$	SO_4^-	Total solids	Total hardness
***Ruppia occidentalis*:**						
BROWN County						
Rush L.	9.8	1,400				
BOX BUTTE County						
Bronco L.	8.9	1,189	691	483	2,080	318
CHERRY County						
Big Alkali L.	9.2	720	1,913	127	1,000	238
Goose L.	9.0	2,680			3,100	175
Miles L.	8.8	2,514			2,000	
S. Twin L.	9.5	1,836	810	25	2,292	128
GARDEN County						
Goose L.	9.8	3,480	1,600	40	4,100	308
Reno L.	10.3	34,700			38,600	
Smith L.	9.5	1,460	940	225	2,150	804
SHERIDAN County						
Diamond L.	9.8	2,085	2,200		4,018	168
Tin Can L.	9.3	1,188				
***Ruppia maritima*:**						
LANCASTER County						
Oak L.	9.5	265	1,137			

*Figures are maxima reported in the growing season, April through September (except Rush L., December) by Durum (in Nace, 1953) for Box Butte County; McCarraher (1977) for Brown, Cherry, Garden, and Sheridan counties; and Brakhage (1992) and Holland (pers. comm.) for Lancaster County.

have not been chemically analyzed, except for Oak Lake in Lancaster County (Table I).

Associated submersed macrophytes

Sago pondweed (*Potamogeton pectinatus* L.) is often present with both species of *Ruppia* in Nebraska, with or without other submersed macrophytes (Table II). These are the most salt-tolerant macrophytes in Nebraska (McCarraher, 1960; cf. Kantrud, 1990). Ungar et al., (1969), studying halophytes in Lancaster County, noted that "This broad salt tolerance allows these submerged aquatics to invade many ponds of varied salinity throughout the prairie and plains province." The tolerances are not identical (Kantrud, 1990, 1991), however, and sago pondweed is much more common across the State, even in non-saline waters of only moderate alkalinity, and is recorded from 42 of the 93 counties (Great Plains Flora Assn., 1977, with added data from subsequent collections) and doubtless is in most of the others. Of the 43 Sandhills lakes studied by Thomson (as reported in McAtee, 1920) in Brown, Cherry, and Garden counties, 42 had sago pondweed but only three had *Ruppia occidentalis*.

McCarraher (1960) found that submersed aquatic macrophytes are completely absent from 65% of Sheridan County lakes, but sago pondweed and *Ruppia occidentalis* are common in 95% of the lakes with such vegetation. He also noted that, for Sandhills lakes in

Table II. Submersed macrophytes growing with *Ruppia* in Nebraska, as noted on labels of herbarium specimens and as taken from the literature (McAtee, 1920; McCarraher, 1960) and from the author's observations.

Species	**Associated plants**					
County	*Potamogeton*	*Potamogeton*	*Chara*	*Myriophyllum*	*Utricularia*	*Zannichellia*
Lake	*pectinatus*	*pusillus*	sp.	sp.	*vulgaris*	*palustris*
***Ruppia occidentalis* :**						
BROWN County						
Rush L.	*					
CHERRY County						
Big Alkali L.	*		*	*		
Goose L.	*		*			
GARDEN County						
Goose L.	*					
Peterson L. #2	*					
Reno L.	*	*			*	
Smith L.	*		*		*	
Trainor L.	*	*	*		*	
SHERIDAN County						
Diamond L.	*					
Tin Can L.	*					
***Ruppia maritima*:**						
LANCASTER County						
Little Salt Creek						*
Oak L.	*			*		

general, both species "fluctuate in occurrence and abundance according to water levels and yearly alkalinity values." He observed that some extremely alkaline Sheridan and Garden county lakes having total solids above 30,000 ppm, pH above 10, and high potassium oxide, were devoid of aquatic plants.

Mahoney (1977) studied species-richness (number of species present) and diversity (Shannon-Weaver H′) of aquatic plants in alkaline and non-alkaline Nebraska lakes as related to water chemistry. He concluded that species-richness is inversely related to total alkalinity, solids, and hardness of the waters, and that total alkalinity has more effect on shoreline species and pH more on submersed species.

Ruppia in Nebraska grows only in waters of low species-richness of submersed macrophytes. That is true almost everywhere, as is evident from Kantrud's (1991) list of submersed-macrophyte species that grow with *R. maritima*, as reported in the worldwide literature; of the 75 sites he summarized, the range of associated species was 1–14 and the average was six, but 63 sites had five or fewer, 23 had just one, and only three had ten or more. In 1915, Thomson (reported by McAtee, 1920) found *Ruppia occidentalis* in three Nebraska Sandhills lakes with 1, 6, and 7 other macrophyte species, but 40 lakes without *Ruppia* had 1–16 such species.

The curious marine diatom *Campylodiscus clypeus* Ehr. is known with *Ruppia occidentalis* in Big Alkali Lake, Cherry County (Andersen and Walker, 1920; Elmore, 1921); Diamond Lake, Sheridan County (Gibson, 1975a, b); and Goose Lake, Garden County (Naugler, pers. comm. 1975).

TAXONOMY

Nebraska material falls into two groups based upon the character states shown in Table III and Figures 2 and 3, the Sandhills specimens being distinct from those of the Platte Valley and Lancaster County. The differences between these groups justify recognition at the specific level in Nebraska. I provisionally use *Ruppia maritima* L. for the Platte Valley and Lancaster

Table III. Taxonomic character states of *Ruppia* in Nebraska.

Character	Sandhills (*R. occidentalis*)	Platte Valley & Lancaster (*R. maritima*)
Plant habit	Coarse, wiry	Finer, nearly delicate
Color	Leaves and stems often red-spotted	Unspotted
Leaf tip	Obtuse	Acute-acuminate
Leaf margin	Entire	Remotely denticulate apically
Leaf section	Round	Oblate
Leaf sheath	14–57 mm	8–16 mm
Stamen width	ca 1 mm	ca. 0.6 mm
Carpel number	4–8(9)	3, 4
Peduncle in fruit	Strongly coiled	Not coiled
Fruit length	1.8–3 mm	1.2–1.9 mm
Fruit width	1.6–2.4 mm	1–1.3 mm
Endocarp spots	Elliptic	Nearly circular

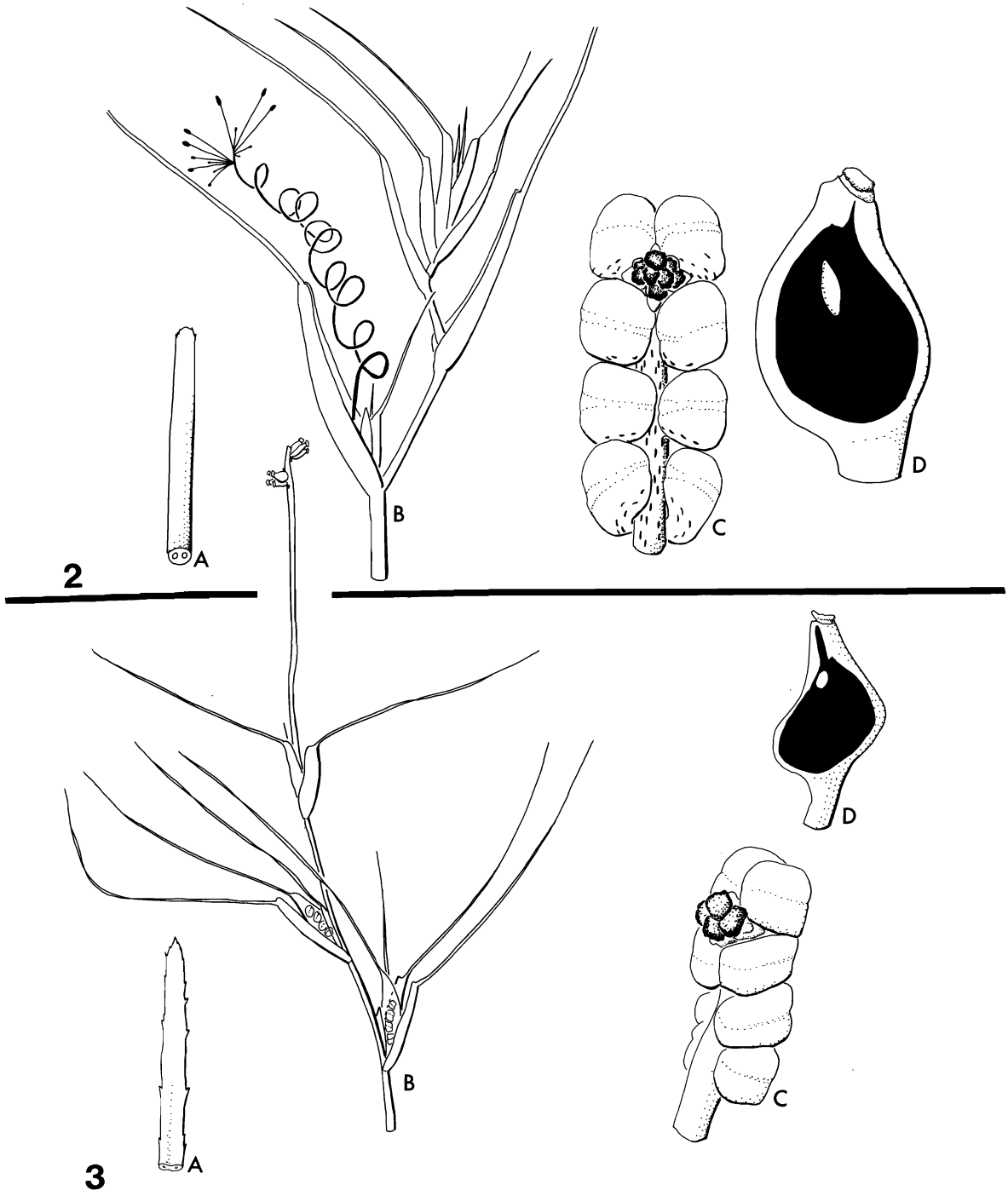
County specimens and *R. occidentalis* S. Wats. (western wigeongrass) for the Sandhills plants, pending resolution of the debated taxonomy and nomenclature in the genus worldwide.

The distinctive red-spotting of the leaves and stems (but not the peduncles and podogynes) of *Ruppia occidentalis* (Fig. 2C) becomes more evident as the season progresses and is preserved when the plants are dried for herbarium specimens; even the soft part of the pericarp shows it. The thinner, flatter, acute-acuminate, and remotely-denticulate leaves of *R. maritima* (Fig. 3A) are easily distinguished from the thicker, terete, blunt-tipped, entire leaves of *R. occidentalis* (Fig. 2A), especially when fresh. There is little overlap in measurements of sheaths and fruits between the two species (Tab. III), and the coarser nature of *R. occidentalis* is especially apparent when numerous coiled peduncles are present (Fig. 2B). By contrast, *R. maritima* remains finer and more delicate throughout its life and its peduncles usually remain uncoiled (Fig. 3B) or occasionally have a few loose coils.

The species can also be distinguished by their flowers and fruits (Table III). The stamens of *Ruppia occidentalis* are larger and usually there are more carpels—as many as 9 in specimens I examined, with 6–8 usual (Fig. 2C). There were two stamens in every flower I examined in both species (Figs. 2C, 3C). The flowers of *R. maritima* have three or four carpels (Fig. 3C).

In the literature, fruit shape and size are often used as a diagnostic character and are said to vary with season and environment (e.g., Mayer, 1969), but I cannot yet confirm that in Nebraska populations. I find that immature fruits are strongly oblique (and thus appear distinctly beaked) and mature ones are less so (Figs. 2, 3), and I suspect that at least some of the reports of differences in fruit shapes are based upon observations of immature fruits.

More useful is the lustrous, ebony-black endocarp that remains when the soft outer tissue disintegrates upon maturity of the fruit, while it is still attached to the podogyne: that of *R. occidentalis* is larger and the



Figures 2, 3. *Ruppia* in Nebraska. Fig. **2**. *Ruppia occidentalis* from Big Alkali Lake, Cherry County. **A**. Shoot with leaves and coiled peduncle of an inflorescence; some carpels in each flower have become immature fruits at this stage. **B**. Leaf tip and section; leaf is terete (shown in section) but becomes oblate in section very near the tip. **C**. Inflorescence with two flowers, both with two stamens and the upper flower showing eight carpels (stigmas darkened for emphasis). Elongate red spots shown on axis and stamens. **D**. Mature fruit with soft parts of pericarp intact (elongate red spots not shown) and hard endocarp (black) visible through the softer tissues. One of the two elliptic white spots is visible on the endocarp. Fig. **3**. *Ruppia maritima* from Oak Lake, Lancaster County. **A**. Shoot with leaves and an inflorescence with two flowers just after pollination; anthers have fallen but the four carpels in each flower remain. **B**. Leaf tip and leaf section. **C**. Inflorescence with two flowers; each has four carpels and two stamens. **D**. Mature fruit with soft part of pericarp intact and hard endocarp (black) visible through the softer tissue. One of the two nearly-circular white spots is visible on the endocarp. Figs. 2B, 3B ×2, all others ×12.

two white spots are elliptic (Fig. 2D), while the spots of *R. maritima* are nearly circular (Fig. 3D).

The occurrence or not of post-pollination coiling of the peduncle has been used taxonomically. Species pollinated at the surface are said to have such coiling, which pulls the developing fruits underwater (e.g., Van Vierssen et al., 1982); *Ruppia occidentalis* in Nebraska fits that pattern. Species supposedly pollinated underwater are said to lack the coiling, but I found that *R. maritima* in Nebraska is pollinated at the surface (its flowers are displayed there when the pollen is floating), but its peduncles remain uncoiled and the pollinated flowers and developing fruits are nevertheless underwater.

Habitat differences between the two species, as noted above for Nebraska, have been found in North Dakota: Larson (1979), recognizing the plants as varieties of *R. maritima*, noted *R. m.* var. *occidentalis* in alkaline waters and *R. m.* var. *rostrata* in saline waters; Kantrud (in litt., 1992) reported *R. maritima* in shallow, saline, impermanent waters and *R. occidentalis* in deeper, less saline, permanent waters. In Nebraska, I have found both species in permanent waters and *R. maritima* occasionally in impermanent ones. Other differences between the species perhaps exist, as suggested by the literature, such as those of chromosome numbers and lifespans (annual or perennial habit), but I cannot confirm them now.

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