B o t a n i c a l N o t e s

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NOTES ON *BOLBOSCHOENUS* IN MAINE

by Arthur D. Haines

The genus *Bolboschoenus* is comprised of a small group of grass-like, perennial sedges of saline to fresh water shores and marshes. These plants are often collectively referred to as the tuberous bulrushes. Formerly included in the genus *Scirpus*, *Bolboschoenus* has been separated as a distinct taxon on the basis of morphology, anatomy, and embryology (Goetghebeur and Simpson 1991, Oteng-Yeboah 1974, Schuyler 1971). Tuberous rhizomes, pubescent floral scales, lack of ligules, and spikelets greater than 1.5 cm long all serve to separate this genus from other bulrush genera in Maine.

Despite its small size (13 species world wide (Smith, in ed.)), this group has a reputation for difficulty. However, many problems that arise during determination of species are likely based on lack of data. This note summarizes ecological and taxonomic information critical for identifying *Bolboschoenus* species in the northeast and introduces two relatively recent additions to Maine's flora.

Currently six taxa of *Bolboschoenus* are documented from Maine. These are:

B. fluviatilis (Torr.) Sojak
B. maritimus (L.) Palla
  subsp. *maritimus*
  subsp. *paludosus* (A. Nelson) Koyama
B. novae-angliae (Britton) S.G. Smith
B. robustus (Pursh) Sojak
B. maritimus × *robustus*

Morphological Characters

The tuberous bulrushes possess a large array of useful taxonomic characters for separating species. However, many of the most reliable and diagnostic characters are not found in some of the regional manuals covering our area. A selection of lesser-known characters follows.

ANTHER COLOR

As in most species of the Cyperaceae, the anthers of *Bolboschoenus* are predominantly yellow when fresh, fading to yellow-brown on herbarium specimens. One species in our area, however, possesses red anthers. In fact this species, *B. robustus*, is the only species of tuberous bulrush in the world to possess this character state. The actual color ranges from brown-orange to brown-red when fresh, and fades to red-brown on herbarium specimens. This character is very reliable and is readily assessed in the field. An intermediate state does occur in the hybrid-derived *B. novae-angliae*. Its anthers range from dark-yellow to orange-yellow when fresh.

SCALE TRANSLUCENCE

The floral scales of Maine *Bolboschoenus* range in texture from very thin and hyaline to thicker and papery. This dissimilarity in thickness imparts a difference in translucence between the various types of floral scales. Scale translucence is best assessed under good illumination utilizing a dissecting scope at 10–20× magnification. Floral scales can be removed from the spikelet and placed on a flat surface. The tip of a pointer or probe can be directed under the scale. In thin-textured scales, the pointer can be seen through the scale. This is not the case with thick-textured scales as they are opaque to transmitted light. The thinner floral scales are possessed only by *B. maritimus* in Maine. Regardless of the

color, the scales are translucent and needles or probes can be observed through them with proper lighting. Thicker, opaque scales are possessed by *B. fluviatilis* and *B. robustus*. *Bolboschoenus novae-angliae* is intermediate, and its floral scales are nearly opaque. A pointer can marginally be seen under the scale with proper lighting.

AWN WIDTH

The floral scales in *Bolboschoenus* are bilobed and awned at the apex. The awn emerges at the apex of the floral scale from within the notch between the two apical lobes. The awn varies in orientation from somewhat outcurved to recurved. Of importance taxonomically is the width of the awn, measured from the base (within the apical notch). Awn width is most useful in separating *B. maritimus* and *B. robustus*, two morphologically similar species. *Bolboschoenus maritimus* possesses slender awns (*ca.* 0.25 mm wide) while *B. robustus* has stouter awns (*ca.* 0.50 mm wide). Though only 0.25 mm (on average) separates the width of their awns, the difference is clear when representatives of these species are compared.

ACHENE ANATOMY

A wealth of information has been gathered by Browning *et al.* (1995) during their examination of achene structure in North American *Bolboschoenus*. Several important characters for species determination have been revealed. The most valuable characters lie in the dimensions of the achene exocarp cells. These cells resemble hollow chambers and are easily viewed at 20× magnification when the achenes are cut in half using a scalpel or razor. Figure 1 illustrates the cross-section of an achene of *B. maritimus*.

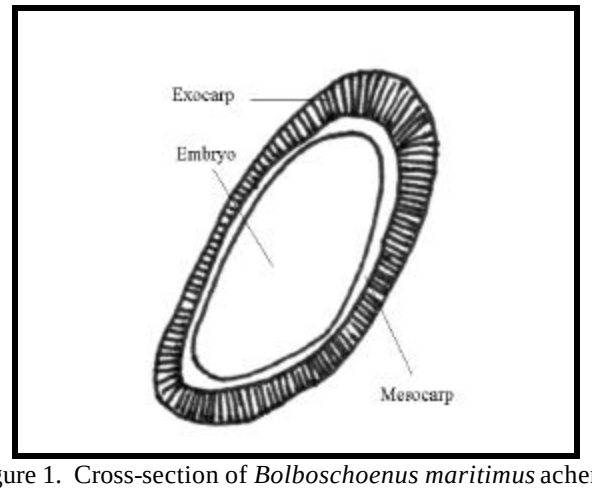

Figure 1. Cross-section of *Bolboschoenus maritimus* achene (width of achene equals 2.03 mm).

The dimensions of the achene exocarp cells provide two character sets. The height to width ratio of the individual exocarp cells and the ratio of exocarp layer depth to mesocarp layer depth are both easily determined with minimal training. There are sufficient differences among our taxa that precise measurements are rarely necessary. Three correlated character states are present in Maine for these two traits. Following is a description and illustration of each character state.

(1) The first character state combines exocarp cells *ca.* 3.0 times as tall as wide and an exocarp layer *ca.* 2.0 times as thick as the mesocarp layer. This achene morphology is possessed by *B. maritimus* and *B. robustus* and is illustrated in Figure 2.

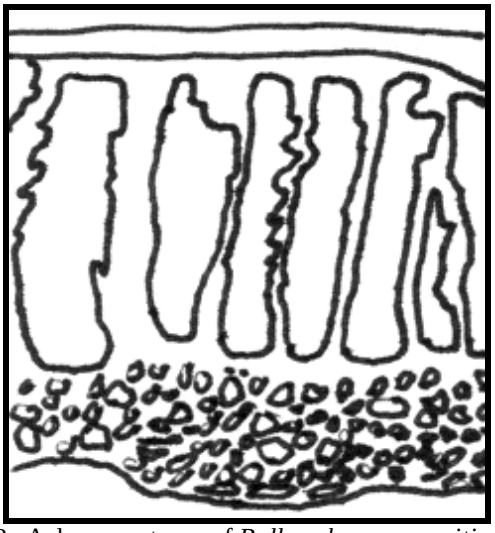

Figure 2. Achene anatomy of *Bolboschoenus maritimus* portraying exocarp cells (large chambers near top) and mesocarp cells (small fibers near bottom) (width of illustration equals 0.15 mm).

(2) The second character state is possessed by *Bolboschoenus fluviatilis*, a species that shows a reduced exocarp cell layer. The individual exocarp cells of this species are *ca.* 1.0 times as tall as wide and the exocarp layer is 0.15–0.25 times as deep as the mesocarp layer. A cross-section of the achene is illustrated in Figure 3.

Figure 3. Achene anatomy of *Bolboschoenus fluviatilis* (width of illustration equals 0.15 mm).

(3) The third character state is intermediate between the previous two. This character expression shows individual exocarp cells 1.5–3.0 times as tall as wide combined with an exocarp layer 0.15–0.5 times as deep as the mesocarp layer. The intermediate character state is possessed by *Bolboschoenus novae-angliae* and is illustrated in Figure 4.

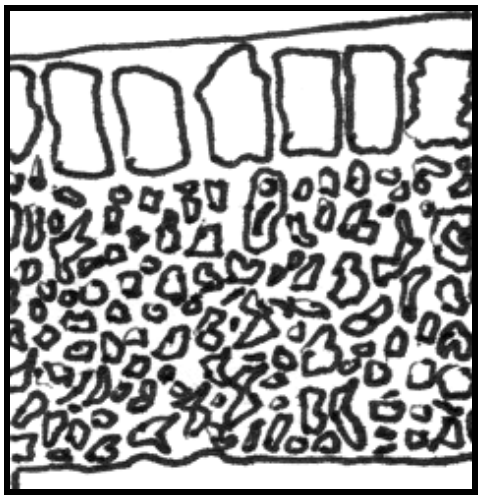

Figure 4. Achene anatomy of *Bolboschoenus novae-angliae* (width of illustration equals 0.15 mm).

ACHENE DENSITY

The achenes of Maine *Bolboschoenus* demonstrate two densities relative to water. *Bolboschoenus fluviatilis* is denser than water, and will sink if pressed through the surface layer of water in a container. Those of *B. maritimus* and *B. robustus* will float, even after prolonged soaking. The achenes of *B. novae-angliae* vary in density, some will float, others sink.

ACHENE SURFACE

The achene surfaces of Maine *Bolboschoenus* range from very lustrous to dull. Achenes of *B. maritimus* and *B. robustus* are very glossy, due in part to a covering of wax-like material. Those of *B. fluviatilis* range from dull to somewhat polished, but lack the luster of the previous species. *Bolboschoenus novae-angliae*, not surprisingly, shows variation, even within a single individual, ranging from dull to lustrous.

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Several characters that are heavily relied upon in regional manuals warrant caution. Style branch number is frequently used and does possess value. However, it should be noted that *Bolboschoenus maritimus* and *B.* robustus may have bifid or trifid styles, and this variation can cause confusion with other species.

Inflorescence structure is a variable character that is also overly relied on. It ranges from congested with no branch formation, as commonly found in *Bolboschoenus maritimus* (Figure 5) to open with elongate branches in *B. fluviatilis* (Figure 6). This character seems to be correlated with water salinity. Saline marsh species (*B. maritimus* and *B. robustus*) normally possess congested inflorescences compared to the fresh-water species *B. fluviatilis*, which normally possesses an open inflorescence. However, variation does exist, and saline marsh species do sometimes show elongated inflorescence branches. This can be seen from collections on Arrowsic Island (Sagadahoc County).

Figure 5. Inflorescence of *Bolboschoenus maritimus.*

Figure 6. Inflorescence of *Bolboschoenus fluviatilis*.

The apex of the leaf sheath opposite the leaf blade is one of the most frequently cited characters for identification of the saline species. This character, unfortunately, is variable, even on the same plant. Leaf sheath characters do possess value, but must be used with caution and in conjunction with other characters. Two character states exist. In *Bolboschoenus maritimus*, the veins of the leaf sheath usually diverge gradually, toward the margins of the blade, at the apex. As well, the apex has an obtriangular, veinless, hyaline area. This type of leaf sheath is shown in Figure 7.

Figure 7. Apex of leaf sheath opposite the leaf blade in *Bolboschoenus maritimus.*

All other species of *Bolboschoenus* in Maine possess a leaf sheath apex that possesses abruptly diverging veins with little or no veinless area.

Cross-sectional shape of achenes is another frequently used identification feature. Again, this character does possess value, but is more complex than frequently portrayed. Three states are found in Maine *Bolboschoenus*: lenticular, compressed-trigonous; and equilaterally-trigonous. Lenticular cross-section can be seen in Figure 1. Compressed-trigonous and equilaterally trigonous achenes are illustrated in Figures 8 and 9, respectively. Achene cross-sections of each taxon can be found in the identification key.

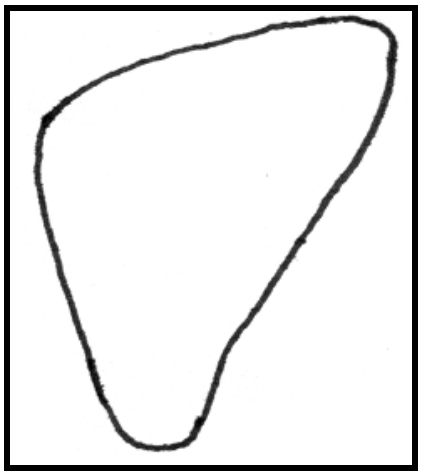

Figure 8. Cross-section of *Bolboschoenus novae-angliae* achene, illustrating a compressed-trigonous shape (width of achene equals 2.57 mm).

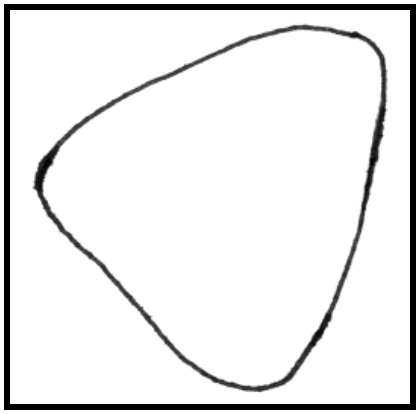

Figure 9. Cross-section of *Bolboschoenus fluviatilis* achene, illustrating an equilaterally-trigonous shape (width of achene equals 2.05 mm).

A final, frequently used pair of characters is the achene outline and perianth bristle stature. Many manuals focus on the shape of the apex when describing achene shape, which varies from nearly truncate to convexly tapered. This character is extremely subtle and requires familiarity with these species (and therefore has less value for new students of this group). The achene apex shape is correlated with perianth bristle stature. Perianth bristles range from slender and weakly attached to stout and firmly attached. Due to extensive overlap in character states, this trait is also difficult to use alone. However, these two characters work reasonably well in conjunction with each other.

Both *Bolboschoenus maritimus* and *B. robustus* possess achenes that very abruptly taper to the apex (Figure 10), and can be described as nearly truncate. Both of the species also have diminutive (up to 0.5 times as long as the achene), caducous perianth bristles that are rarely present on mature achenes. At the other end of the spectrum is *B. fluviatilis*. This species possesses a convexly tapered apex of the achene (Figure 11). It also has long (about 1.0 times as long as the achene), stout, persistent perianth bristles. *Bolboschoenus novae-angliae* is intermediate between the above two character states. Its achene apex rapidly tapers to the apex, but is not truncate (Figure 12). Its perianth bristles are moderately long (0.5–1.0 times as long as the achene), and somewhat persistent in fruit. Examples perianth bristle stature are available in Browning *et al.* (1995) and Schuyler (1974–1975).

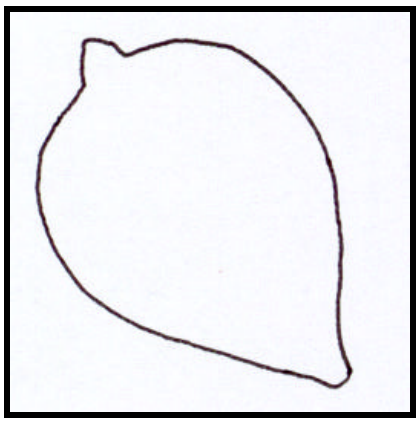

Figure 10. Achene outline of *Bolboschoenus maritimus* (length of achene equals 3.20 mm).

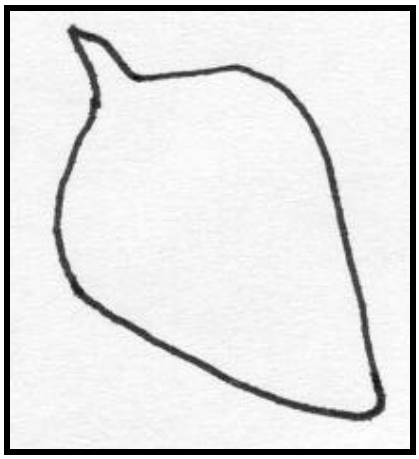

Figure 11. Achene outline of *Bolboschoenus fluviatilis* (length of achene equals 4.23 mm).

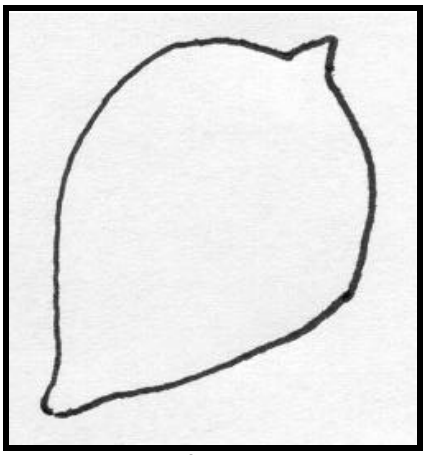

Figure 12. Achene outline of *Bolboschoenus novae-angliae* (length of achene equals 3.50 mm).

Identification Key

1a. Inflorescence normally with elongate branches; styles mostly trifid; achenes compressed-trigonous to equilaterally-trigonous; perianth bristles present on mature achenes, sometimes a few caducous; achene exocarp layer 0.15–0.5 times as deep as the mesocarp layer; plants of fresh to slightly brackish shores

2a. Achenes 3.8–5.5 mm long, usually equilaterally trigonous, with exocarp cells 1.0 times as tall as wide; perianth bristles firmly attached to achene, equaling the length of the achene; anthers yellow ..... ***B. fluviatilis***

2b. Achenes 3.0–4.3 mm long, usually compressed-trigonous, with exocarp cells 1.5–3.0 times as tall as wide; perianth bristles weakly attached to achene, 0.5–1.0 times the length of the achene; anthers dark yellow to orange-yellow ..... ***B. novae-angliae***

1b. Inflorescence normally congested and lacking elongate branches; styles bifid or trifid; achenes plano-convex to compressed-trigonous; perianth bristles rarely present on mature achenes; achene exocarp layer +/- 2.0 times as deep as the mesocarp layer; plants of saline to brackish shores

3a. Floral scales opaque, papery-textured, with awns 0.5 mm wide at the base; anthers red; achenes dark brown, often compressed trigonous; apex of leaf sheath opposite the leaf blade with abruptly diverging veins, green and firm-textured ..... ***B. robustus***

3b. Floral scales translucent, membranous-textured, with awns 0.25 mm wide at the base; anthers yellow; achenes light brown to dark brown, lenticular or rarely compressed-trigonous; apex of leaf sheath opposite the leaf blade with gradually diverging veins, with a hyaline obtriangular area ..... ***B. maritimus***

4a. Styles mostly trifid; achenes medium to dark brown, lenticular to, more commonly, compressed-trigonous; floral scales medium to dark brown ……***B. m.* subsp. *maritimus***

4b. Styles mostly bifid; achenes white-brown to medium brown (dark brown), usually lenticular; floral scales light yellow-brown to medium brown (dark brown) ..... ***B. m.* subsp. *paludosus***

Ecology and Distribution

Bolboschoenus fluviatilis

This species occurs in fresh and fresh tidal marshes, particularly on larger river systems. It is found upstream (with respect to salinity) of all other tuberous bulrushes and has not been found to occur with any other species in Maine. In North America, it is most common in northeastern and midwestern United States and Canada. It is also known from a few areas on the west coast (CA). In Maine, *Bolboschoenus fluviatilis* is most common on major tributaries and downstream reaches of large rivers (*e.g.*, Kennebec River, Penobscot River).

Bolboschoenus maritimus

This saline to brackish marsh species is the most common tuberous bulrush in Maine and is found in a variety of coastal wetlands. It is represented by two infraspecific taxa. *Bolboschoenus maritimus* subsp. *paludosus* is our native species and is distributed throughout the Atlantic coast of Maine. *Bolboschoenus maritimus* subsp. *maritimus* is a rare introduction from Europe. The dark colored and compressed-trigonous achenes suggest *B. robustus.* However, *B. maritimus* subsp. *maritimus* has translucent floral scales, yellow anthers, and gradually diverging veins at the apex of the leaf sheath, characteristic of the species. This rare introduction is known from Herrick Bay in Brooklin (1913 collection).

Bolboschoenus novae-angliae

This species is ecologically intermediate between *Bolboschoenus fluviatilis* and *B. robustus*, and in fact is derived through hybridization between them. It is found on brackish river shores in an intermediate position (with respect to salinity) between its parental taxa. In Maine, it has been found sympatric with *B. maritimus* and *B. robustus* (Schuyler 1974–1975). Despite the co-occurrence of *B. fluviatilis* and *B. robustus* on the west coast, *B. novae-angliae* is only known from Atlantic coast region of the United States. Of interest is that the *B. fluviatilis* × *maritimus*, which closely resembles *B. novae-angliae* morphologically, is only known from the west coast, again, despite sympatry of parental species on both coasts. In Maine, *B. novae-angliae* has been documented from the Nonesuch River (Cumberland County), Pleasant Cove (Sagadahoc County), Back River Creek (Sagadahoc County), Arrowsic Island (Sagadahoc County), and South Branch Marsh River (Waldo County).

Bolboschoenus robustus

This species is similar to *Bolboschoenus maritimus* in that it inhabits saline to brackish marshes. It is typically found further downstream, in relatively more saline conditions, than *B. novae-angliae*. In North America, this species is found along the Atlantic coast from Nova Scotia to Texas, and in a few locations on the Pacific Coast in California. There are no extant stations known for this species in Maine, despite a number of records from the 1970s. Historically, *B. robustus* is known from the Penobscot and Kennebec River systems (Schuyler 1974–1975). Both Arrowsic Island

(Sagadahoc County) and the South Branch Marsh River (Waldo County) are historic sites for this species.

Bolboschoenus maritimus × *robustus*
This hybrid is commonly produced where *Bolboschoenus maritimus* and *B. robustus* are sympatric. Though documented by a large number of collections from both coasts, it is a rare hybrid in Maine. *Bolboschoenus maritimus* × *robustus* has nearly opaque floral scales and dark yellow to orange-yellow anthers, similar to *B. novae-angliae*. However, its achene morphology and anatomy are consistent with *B. maritimus* and *B. robustus.* This hybrid is a relatively recent addition to our flora, first identified by Galen Smith. It is known extant from a single locality on Arrowsic Island (Sagadahoc County) (Haines, unpublished).

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