The separation of *Eleocharis obtusa* and *Eleocharis ovata* (Cyperaceae) in eastern Canada

B.M.H. Larson and P.M. Catling

Abstract: *Eleocharis obtusa* and *Eleocharis ovata* are recognized as distinct species or combined in recent taxonomic literature. To assess their morphological relationship and to evaluate all morphological characters potentially useful for their separation, 11 floral and achene characters were measured on 130 eastern Canadian herbarium specimens. Tubercle width was bimodally distributed and completely separated groups established on the basis of stamen number: plants referable to *E. ovata* had tubercles less than 0.5 mm wide and two stamens, whereas plants referable to *E. obtusa* had tubercles greater than 0.5 mm wide and three stamens. Since determination of stamen number requires dissection under a microscope and tubercle width requires accurate measurement, the most readily utilized character was found to be the ratio of tubercle width to achene width, which can be measured or estimated. The tubercle was less than 2/3 the width of the achene in *E. ovata* and more than 2/3 in *E. obtusa*. Differences in these characters were associated with significant but less dramatic differences in other characters, suggesting that the two taxa should be treated as distinct species.

Key words: *Eleocharis obtusa*, *Eleocharis ovata*, Cyperaceae, taxonomy, classification, Canada.

Résumé : L'*Eleocharis obtusata* et l'*Eleocharis ovata* ont été tour à tour considérés comme des espèces distinctes et comme une seule entité dans la littérature systématique récente. Afin d'examiner leurs relations morphologiques et d'évaluer tous les caractères morphologiques susceptibles d'être utiles pour les séparer, 11 caractères de la fleur et de l'achène ont été mesurés sur 130 spécimens d'herbiers, provenant de l'est canadien. La largeur des tubercules est distribuée de façon bimodale et on reconnait des groupes complètement séparés sur la base du nombre d'étamines; les plants reconnus comme appartenant à l'*E. ovata* ont des tubercules plus petits que 0,5 mm de large et deux étamines, alors que les plants appartenant à l'*E. obtusata* ont des tubercules plus larges que 0,5 mm et trois étamines. Comme le décompte des étamines nécessite une dissection sous le microscope et que la largeur des tubercules nécessite des mesures préçises, le caractère le plus facile à utiliser est basé sur le rapport de la dimension du tubercule sur la largeur de l'achène, qui peuvent être mesurés ou estimés. La largeur du tubercule est inférieure à 2/3 de fois la largeur de l'achène chez l'*E. ovata* et supérieure au 2/3 chez l'*E. obtusa*. Les différences dans ces caractères sont associées avec des différences moins marquées, mais significatives pour d'autres caractères, ce qui suggère que les deux taxons devraient être traités comme des espèces distinctes.

Mots clés : *Eleocharis obtusa*, *Eleocharis ovata*, Cyperaceae, taxonomie, classification, Canada.
[Traduit par la rédaction]

Introduction

Eleocharis engelmanii Steud., *Eleocharis ovata* (Roth) R. & S., and *Eleocharis obtusa* (Willd.) Schultes of *Eleocharis* series *Ovatae* (Svenson 1929, 1953, 1957) are distinctive in being cespitose annuals with smooth, brown, lenticular achenes and differentiated tubercles. They are prevalent in some wetland communities and are sometimes important for the stabilization of shorelines. The southern *E. engelmanii* is very rare and localized in eastern Canada. It is distinctive because its tubercle is less than 1/3 as tall as wide, and although it is as wide as the achene, it is depressed so that it is less than 1/4 of the achene's height (Fernald 1950; Voss 1972; Hines 1975). This species may also be distinguished by its short bristles that do not exceed the achene and by its relatively long, ellipsoid spikelets. In contrast, the separation of *E. ovata* and *E. obtusa*, taxa that extend further north throughout much of the southern portion of eastern Canada, has long been problematic. They were recognized as distinct species by Svenson (1929, 1953, 1957), Fernald (1950), Voss (1972), Hines (1975), Scoggan (1978), Hinds (1986), and in Kartesz's (1994) North American list. Drapalik and Mohlenbrock (1960) recognized the two taxa as varieties of *E. obtusa*. Despite this widespread recognition, the persistent difficulty with their identification is evident in some of the recent literature, in which *E. obtusa* is placed in synonymy under *E. ovata* (e.g., Hitchcock and Cronquist 1973; Gleason and Cronquist 1991; Boivin 1992; Douglas et al. 1994).

The only extensive study of *E. ovata* and *E. obtusa*, and the characters used to separate them, was that of Hines (1975). He produced a key that separated a group including *E. ovata*, with two stamens, from a group including *E. obtusa*,

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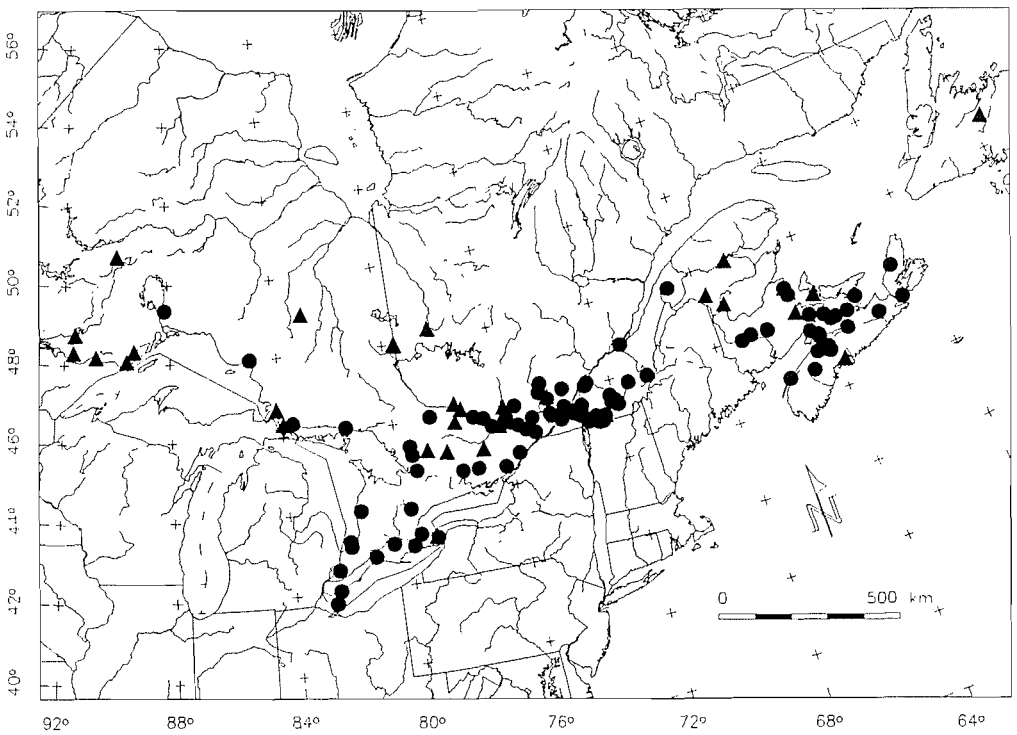
Fig. 1. Geographic origin of specimens utilized in the assessment of the morphological relationship between *E. ovata* (▲) and *E. obtusa* (●) in eastern Canada.



with three stamens. The evidence for this dichotomy was a discriminant analysis, based on characters other than stamen number, and a principal components analysis (Hines 1975, Figs. 13 and 14, respectively). A table of maximum and minimum values, with standard deviations, for the eight characters and two ratios that he measured was also provided. While these data substantially improved our understanding of these two taxa, there were some limitations with Hines' (1975) work. First, the collection locality for the approximately 30 specimens of each taxon that he measured is unknown. He stated only that the plants were collected "from a diversity of geographical areas within their ranges." He borrowed specimens only from United States herbaria, and it is clear from his distribution maps that he used relatively little Canadian material. In addition, the principal components analysis utilized the difficult character of stamen number, which was a nearly complete discriminator between these two taxa, and thus gave no indication of the value of more readily employed characters. Furthermore, his study gave no reliable means of assessing the amount of difference between the taxa, which would contribute to a decision on appropriate taxonomic rank. Lastly, although he presented useful quantitative data for differences in some traditional characters, his key separated *E. ovata* and *E. obtusa* on stamen number alone.

Our preliminary observations of this group suggested that *E. obtusa* and *E. ovata* were distinct taxa, as suggested by Hines (1975) and contrary to some recent taxonomic treatments. The objectives of the work reported here were (*i*) to assess the morphological relationship of *E. obtusa* and *E. ovata* in eastern Canada, a region understudied by Hines (1975), and (*ii*) to evaluate all potentially useful taxonomic characters in terms of both discrimination and utility.

Methods

To obtain a representative sample of eastern Canadian variation within these species, 130 specimens in DAO and CAN (acronyms from Holmgren et al. 1990) were selected to represent a broad geographic area (Fig. 1). The sample included a wide variation in plant size and habit and included plants referable to *E. ovata* var. *ovata* and *E. ovata* var. *heuseri* Uechtritz, *E. obtusa* var. *obtusa*, and *E. obtusa* var. *jejuna* Fernald. Both var. *heuseri* and var. *jejuna*, plants with short culms of varying lengths, are a late-season growth response to decreasing daylengths (Hines 1975). The majority of the specimens selected were from DAO (specimen accession numbers listed in Appendix), but a few specimens from CAN were selected to complete geographic coverage. On each specimen, a spikelet with fully developed achenes at its base was chosen for measurement or evaluation of 11 characters, including those listed in Table 1, as well as stamen and stigma number and scale colour and shape (as the area between the tip and a line 1 mm proximal to it). Prior to measuring, the spikelets were soaked in soapy water to facilitate dissection and reduce breakage.

For measurement of fruit and scale characters, an achene and its associated scale were selected from near the base of the spikelet. The scales were placed on a slide and drawn using camera lucida, so that the area of their tip and their length could be measured using SIGMA-SCAN version 3.9 (Jandel Scientific, Corte Madera, Calif.). The length of the longest bristle was measured as the distance from its tip to the base of the achene, without correcting for curvature. Measurements were taken on the adaxial surface of the fruit. Achene height was measured as the distance from the base of the achene, below the point of bristle insertion, to the base of the tubercle. Tubercle height was measured as the distance between the apex of the achene and the tip of the tubercle. The width of the tubercle and the achene were measured at their widest points. After all of the specimens had been measured, spikelet colour (as a reflection of scale colour) was scored as either reddish brown or purple, using standards for each colour, during a single examination session.

Fig. 2. Histograms illustrating frequencies of tubercle width values for 35 plants with two stamens, referable to *E. ovata* (left), and 95 plants with three stamens, referable to *E. obtusa* (right), all from eastern Canada.

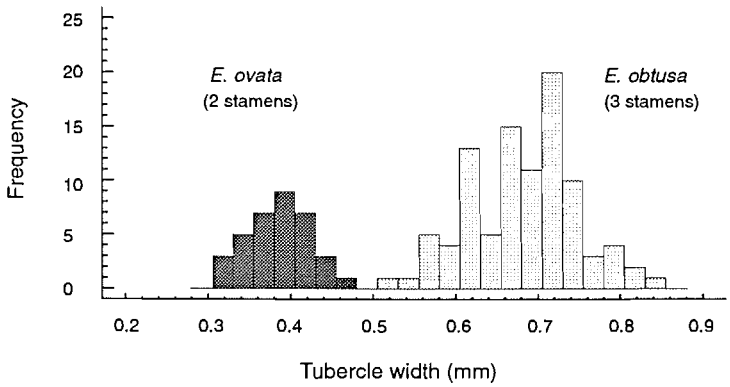
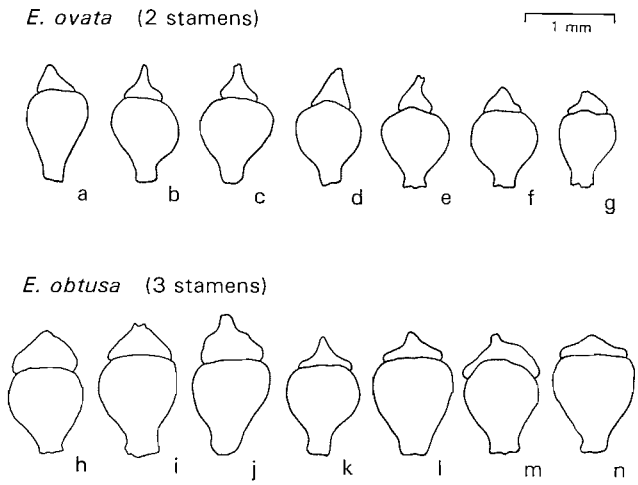


Fig. 3. Representative variation in achene and tubercle size and shape of *E. ovata* (*a*–*g*) and *E. obtusa* (*h*–*n*). (*a*) Thunder Bay District, Ontario, *Garton 2186* (DAO 252544). (*b*) Argenteuil County, Québec, *Rolland-Germain 37402* (DAO 208983). (*c*) Algoma District, Ontario, *Riley 2882* and *Hoy* (DAO 284442). (*d*) Gatineau County, Québec, *Dore et al. 16342* (DAO 624521). (*e*) Kouchibouguac National Park, New Brunswick, *Munro 1850* (DAO 228994). (*f*) Renfrew County, Ontario, *Hay and Morisset 80109* (DAO 329796). (*g*) Madawaska County, New Brunswick, *Roberts and Drury 63-1705* (DAO 252339). (*h*) Gatineau County, Québec, *Calder 377* (DAO 252397). (*i*) Grenville County, Ontario, *Catling 5031* (DAO 662708). (*j*) Manitoulin District, Ontario, *Macdonald 19379* (DAO 573662). (*k*) Parry Sound District, Ontario, *Shields and Shields 1581* (DAO 252420). (*l*) Québec County, Québec, *Lemieux* 18.7.61 (DAO 252358). (*m*) Essex County, Ontario, *Oldham 5564* (DAO 465487). (*n*) Île de Montréal, Québec, *Rouleau 1009* (DAO 252362).



Floral characters were measured by dissecting flowers from near the apex of the same spikelet on which fruit characters were measured. The number of stamens and stigma lobes was recorded from the first flowers encountered with elongated filaments and dehiscing anthers. Variation in these numbers was also recorded. Anther length was recorded for the longest, mature, dehisced anther.

Summary statistics, *F*-ratios from one-way ANOVA using stamen number, correlations, histograms, and bivariate plots were obtained using STATGRAPHICS PLUS version 7.0 (Statistical Graphics Corporation, Manugistics Inc., Rockville, Md.). To correct for multiple simultaneous comparisons, a Bonferroni correction (Rice 1989) was used for the derivation of ANOVA probabilities. All characters, including ratios, could be fitted to a normal distribution without significant ($p < 0.05$) departure, so the statistical results should be sound.

Results and discussion

Groups established on the basis of stamen number were completely separable by tubercle width (Figs. 2 and 3). This supports the use of one or both of these characters by Fernald (1950), Svenson (1953, 1957), and Hines (1975), and the treatment of the two taxa as species by the same authors. As suggested by Hines (1975), plants with two stamens, subsequently referred here to *E. ovata*, had a tubercle width less than 0.5 mm, whereas plants with three stamens, hereafter *E. obtusa*, had a tubercle greater than 0.5 mm wide. There was a strong correlation between stigma number and stamen number (0.88; $p < 0.0001$), with *E. ovata* tending to have two stigmatic lobes. However, the correspondence was not complete: only 77% of the variation in stigma number was attributable to stamen number in the recorded flowers. Moreover, 28 of 95 (29.4%) *E. obtusa* plants had flowers with either two or three stigmatic lobes.

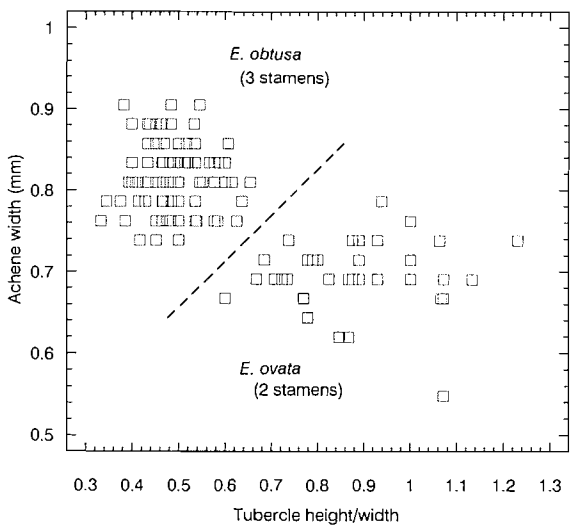
Tubercle width was a better discriminator than the ratio of tubercle width to achene width (Table 1). However, tubercle width requires accurate measurement, whereas the estimation of tubercle width with respect to achene width is relatively easily evaluated and has been used in many keys. Our studies indicate that *E. ovata* has tubercles mostly less than 2/3 the width of the achene, whereas *E. obtusa* has tubercles greater than 2/3 the width of the achene, corresponding to keys produced by Fernald (1950) and Svenson (1953, 1957). A complete separation of the two species also resulted from a scatterplot of achene width versus tubercle height to width (Fig. 4). Other continuous characters and ratios analyzed were much less valuable in distinguishing the two taxa (Table 1).

A significant relationship between stamen number and scale colour was found (χ^2, $p < 0.0001$). All plants referable to *E. ovata* had purple scales. On the other hand, 31.6% of the plants referable to *E. obtusa* were evaluated as having

Table 1. Means, minima, maxima, standard deviations (SD), F-ratios from one-way ANOVAs, and corresponding probabilities corrected for multiple comparisons (Rice 1989), for 35 plants with two stamens, referable to *E. ovata*, and 95 plants with three stamens, referable to *E. obtusa*, all from eastern Canada.

	Eleocharis ovata				*Eleocharis obtusa*					
	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD	$F_{[1,128]}$	p
Character (mm)										
Scale length	1.92	1.40	2.30	0.24	2.07	1.50	2.60	0.22	12.59	<0.001
Bristle length	1.52	1.26	1.78	0.11	1.73	1.26	2.19	0.17	44.50	<0.001
Achene height	0.86	0.71	1.02	0.07	0.94	0.71	1.10	0.07	33.20	<0.001
Achene width	0.70	0.55	0.79	0.04	0.82	0.74	0.90	0.04	200.17	<0.001
Tubercle height	0.33	0.24	0.40	0.04	0.33	0.24	0.43	0.04	0.01	>0.05
Tubercle width	0.38	0.31	0.48	0.05	0.68	0.52	0.83	0.06	662.39	<0.001
Anther length	0.38	0.29	0.50	0.06	0.48	0.26	0.71	0.07	60.23	<0.001
Ratios										
Tubercle height to achene height	0.39	0.30	0.46	0.04	0.36	0.24	0.50	0.05	13.88	<0.001
Tubercle width to achene width	0.55	0.42	0.71	0.07	0.84	0.67	1.03	0.07	423.25	<0.001
Bristle length to achene + tubercle height	1.28	1.07	1.43	0.09	1.36	1.08	1.77	0.12	11.52	<0.001
Tubercle height to tubercle width	0.88	0.60	1.23	0.15	0.49	0.33	0.65	0.07	430.25	<0.001

Fig. 4. Plot of achene width versus tubercle height to width for 130 plants from eastern Canada, including 35 plants with two stamens, referable to *E. ovata*, and 95 plants with three stamens, referable to *E. obtusa*.



purple instead of reddish brown scales. Although the difference is significant, the relatively high level of misclassification of *E. obtusa* plants suggests a limited diagnostic value for scale colour in eastern Canada.

Because of breakage, only 22 scale tips from *E. ovata* flowers and 54 from *E. obtusa* flowers were available for analysis. Scale tip shape, as evaluated using scale tip area, was different between the two taxa ($p < 0.055$), with *E. ovata* tending to have narrower scale apices. Considering its marginal significance, however, scale tip shape is of limited diagnostic value.

Although comprehensive distribution mapping of the two taxa was beyond the scope of the present study, their distributions differed in the herbarium sample used (Fig. 1). As suggested by the literature (e.g., Fernald 1950; Hines 1975), *E. ovata* occurs further to the north than *E. obtusa*, from Newfoundland to the north shore of Lake Superior, reaching its southern limit in New Jersey and southern Illinois. *Eleocharis obtusa* occurs throughout much of southeastern North America, from northern Florida to eastern Texas, reaching its northern limit on the north shore of Lake Superior and in southern Quebec. Both taxa occur on the central west coast of North America, and *E. ovata* also occurs in Europe. In addition to these distributional differences, the taxa have contrasting habitat preferences. In eastern Canada, *E. ovata* is the more prevalent species in acidic, nutrient-poor sites on the Canadian Shield, where granite and sand-derived substrates are frequent. It is also disjunct in the western Lake Erie region (A.A. Reznicek, personal communication), although specimens from that region are not represented in our sample. In contrast, *E. obtusa* is the more prevalent species south of the Canadian Shield, where it occurs on alkaline or neutral substrates, often in nutrient-rich sites.

Conclusion

Tubercle width was found to have a non-overlapping bimodal distribution in the *E. ovata* – *E. obtusa* group in eastern Canada. The cluster with narrower tubercles, referable to *E. ovata*, corresponds to a stamen number of two, whereas the cluster with wider tubercles, referable to *E. obtusa*, corresponds to a stamen number of three. These differences were associated with significant but less dramatic differences in other characters, including distribution and habitat, which suggests that the two taxa should be treated as distinct species.

Given the preceding discussion and the data in Table 1, and noting that the determination of stamen number requires careful dissection using a microscope, a reliable and efficient key couplet for separating these taxa is as follows:

1*a*. Tubercle width 0.31–0.48 mm (dry); tubercle less than 2/3 (0.42–0.71) the width of the achene; stamens two ..... *E. ovata*

1*b*. Tubercle width 0.52–0.83 mm (dry); tubercle more than 2/3 (0.67–1.03) the width of the achene; stamens three ..... *E. obtusa*

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Appendix

Herbarium accession numbers of plant specimens utilized for this study.

Specimens from DAO: 141540, 141541, 146572, 167535, 169759, 186837, 186839, 208983, 228994, 228996, 229006, 235751, 252302, 252303, 252305, 252308, 252309, 252310, 252312, 252313, 252314, 252315, 252316, 252320, 252330, 252332, 252333, 252334, 252335, 252336, 252337, 252338, 252339, 252340, 252341, 252342, 252344, 252345, 252346, 252347, 252348, 252349, 252350, 252351, 252352, 252353, 252354, 252358, 252360, 252361, 252362, 252363, 252364, 252366, 252367, 252372, 252376, 252377, 252379, 252381, 252383, 252384, 252385, 252397, 252403, 252408, 252409, 252410, 252413, 252416, 252420, 252422, 252423, 252424, 252427, 252521, 252523, 252524, 252525, 252526, 252529, 252533, 252538, 252539, 252540, 252542, 252543, 252544, 284442, 329796, 337198, 344034, 458639, 462496, 464958, 464959, 464963, 465487, 466804, 542516, 544496, 571380, 573662, 579178, 582242, 582245, 582561, 585006, 585893, 586279, 586457, 587344, 597183, 603969, 615040, 624521, 625681, 625716, 627944, 632698, 637885, 641738, 662708, 664095, 667913, 683576, 683577.

Specimens from CAN: 27515, 27516, 440204.