
Identification and Distribution of Barnyard Grass (*Echinochloa crus-galli* and *E. muricata*)

S.J. Darbyshire¹, J.Y. Leeson², A.G. Thomas²

¹Agriculture and Agri-Food Canada, Eastern Cereal and Oilseed Research Centre, Wm. Saunders Building #49, Ottawa, Ontario, K1A 0C6

²Agriculture and Agri-Food Canada, Research Centre, 107 Science Place, Saskatoon, Saskatchewan, Canada, S7N 0X2

Key Words: barnyard grass, *Echinochloa crus-galli*, *Echinochloa muricata*, weeds

Abstract

Barnyard grasses (*Echinochloa* spp.) have become increasingly prevalent in agricultural fields of the Prairie Provinces during the past 30 years. The taxonomy and identification of the barnyard grasses has been controversial and difficult. At least two annual species occur as weeds in arable fields; the Eurasian *Echinochloa crus-galli* and the native *E. muricata*. Although they are relatively easy to distinguish from other Canadian grass weeds by the absence of a ligule, both exhibit considerable morphological variation and are often confused or simply reported as a single species, *E. crus-galli*. The two species can be most readily distinguished using characteristics of the mature fertile lemmas and paleas. In *E. crus-galli* the top of the body of the lemma is broadly rounded with an irregular row of hairs. The short acute tip is abruptly different in colour and texture from the body of the lemma. The top of the lemma in *E. muricata* gradually and smoothly tapers into a pointed tip, without a sharp contrast in texture, colour or pubescence. An examination of about 100 plants collected in 2006-8 and over 240 herbarium specimens suggests that the Eurasian *E. crus-galli* is less common in the Prairie Provinces than the native *E. muricata*. The distribution of the species was found to overlap and the two species were occasionally found at the same site. In order to understand any ecological differences that may be important in their effective management, it is critical to be able to recognize the differences between the species in research and control programs. Inconsistencies in reported behaviours and responses, within Canada and other parts of the world, may be at least in part due to the confusion of these two species.

Introduction

The grass genus *Echinochloa* contains about 40–50 species distributed throughout the world primarily in tropical and warm-temperate regions (Michael 2003). A few species have been domesticated as cereals or forages crops (e.g. Japanese millet, *Echinochloa crus-galli* var. *frumentacea*) and many are important weeds of cultivated lands.

Barnyard grass (*Echinochloa* spp.) has become increasingly prevalent in agricultural fields of the Prairie Provinces during the past 30 years. Based on weed survey data, the occurrence of barnyard grass has increased steadily from 3.3% of fields in the 1980s to 8.4% in the 2000s

(Leeson *et al.* 2005). Within fields where barnyard grass occurs the proportion of infested area has also increased from 0.5% of field in the 1980s to 1.8% in the 2000s and the average density of plants within those fields has increased from 4.4 plants per metre square in the 1980s to 8.2 plants per metre square in the 2000s. In the 2000s barnyard grass was the 15th most abundant weed in the Prairie Provinces, increasing in rank from 35th in the 1980s. The majority of fields with barnyard grass are in Manitoba and eastern Saskatchewan; however, the distribution of barnyard grass appears to be increasing in both a westerly and northerly direction (Figure 1).

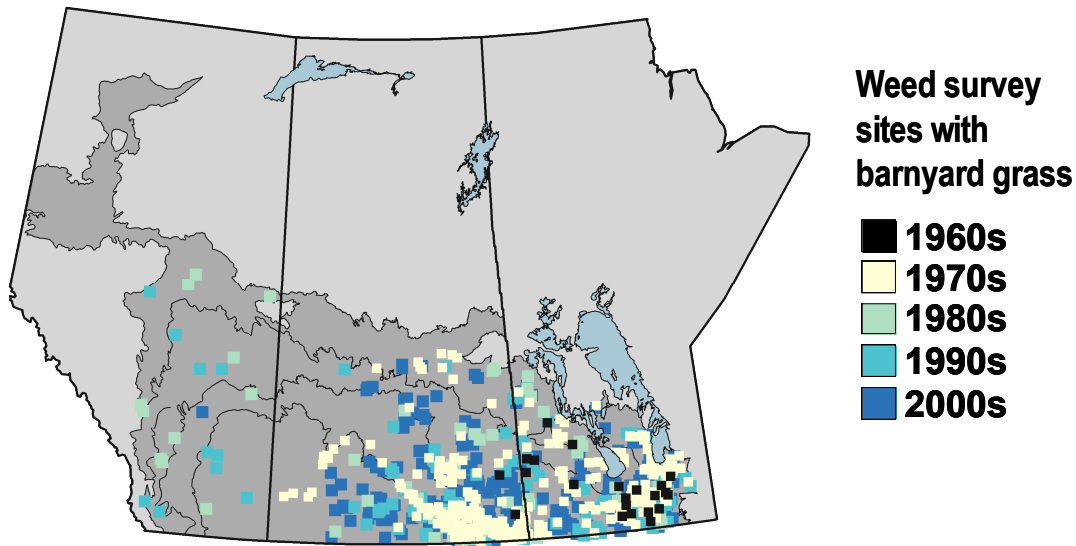


Figure 1. Distribution of barnyard grass (*Echinochloa* spp.) in weed surveys. Surveyed area is indicated in dark grey. The 1960s sites are centres of municipal units reporting barnyard grass as a weed in fields (Alex 1966). From the 1970s to 2000s sites are fields. Barnyard grass was not included in the 1970s Alberta survey. Number of sites surveyed in 1960s = 484, 1970s = 8878, 1980s = 2729, 1990s = 2294, and 2000s = 3806.

The grass genus *Echinochloa* is distinctive in Canada. Species of the genus in Canada are all annuals and the only common grasses which completely lack a ligule at the inside junction of the leaf sheath and leaf blade. Distinguishing between species in the genus, particularly those which are weedy in agricultural situations, has been a much bigger problem due to species similarities and the tremendous morphological variation seen within each species.

Among plant taxonomists it is generally recognized that barnyard grass forms a species complex which naturally extends throughout temperate regions of the northern hemisphere. Within this complex, the Eurasian *Echinochloa crus-galli* is the best known species and has been introduced as a weed to most temperate regions in the world, including North America. In North America the introduced *E. crus-galli* has long been confused with native genotypes in the complex and the native forms, when recognized, are sometimes further divided into multiple species or varieties (Table 1).

Table 1. Treatment of Barnyard Grass found in Canada by Various Plant Taxonomists.

	Hoste 2004 Michael 2003 Crins 1991 Gleason & Cronquist 1991 Gould et al. 1972	Boivin 1981 Scoggan 1979	Dore 1980	Shinners 1954
Eurasian (introduced)	<i>E. crus-galli</i>	<i>E. crus-galli</i>	<i>E. crus-galli</i>	<i>E. crus-galli</i>
North American (native)	<i>E. muricata</i> var. <i>muricata</i> var. <i>microstachya</i>	<i>E. crus-galli</i>	<i>E. muricata</i> <i>E. microstachya</i> <i>E. wiegandii</i>	<i>E. crus-galli</i> var. <i>muricata</i> var. <i>microstachya</i>

Various studies have indicated that, in Canada, the barnyard grass complex is represented by both native and introduced populations and that these are significantly different genetically. It is vital to the study of weed ecology and development of management strategies to be aware of the different populations and to be able to distinguish between them.

In this paper diagnostic characteristics and distribution of the introduced versus native forms on the Canadian Prairie Provinces are analysed. The introduced form is referred to as “barnyard grass” or *Echinochloa crus-galli* and the native form to “western barnyard grass” or *Echinochloa muricata* var. *microstachya*. The more easterly native taxon, *E. muricata* var. *muricata*, has somewhat larger spikelets (> 3.5 mm) and longer lemma awns (when present) than the form found in the Prairie Provinces.

Materials and Methods

A total of 244 specimens of *Echinochloa* specimens from the Prairie Provinces were examined from seven herbaria (ALTA, DAO, DAS, MMMN, PMAE, SASK, WIN (Holmgren and Holmgren 1998)) representing 190 unique collections dating from 1906 to 2005.

In 2006, collection *Echinochloa* specimens for this project began in the Prairie Provinces. In addition to collections by the authors, experts from the federal government, provincial governments and industry throughout the Prairie Provinces were contacted and asked to submit specimens for identification. In 2008, *Echinochloa* species were also collected from fields included in the Manitoba Weed Resistance Survey. A total of 98 new specimens were collected from 2006 to 2008 and deposited at the DAO herbarium.










The habitat of each collection was categorized as either cultivated field, garden, disturbed or native area. The cultivated fields include annual crops and summer fallow. The disturbed areas include waste areas, ditches and hay (i.e., perennial crop). The significance in changes in the frequency of the introduced versus native species within specific habitats was determined using the G-test of independence with William’s correction (Sokal and Rohlf, 1995).

Identification

While *E. crus-galli* and *E. muricata* var. *microstachya* are genetically distinct species having different chromosome numbers, $2n=54$ and $2n=36$, respectively (Gould *et al.* 1972), it is difficult to distinguish between the two species. Populations of the barnyard grass complex exhibit great phenotypic variation in many morphological characteristics. Several characteristics which have been used to distinguish between the taxa, including spikelet hairiness and awn length, are particularly variable even within individual plants. The length of awns on the lower lemma varies considerably, often within a single inflorescence or plant. The large hairs on the upper glume and the lower lemma in the native *E. muricata* var. *microstachya* tend to be courser, more spreading and have yellowish bulbous bases, but these characteristics are not reliable for identification. The attachment of the flag leaf blade to the sheath, as seen in the shape of the collar, tends to be more oblique and sharply angled in the native *E. muricata* var. *microstachya*, but again, this characteristic is too variable to be dependable.

Other than differences in chromosome number, the most useful characteristics for distinguishing native from introduced forms lie in the spikelet bracts (Table 2). The critical characteristics are small (best viewed at magnifications of 20–40 \times) and most clearly seen on fully mature spikelets (at or close to shattering). The characteristics of the upper palea tips are sometimes hard to see without dissecting the fertile floret which can be a difficult task due to the hard texture of the enclosing upper lemma. Although the features of the tips of the upper lemma and palea in the two species are distinctive, they can be obscure and may require the examination of several florets in an inflorescence before one is confident of the identification.

Table 2. Characters used to Distinguish Between *E. crus-galli* and *E. muricata* var. *microstachya*.

Character	<i>Echinochloa crus-galli</i>	<i>Echinochloa muricata</i> var. <i>microstachya</i>
<p>lower palea^a</p> 	 <p>usually rounded at the apex or with a short, abrupt tip (tip less than 2× as long as wide)</p>	 <p>usually pointed with a gradually tapering tip or, if abruptly tapered, then much longer than wide</p>
<p>upper lemma</p> 	 <p>lemma body usually whitish, greenish or yellowish white (rarely brownish yellow)</p> <p>a wrinkled, membranous tip is distinct and more or less abruptly demarcated from the stiff leathery body</p> <p>fine hairs are concentrated at the base of the tip and the top of the body, appearing to form a line of hairs in this region</p>	 <p>lemma body usually yellowish brown or greenish yellow (rarely whitish)</p> <p>a wrinkled, membranous tip is gradually tapered and not abruptly distinct from the stiff leathery body</p> <p>fine hairs, if present, are usually scattered throughout the tip and do not appear to form a line of hairs</p>
<p>upper palea</p> 	 <p>apex rounded or with a short, abrupt tip less than 2× as long as wide (often distinctly hairy)</p> <p>palea distinctly shorter than the adjacent lemma, the tip reaching to about the base of the lemma tip</p>	 <p>x gradually tapering to a longer pointed tip more than 2× as long as wide (usually not distinctly hairy)</p> <p>palea almost or as long as the adjacent lemma, the tip reaching to about the middle of the lemma tip or sometimes of equal length</p>

^a The upper part of the lower palea is often folded when dry and tends to appear more pointed than it is. It is best viewed when moistened and spread out.

Distribution

The distribution of *Echinochloa* in Canada may be at least partly limited by its C₄ photosynthetic physiology. In spite of the fact that the C₄ pathway is usually associated with grasses in warmer and drier regions than those with a C₃ pathway, a surprising number of C₄ species occur in northern regions. Herbarium records indicate that both species are found throughout the southern half of the Prairie Provinces, extending to at least 53° north latitude (Figure 2).

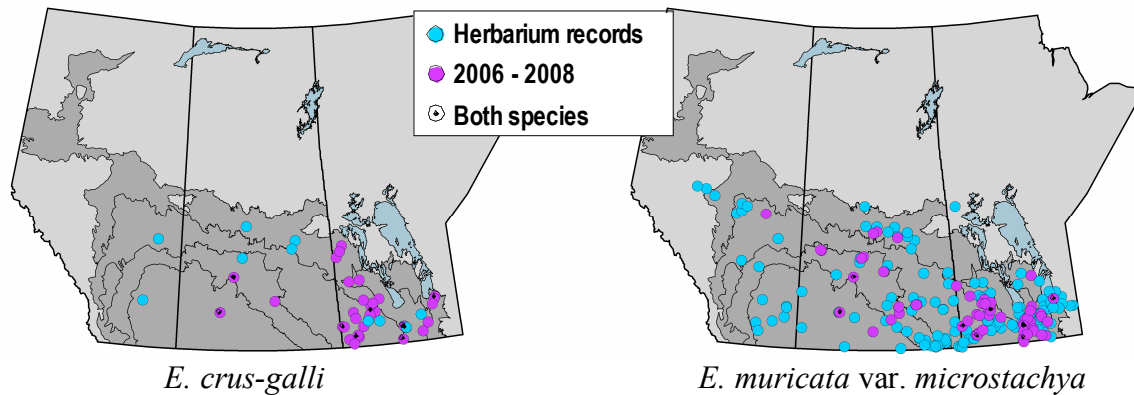


Figure 2. Distribution of *E. crus-galli* and *E. muricata* var. *microstachya* from herbarium records and recent collections.

The earliest specimens in the Prairie Provinces of the introduced *E. crus-galli* were found were in 1928 (Alberta) and 1937 (Manitoba and Saskatchewan). For the rest of the 20th Century, few specimens of this species were collected and it was mostly seen as a garden weed. The native *E. muricata* var. *microstachya* was by far the most common species, found on shorelines, in ditches and arable fields.

Recent collections in the Prairie Provinces indicate that *E. crus-galli* is becoming more prevalent and is sometimes found in the same fields as the native *E. muricata* var. *microstachya*. Among herbarium collections *E. crus-galli* accounted for 4% of specimens from cultivated fields, but increased significantly ($P < 0.001$) to 40% of recent survey collections in this type of habitat. A significant increase in the presence of *E. crus-galli* was also found in other disturbed habitats, from 1% of specimens in the herbarium records to 14% of recent collections ($P < 0.043$). Only three recent collections were from gardens; therefore, it was not possible to detect any significant change in the presence of *E. crus-galli* in this habitat. No recent collections were made in native habitats.

Conclusion

The most distinctive differences between *E. crus-galli* and *E. muricata* var. *microstachya*, are in the shape of the apex of the lower palea, upper lemma and upper palea; the relative position of the upper palea tip to the upper lemma tip; and, the shape of the lower lemma apex. These characteristics are unfortunately very difficult to see in the field without mature plants and substantial magnification. Other characteristics which help in discriminating the two species are spikelet size, spikelet hairiness, and collar shape.

Both species appear to be increasing in prevalence in the Prairie Provinces and becoming more common as agricultural weeds.

References

- Alex, J. F. 1966. Survey of the Weeds of Cultivated Land in the Prairie Provinces. Regina, SK: Canada Agriculture, Experimental Farm. 68 p.
- Boivin, B. 1981. Flora of the Prairie Provinces: a handbook to the flora of the provinces of Manitoba, Saskatchewan and Alberta. Part V. Gramineae. *Provancheria* 12. 108 pp.
- Crins, W. 1991 The genera of Paniceae (Gramineae: Panicoideae) in the southeastern United States. *J. Arnold Arb.*, suppl. ser. 1: 171-312
- Dore, W. G.; McNeill, J. 1980. Grasses of Ontario. *Agric. Can. Res. Branch Monogr.* 26. 566 pp.
- Gleason, H. A.; Cronquist, A. 1991. Manual of the vascular plants of the Northeastern United States and adjacent Canada. 2nd ed. The New York Botanical Garden, New York, U.S.A. 910 pp.
- Gould, F. W.; Ali, M. A.; Fairbrothers, D. E. 1972. A revision of *Echinochloa* in the United States. *Am. Midl. Nat.* 87:36-59.
- Holmgren, P. K.; Holmgren, N. H.. 1998 [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/ih/>
- Hoste, I. 2004. The naturalisation history of *Echinochloa muricata* in Belgium, with notes on its identity and morphological variation. *Belg. J. Bot.* 137:163-174.
- Leeson, J. Y.; Thomas, A. G.; Hall, L. M.; Brenzil, C. A.; Andrews, T.; Brown, K. R.; Van Acker, R. C. 2005. Prairie weed surveys of cereal, oilseed and pulse crops from the 1970s to the 2000s. Weed Survey Series Publication 05-1. Agriculture and Agri-Food Canada, Saskatoon Research Centre, Saskatoon, Saskatchewan.
- Michael, P. W. 2003. *Echinochloa* P Beauv. Pages 390-403 in: Barkworth, M. E. et al. (eds), Flora of North America North of Mexico. Volume 25. Oxford University Press, New York, U.S.A.
- Scoggan, H. J. 1978. The flora of Canada. *Natl Mus. Nat. Sci. Publ. Bot.* No. 7 (2): 93-545.
- Shinners, L. H. 1954. Notes on north Texas grasses. *Rhodora* 56:25-38.
- Sokal, R. R. and F. J. Rohlf. 1995. Biometry : the principles and practice of statistics in biological research. W. H. Freeman and Company, New York, U.S.A. 887 pp.