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NOTE

EVIDENCE OF SEXUAL REPRODUCTION IN THE INVASIVE COMMON REED (*PHRAGMITES AUSTRALIS* SUBSP. *AUSTRALIS*; POACEAE) IN EASTERN CANADA: A POSSIBLE CONSEQUENCE OF GLOBAL WARMING?

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Phragmites australis (Cav.) Trin. *ex* Steud. (common reed) is native to North America and has always been a minor component of wetlands. However, this species has undergone a rapid expansion in the northeastern United States and Canada during the last century, to the point of becoming a nuisance in some areas (Mal and Narine 2004). At its northern limit in eastern Canada, it is particularly invasive in canals, waterways, roadside ditches, and wetlands (Hudon et al. 2005; Lavoie et al. 2003). There is increasing evidence that this recent expansion was a consequence of the introduction of a European genotype (haplotype M) in the 19th and 20th century (Lelong et al. 2007; Saltonstall 2002). The invasive European haplotype has been designated as *P. australis* (Cav.) Trin. *ex* Steud. subsp. *australis*, while the native haplotype is now referred to as *P. australis* (Cav.) Trin. *ex* Steud. subsp. *americanus* Saltonstall, P.M. Peterson & Soreng (Saltonstall et al. 2004). Several morphological characteristics such as basal internode color, glume length, and inflorescence morphology have been used to distinguish between the native and introduced subspecies in the field (Catling 2006, 2007).

In eastern Canada, range expansion of *Phragmites* has been entirely attributed to vegetative reproduction since no seedlings (from either the native or the exotic variety) had ever been reported in the field (Dore and McNeil 1980; Gervais et al. 1993; Grandtner 1999; Small and Catling 2001). Dore and McNeil (1980, pg.167) stated that ''no sound grains are known to be formed'' in southern Ontario, and that the condensed nature of the clones and their

apparent confinement are further evidence of the ineffectiveness of seed propagation. For southern Quebec, Gervais et al. (1993) found a successful, albeit low, seed production and germination potential for common reed in laboratory conditions, but they raised doubts concerning its possible establishment in the field due to the very slow development of the seedlings in the greenhouse. Both in North America and in Europe, northward decrease in seed production, seed viability, and seedling establishment is thought to be related to a shorter growing season (McKee and Richards 1996; Small and Catling 2001). In Europe, at latitudes where seeds can germinate, the mortality rate of seedlings during the first winter is reported to be very high when the previous growth season had not been long enough or warm enough for the newly emerged seedlings to reach a critical size and amount of resources in their storage organs (Haslam 1975; Weisner and Ekstam 1993).

In Canada, *Phragmites australis* is believed to spread through rhizome fragments generated by human activities (e.g., plowing and cleaning out ditches) or rodents. These fragments would then be carried to newly opened sites by machinery, floodwater, birds gathering nesting material, or possibly wind (Small and Catling 2001). However, using aerial photographs, Maheu-Giroux and de Blois (2007) reported a recent invasion of unconnected ditches in the region of St-Bruno-de-Montarville (Quebec), especially within the period 1995–2002, that could hardly be explained by vegetative dispersion alone. Hudon et al. (2005), also in a study based on aerial photographs, similarly suspected that seed dispersion may have played a role in the recent accelerated progression of common reed along the St. Lawrence River (Quebec). Here, we report the first record of significant spontaneous establishment of common reed by sexual reproduction in southern Quebec.

In June 2004, in the context of an ongoing study of *Phragmites* invasion in Quebec (Bellavance 2006), we conducted a survey over three km of a roadside ditch excavated two years before, along a new segment of Highway 335 in Laval, near Montreal, Quebec (45°37′16″N, 73°42′49″W). There were small common reed clumps already established. We suspected some of the smallest ones to be of seed origin because they consisted of a few short aerial shoots (maximum height: 0.5 m) and they could be uprooted without much difficulty. In addition, the roots and thin rhizomes could be followed entirely to the end and there was no apparent rhizome fragment of external origin. These individuals were collected and

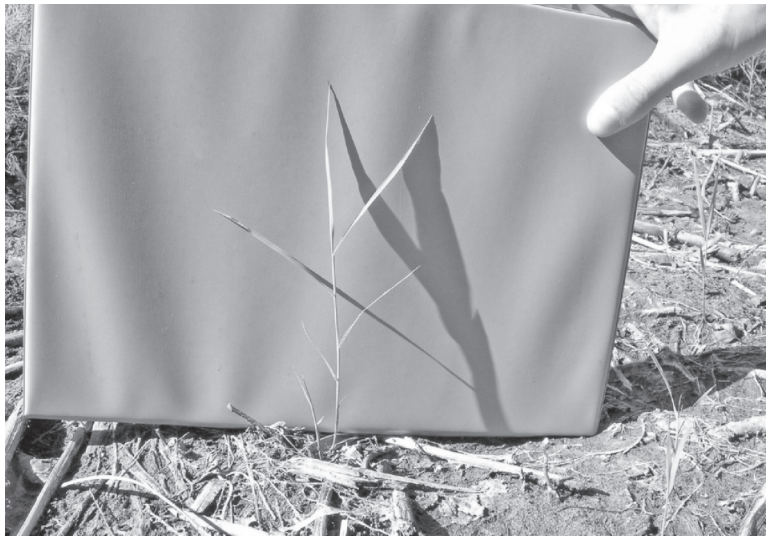

Figure 1. One of the newly emerged seedlings of *Phragmites australis* subsp. *australis*, in a roadside ditch of southern Quebec, Canada.

deposited in the Marie-Victorin Herbarium (MT). In July and August 2005, we surveyed the same ditch, then overgrown and much drier, but found no new common reed seedlings. This was not entirely surprising since seedlings in other parts of the world are known to establish primarily in newly exposed, moist sites (Ekstam and Forseby 1999).

Another of our study sites was an older roadside ditch colonized by the European *Phragmites australis* subsp. *australis* along Highway 640 near Oka, in the Montreal region, Quebec (45°32′32″N, 73°56′25″W). In May 2005, in the context of an experiment on competition between common reed and cattail, we removed all plants and dug out all rhizomes from 12 sections of this ditch, each five meters long, in order to re-create the conditions of a newly excavated ditch (Bellavance 2006). At the end of August 2005, we carefully examined these sections for recolonization and found 38 newly emerged common reed seedlings distributed among 9 of the 12 experimental sections (Figure 1). In one section, we found 14 seedlings (average density 2.4 seedlings/m^2). Common reed seedlings are characterized by the emergence of a small aerial shoot, soon followed with several side shoots appearing in succession, each one generally reaching a larger size than the

previous one (Haslam 1971). The first shoot generally lacks the distinctive hairy ligules of the species, but this character soon appears in the later shoots. Analysis of DNA of plant tissues of one of the seedlings, following the method described in Saltonstall (2003), showed that it belonged to the exotic *P. australis* subsp. *australis*. This is not surprising since all the nearby roadside mature reed colonies also belong to this European subspecies, as confirmed by their morphology: dull, tan-brown stems at base (glossy, reddish-purple in the native subspecies); and large, dense inflorescences (smaller, sparse in the native subspecies). Note that the large majority of common reed colonies in highway roadside ditches of southern Quebec also are from the exotic subspecies (Lelong et al. 2007).

Successful establishment of *Phragmites* occurs only if the seedlings withstand the critical period of the first winter. The year following our excavation experiments, in July 2006, we revisited the site and found that 11 of the 38 seedlings had survived to their second year. The overall density of the vegetation was higher and we did not find newly emerged seedlings that year. The size and morphology of the second-year individuals matched that of the specimen we had collected on Highway 335 in 2004.

Our observations suggest that *Phragmites australis* subsp. *australis* can not only germinate and establish by seed in eastern Canada, but also that the seedlings can survive their first winter and thus very likely form mature individuals, contrary to what has been previously reported in the literature. One possible reason for this is that the seedlings could have been simply overlooked before. In this case, the past expansion of common reed would then be more easily explained by an initial establishment phase of seedlings in freshly opened sites, which went unnoticed, followed by an expansion phase largely dominated by clonal growth. Yet, it appears rather surprising that common reed seedlings could have been totally overlooked considering the large interest in the species, the number of researchers mentioning the absence of seedlings, and the fact that common reed seedlings are not particularly small or indistinct. A second possible explanation is that seedling establishment is a new phenomenon made possible by recent climate change. Eight of the 12 warmest years between 1942 and 2006 in Montreal (P.-E. Trudeau Airport meteorological station) occurred since 1990, with 2005 and 2006 being 8th and 4th, respectively (Environment Canada 2007). The two hypotheses are not mutually exclusive, and while we suspect that the presence of seedlings may have been

overlooked in the past, the recent warming trend likely increased the potential for seedling establishment, as well. While there are still few documented changes in plant species distribution caused by recent global warming, increases in sexual reproduction attributed to climate change within existing distributions have been reported for other plant species (Walther 2003). This documentation of successful sexual reproduction of the invasive *P. australis* subsp. *australis* in southern Canada highlights the need to radically change management strategies, since controlling for rhizome transport alone will not prevent common reed from establishing in newly exposed sites.

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