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Prospects for biological control of teasels, *Dipsacus* spp., a new target in the United States

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Abstract

Two closely related teasels (Dipsacales: Dipsacaceae, *Dipsacus* spp.) of European origin have become invasive weeds in the United States. Common teasel (*Dipsacus fullonum* L.) and cutleaf teasel (*Dipsacus laciniatus* L.) have likely been in North America for more than two centuries, having been introduced along with cultivated teasel [*D. sativus* (L.) Honckney], an obsolete crop plant. There are few records of American insects or pathogens attacking *Dipsacus* spp. Invasive teasels have recently begun to spread rapidly throughout much of their current range, for reasons that are not yet known. Common and/or cut-leaf teasel have been listed as noxious in five US states and as invasive in 12 other states and four national parks. Because the family Dipsacaceae is an exclusively Old World family, classical biological control is an important component of the overall management strategy of this weed in the US. Field surveys for natural enemies of *D. fullonum* and *D. laciniatus* in their native ranges and literature reviews of natural enemies of plants in the family Dipsacaceae have yielded 102 species of insects in six orders, as well as 27 fungi from 10 orders, three mites, one nematode, and two viruses. Due to the biennial nature of these weeds, a strategy to assign highest priority to biological control candidates attacking first-year (rosette) plants has been established. Candidates selected for further study based on this strategy include *Chromatomyia ramosa* (Hendel) (Diptera: Agromyzidae), *Longitarsus strigicollis* Wollaston (Coleoptera: Chrysomelidae), *Epitrimerus knautiae* Liro (Acarina: Eriophyiidae), *Euphydryas desfontainii* (Godart) (Lepidoptera: Nymphalidae), *Erysiphe knautiae* Duby (Erysiphales: Erysiphaceae), and *Sphaerotheca dipsacearum* (Tul. and C. Tul.) (Erysiphales: Erysiphaceae).

Keywords: Classical biological control; Invasive species; *Dipsacus fullonum*; Common teasel; *Dipsacus laciniatus*; Cutleaf teasel; *Dipsacus sativus*; Cultivated teasel; *Chromatomyia ramosa*; *Longitarsus strigicollis*, *Epitrimerus knautiae*; *Erysiphe knautiae*; *Euphydryas desfontainii*; *Sphaerotheca dipsacearum*

1. Introduction

Teasels (*Dipsacus* spp.; Dipsacales: Dipsacacae) are increasing their status as invasive alien weeds in non-agricultural habitats in the US (Sforza, 2004). Invasive teasels occur in 43 US states, being absent only from the extreme southeastern states, North Dakota, Alaska, and Hawai'i (Singhurst and Holmes, 2001; USDA, 2004; Rector, unpublished data). Teasels also occur in the Canadian provinces of Ontario, Quebec, British Columbia (Werner, 1975a), and Manitoba (Environment Canada, 2003). Four states in the western and midwestern US (CO, IA, MO, and NM) have declared *Dipsacus fullonum* L. (common teasel) noxious, and *Dipsacus laciniatus* L. (cutleaf teasel) is considered noxious in Colorado and Oregon. Cultivated teasel, *Dipsacus sativus* (L.) Honckney, is also present in the US. Teasels are listed as invasive by 12 other states and are listed as affecting natural areas in four national parks (USDI-NPS, 2003). This combined status led to the initiation of a government-sponsored biological control program against these species.

The Dipsacaceae sensu lato is an exclusively Old World family, except in cases where species have been moved by

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humans. Thus, no members of the Dipsacaceae are native to the New World (Sforza, 2004). In addition, there are no plants of significant economic importance within the family Dipsacaceae (Bailey, 1951). The center of origin of the subgenus *Dipsacus* L., which includes all invasive *Dipsacus* spp. in N. America, appears to be in southern Europe, due to the greatest diversity and greatest number of endemic species in that region (Fig. 2A) (Verlaque, 1985). A molecular genetic study is underway to investigate the centers of origin of *D. fullonum* and *D. laciniatus* and the geographical origins of genotypes of these species that are invasive in the US.

This paper documents the known herbivores and pathogens of plants in the family Dipsacaceae in general, and those of *D. fullonum* and *D. laciniatus* in particular. The findings of initial field surveys in the native ranges of *D. fullonum* and *D. laciniatus* are presented, as well as a summary of the existing literature and database resources. Using this information, we make a case for the prioritization of those herbivores and pathogens that have sufficient potential as biological control candidates to warrant intensive impact and host-specificity testing.

2. Teasels in the United States

2.1. Synonomy and history of the target in the US

There has been some confusion over the synonomy of teasel species. Common teasel (sometimes referred to colloquially as "Indian teasel") has frequently been called *D. sylvestris* (Huds.) rather than *D. fullonum*, particularly in the North American literature (e.g., Glass, 1991; Huenneke and Thomson, 1995; Judd, 1983). In addition, those who refer to common teasel as *D. sylvestris* have sometimes used *D. fullonum* as the name for cultivated (or "Fuller's") teasel, which is otherwise known as *D. sativus*. A detailed discussion of this taxonomic issue by Ferguson and Brizicky (1965) concluded that the most appropriate name for common teasel is *D. fullonum*. In addition, because *D. fullonum* is the type species of the genus, the species name cannot be changed (Bobrov, 1957). The Weed Science Society of America refers to common teasel as *D. fullonum*, cutleaf teasel as *D. laciniatus*, and cultivated teasel as *D. sativus* (WSSA, 2005), and we will use this nomenclature for the remainder of the paper.

Cultivated teasel heads were grown in the pre-industrial era for use in carding or "teasing" wool fibers (Ryder, 1998). The intentional cultivation of teasel has been documented to as far back as 12th century France (Andrieu-Ponel et al., 2000) and may date to the Roman Empire (Ryder, 1998). Cultivated teasel (*D. sativus*) was still an important crop in Europe during the height of European colonization of other continents. This was likely the species of "fuller's teasel" that was introduced by John Bartram into Pennsylvania in 1728 (Tabor, 2003).

Dipsacus sativus very closely resembles *D. fullonum* and has long been considered to be domesticated from that species (Darwin, 1859). *D. laciniatus* is also similar in appearance to *D. sativus*, particularly the seeds and seedheads. Introduction and spread of *D. fullonum* and *D. laciniatus* in N. America (as well as other former European colonies) almost certainly arose, at least in part, from contamination of *D. sativus* seed, although the introductions themselves do not appear to have been recorded in the literature.

Despite its utility in the processing of wool, teasel was never a major crop. Relatively little acreage was needed to fulfill the demands of the industry. For example, in 1920 the entire British demand of 10,000,000 teasels could be produced on less than 400 ha of land (Ryder, 1998). As a result, there is little scientific literature concerning teasel production or its associated pests.

Stoner (1951) described an aphid-transmitted virus disease from a "commercial planting of fuller's teasel … south of Sunnyvale, Calif.," in May, 1948. Thus, *D. sativus* was still under cultivation in the US in the mid-20th century. Topham (1968) also states that teasels were being cultivated in the states of Oregon and New York in that period. Based on the above dates and locations, *D. fullonum* and *D. laciniatus* have had many opportunities for introduction into and spread across America over the course of two centuries.

Spread of invasive teasels through commerce and general interest in the plant continues. Gardeners plant teasel for its striking appearance and purple flowers, its use in dried flower arrangements, and its attractiveness to butterflies, bumblebees, and natural enemies of crop pests (Judd, 1983). Teasel seed, as well as dried teasel flower arrangements (including seed heads that may to contain viable seed), can be purchased through the internet. Also on the internet, one can find numerous teasel-related homeopathic medicinal items and testimonials to their purported efficacy (e.g., Hall and Wood, 2001; Nature's Health Co, 2001; Teeguarden, 2004). Consumers wishing to utilize the plant for any of these purposes may be contributing to the spread of teasel by growing the plants in their gardens or inadvertently spreading viable seed. Teasel seed has also been used in birdseed mixes and may have spread through commercial birdseed sales.

2.2. Target life history and factors affecting weediness

Common, cultivated and cutleaf teasels are often considered biennials because sufficient energy for reproduction is not gained in the first full year of growth, with bolting and flowering normally occurring in the second year. However, under adverse biotic or abiotic conditions (including herbivory or other natural enemy attack) the plant may need additional years to bolt, becoming less likely to do so with each passing year (Werner, 1975b). Given that reproduction only occurs once, no matter the length of the preceding vegetative period, these three *Dipsacus* species are properly referred to as monocarpic, short-lived perennials.

Seeds of common teasel germinate from spring to late summer (Werner, 1975a), after which rosette leaves and a taproot form. The plant grows vegetatively as a rosette, storing energy in the taproot until there is sufficient storage