21 Plumeless Thistle (Curled Thistle, Bristly Thistle)

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PEST STATUS OF WEED

Plumeless thistle, *Carduus acanthoides* L., is an introduced Eurasian noxious weed in pastures, rangelands, croplands, and along highways in 19 of the contiguous states in the United States (Frick, 1978). *Carduus acanthoides* and *Carduus nutans* L. in the northeastern United States often occupy the same habitats, such as overgrazed pastures and disturbed roadsides, and these species sometimes occur as mixed stands.

Nature of Damage

Economic damage. Plumeless thistle prefers fertile soils developed over limestone, but it is highly adaptable and can even grow in shallow soil, emerging from stone quarries. Infestations of plumeless thistle reduce productivity of pastures and rangeland by suppressing growth of desirable vegetation and preventing livestock from eating plants growing in the vicinity of thistle stands (Desrochers *et al.*, 1988). It is very persistent and has the ability to regenerate because of the longevity and large number of seeds that it produces.

Ecological damage. Plumeless thistle generally does not pose a great threat to high quality areas although it may retard natural secondary succession. Just like musk thistle, livestock avoid it. Selective grazing and the indirect effects of herbicides used for its control result in bare ground that is ideal for its seed germination the following season.

Extent of losses. *Carduus acanthoides* stands of 90,000 plants per ha were observed in permanent pasture in southern Ontario and parts of Quebec. Such dense infestations are not uncommon in the United States (Desrochers *et al.*, 1988) and result in substantial loss of grazing areas for livestock. As thistles are not subjected to grazing or other stress, they easily outcompete forage grasses to become the dominant vegetation in areas where they have become established. In time, they can spread to dominate entire fields (Kok, unpub.). No documentation is available of the effect of plumeless thistles in agricultural crops because such areas are usually plowed under during cultivation.

Geographical Distribution

The earliest collections of *C. acanthoides* were made at Camden, New Jersey in 1878, and in Virginia in 1926 (Frick, 1978; Kok and Mays, 1991). In the 1940s, plumeless thistle was reported to occur from Nova Scotia to Nebraska, and south to Virginia and Ohio. Later, the weed was reported from the Canadian provinces of Nova Scotia, Quebec, Ontario, and British Columbia. The distribution of *C. acanthoides* in the United States is not as great as that of the *C. nutans* group. It is most widespread in the northeastern United States and in several central and western states (USDA, NCRS, 1999). *Carduus acanthoides* has been declared a noxious weed in Maryland, Minnesota, Nebraska, North Carolina, South Dakota, Virginia, West Virginia, and six western states.

BACKGROUND INFORMATION ON PEST PLANT

Taxonomy

Carduus acanthoides belongs to the small-flowered (sub-globose) group of *Carduus* species and is close to *Carduus crispus* L. The red to purple flowers (13 to 25 mm in diameter) of plumeless thistle are usually about one-third to one-half the size of musk thistle flowers. Flowers may be single or in clusters, are erect on stems, and usually do not droop or nod. Unlike musk thistle, flower stems are branched, with spiny wings extending to the flower heads. Three forms of plumeless thistle have been described, the most common in Virginia being *C. acanthoides* var. *acanthoides* (Kok and Mays, 1991). Hybridization between *C. acanthoides* and *C. nutans* has been reported (referred to as *C.* x *orthocephalus* Wallr.). Flowers of the hybrids are larger than the typical capitula of plumeless thistle, but smaller than capitula of musk thistle (Kok, unpub.).

Biology

Carduus acanthoides is an annual or biennial, reproducing by seed. In the rosette stage (Fig. 1), it may be mistaken for musk thistle. The taproot is large and hollow near the ground surface. The stem is erect, branched, and has spiny wings. The plant is 20 to 150 cm tall (Fig. 2). Leaves are hairy on the undersides and are narrower, more deeply lobed, and finely divided than those of *C. nutans*. *Carduus acanthoides* generally blooms from May to July, but this varies with environmental conditions. The reddish-purple flowers are about 20 mm in diameter (Fig. 3). Seeds are oblong, striate, and slightly curved. The seeds are about one-third the size of musk thistle seeds. Literature on plumeless thistle is much less extensive than that for musk thistle, but the biology, ecology, history, introduction, and control of both thistles are quite similar. However, plumeless thistle is more tolerant of herbicides and requires a higher rate of application. Like *C. nutans*, plumeless thistle does not have specific climatic requirements. In the northeastern United States, it is associated with fertile soils formed over limestone. Plumeless thistle tends to occupy drier, better-drained sites than *C. nutans* within the same pasture. It overwinters either as seeds or rosettes. The many flower heads of plumeless thistle enable it to flower more continuously than *C. nutans*, e.g., between June and October in southern Ontario, and between June and August in Virginia. A typical plant produces 35 to 60 capitula. Mean seed set averages 56 to 83 seeds per seed head for *C. acanthoides* and 165 to 256 for *C. nutans*. Germination occurs mainly in the spring and fall, with resulting plants acting either as winter annuals or as spring or fall biennials (Desrochers *et al.*, 1988).

Analysis of Related Native Plants in the Eastern United States

See this section in the chapter on musk thistle.

Figure 1. Plumeless thistle rosette. (Photograph by L.-T. Kok.)

Figure 2. Plumeless thistle stand. (Photograph by L.-T. Kok.)

Figure 3. Plumeless thistle bloom, close up. (Photograph by L.-T. Kok.)

HISTORY OF BIOLOGICAL CONTROL EFFORTS IN THE EASTERN UNITED STATES

The biological control of *Carduus* spp. started when the USDA overseas laboratory was established at Rome, Italy in 1959. It began with a search of natural enemies in Europe in 1963 (Andres and Kok, 1981). *Carduus acanthoides* was not a primary target weed in the genus *Carduus*. However, this species was included in the European survey carried out by the Commonwealth Institute of Biological Control (now CABI Bioscience) in the 1960s and funded by Canada Department of Agriculture (Zwölfer, 1965).

Area of Origin of Weed

The native distribution of plumeless thistle is Europe and Asia. It is very common in eastern parts of Europe, but absent from most of southwestern and northern Europe (see also this section in the chapter on musk thistle).

Areas Surveyed for Natural Enemies

Areas surveyed included southern England, France, Austria, Germany, northern Italy, and the northern part of the former Yugoslavia (Zwölfer, 1965).

Natural Enemies Found

Most of the *C. acanthoides* populations sampled by Zwölfer (1965) were in southern Germany and eastern Austria. More than 30 insect species were recorded on the target plant. Of these, 15 species were reported to be broadly oligophagous on plants in the subtribe Carduinae (see Table 1 in the chapter on musk thistle). In Europe, fewer phytophagous insect species have been reported from plumeless thistle than from musk thistle. This is probably due to the much smaller geographical distribution of the former species and the lower level of sampling effort directed against plumeless thistle.

The biological control agents that had been selected primarily for musk thistle, i.e., the seed-feeding weevil, *Rhinocyllus conicus* (Frölich) and the rosette weevil, *Trichosirocalus horridus* (Panzer), were used at the same time against plumeless thistle. Attack rates by *R. conicus* on plumeless thistle appear to be low in North America, as they are in Europe, probably because the weevil is poorly synchronized with the plant phenology (Surles and Kok, 1977). Because of increasing concern about effects on non-target species, a more specific agent, the seed-feeding fly *Urophora solstitialis* (L.), was selected in the mid-1980s and released against plumeless thistle. Shortly after, this fly also was used for musk thistle (see also this section in the chapter on musk thistle).

Host Range and Biology

The seed-feeding insects, *R. conicus* and *U. solstitialis*, and the rosette weevil *T. horridus* have been released against plumeless thistle.

***Rhinocyllus conicus* and *Trichosirocalus horridus*.** The host range and biology of these two species released as biological control agents are described in this section in the chapter on musk thistle. The adult of *T. horridus* is a brown weevil of 3.9-4.3 mm in length (Fig. 4). Newly eclosed larvae burrow down the petiole into the growth point. Deterioration of plant tissues due to larval feeding results in blackened necrotic tissues (Fig. 5). There are three larval instars (Kok *et al.*, 1975). Heavy feeding by mature larvae (Fig. 6) can cause collapse and death to young rosettes (Fig. 7).

***Urophora solstitialis* L. (Diptera: Tephritidae).** Literature data include a large number of misleading host records for this species in the tribe Cardueae. Field surveys in Europe indicate that the seed-feeding fly *U. solstitialis* (Fig. 8) is restricted to the genus *Carduus*. In laboratory tests, oviposition and larval development occurred on the three *Carduus* species tested, on one (*Cirsium heterophyllum* [L.] Hill) out of four *Cirsium* species tested, on one (*Arctium lappa* L.) out of two *Arctium* species tested, and on one (*Centaurea montana* L.) out of 10 *Centaurea* species tested (Moeller-Joop and Schroeder, 1986; Moeller-Joop, 1988). This seed-feeding fly overwinters as a fully developed larva in capitula (Fig. 9). The adults then emerge in mid-spring. Adults live for several weeks and lay their eggs in the tubes of developing single florets inside flower buds. Newly hatched larvae mine through tubes and ovules down into the receptacle, inducing a gall. Most larvae developing from eggs laid early in the season pupate and produce a second generation. The proportion of larvae developing to form a second generation declines as the season progresses, and larvae developing late in the season all enter diapause (Moeller-Joop and Schroeder, 1986; Woodburn, 1993).

Figure 4. *Trichosirocalus horridus* adult. (Photograph by L.-T. Kok.)

Figure 5. Necrosis of rosette due to feeding of *T. horridus* larvae. (Photograph by L.-T. Kok.)

Figure 6. Close up of *T. horridus* larva (third instar). (Photograph by L.-T. Kok.)

Figure 7. Collapse of thistle rosette infested by *T. horridus* larvae. (Photograph by L.-T. Kok.)

Figure 8. *Urophora solstitialis* adult. (Photograph by Peter Harris.)

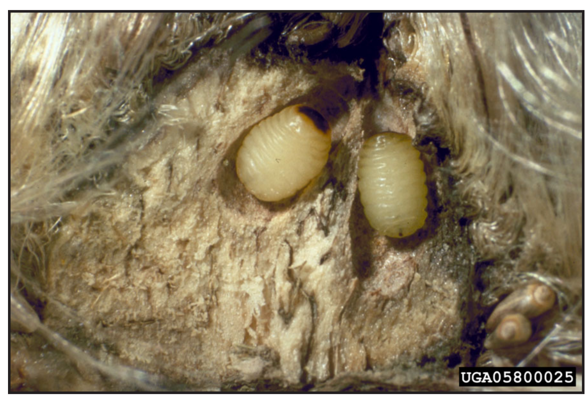

Figure 9. *Urophora solstitialis* larva. (Photograph by Peter Harris.)

Releases Made (from Rees *et al*., 1996; Julien and Griffiths, 1999)

Rhinocyllus conicus. Introductions of *R. conicus* from eastern France via Canada began on *C. acanthoides* in 1969 in Virginia (Surles *et al.,* 1974). Releases were made also in Maryland, Pennsylvania, Idaho, Washington, and West Virginia.

Trichosirocalus horridus. The weevil originating from Italy was first released on *C. acanthoides* in Virginia in 1974 (Trumble and Kok, 1979). After establishment in Virginia, adult weevils were collected from sites in Virginia and released in Kansas, Maryland, Missouri, New Jersey, West Virginia, and several western states, as well as in Canada and Argentina.

***Urophora solstitialis*.** This fly was released in Maryland in 1993.

EVALUATION OF PROJECT OUTCOMES

Establishment and Spread of Agents (from Julien and Griffiths, 1999)

Rhinocyllus conicus. This seed-feeding weevil is established in Virginia (Surles *et al.,* 1974), Maryland, Pennsylvania, Idaho, Washington, and West Virginia.

Trichosirocalus horridus. Establishment of this rosette weevil has been confirmed in Kansas, Maryland, Missouri, and Virginia, but not in New Jersey. In a study conducted in Virginia from 1976 to 1978, establishment was confirmed at two of seven release sites. By1981, the weevil was established at six of these seven sites, and by 1985 it became established in more than 20 sites (Kok and Mays, 1991). In southwest Virginia, 20% of the *C. acanthoides* plants were infested by the weevil in 1985 compared with 54% of *C. nutans*. In sites with mixed stands of musk and plumeless thistles, musk thistle was preferred over plumeless thistle when weevil populations were low. As the *T. horridus* populations increased, plumeless thistle was subjected to increased attack.

Urophora solstitialis. This seed-feeding fly is not established.

Suppression of Target Weed

Rhinocyllus conicus. *Rhinocyllus conicus* provides only partial control of *C. acanthoides* because the ovipositional period of the weevil only coincides with the development of the terminal thistle buds, and not that of the lateral buds (Surles and Kok, 1977). The suppressive effect of this weevil is reduced by the long flowering period of plumeless thistle compared with musk thistle. According to Rowe and Kok (1984), females of *R. conicus* survive longer on plumeless thistle than on musk thistle, and peak oviposition on plumeless thistle is delayed about two weeks, suggesting a possible adaptation of *R. conicus* to plumeless thistle.

Trichosirocalus horridus. Damage to *C. acanthoides* by *T. horridus* is caused by larvae feeding on rosette meristematic tissues and results in crown tissue necrosis. Infested plants produced a greater number of stems per plant, but 50% fewer heads than the non-infested plants (Cartwright and Kok, 1985). Studies in Virginia showed that large weevil populations and grass competition together could have a large effect on thistle densities (Figs. 10 and 11). As larval infestation increases, the stressed thistles become less dominant and more susceptible to competition by pasture grasses, which increase in vigor and density. In 1981, thistle reduction ranged from 11.6 to 80.9% at five sites with *T. horridus*, versus an 11.6% increase at one site where *T. horridus* was not established. At two sites, a reduction in thistle density of more than 80% was found to be due in part to the additional presence of *R. conicus* and improved pasture vigor (Kok, 1986). By 1990, despite occasional resurgence of thistles in some years, plumeless thistle density was very low, with reductions of the original density ranging from 87 to nearly 100%. Thus, the collapse of plumeless thistle was evident after 10 to 12 years following weevil releases (Kok and Mays, 1991).

Figure 10. Plumeless thistle stand before release of *T. horridus*. (Photograph by L.-T. Kok.)

Figure 11. Plumeless thistle stand eight years after release of *T. horridus*. (Photograph by L.-T. Kok.)

Recovery of Native Plant Communities and Economic Benefits

The main replacement vegetation at the five sites after collapse of plumeless thistle in Virginia was dense stands of desirable pasture grasses like tall fescue (*Festuca arundinaria* Schreb.), orchard grass (*Dactylis glomerata* L.), and bluegrass (*Poa* spp.) (Kok and Mays, 1991).

RECOMMENDATIONS FOR FUTURE WORK

There are some indications that *T. horridus* may be a good biological control agent for plumeless thistle, alone or in combination with *R. conicus* and grass competition (Kok *et al*., 1986; Kok and Mays, 1991). The impact by thistle weevils can be greatly enhanced when the insects are used in conjunction with tall fescue grass (Kok *et al*., 1986). Thus, redistribution of this rosette weevil to other infested areas is being continued. Potential feeding on non-target plants, however, deserves further attention. (See also this section in the chapter on musk thistle.)

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