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Spurgia esulae: Permit application information supplement

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Release of nonindigenous biological control agents:
Permit application information supplement

USDA-APHIS-PPQ-BATS

Spurgia esulae
(Diptera: Cecidomyiidae)

1. Proposed action

Field release of *Spurgia esulae* Gagné (Diptera: Cecidomyiidae) for the biological control of the exotic weed, leafy spurge (*Euphorbia esula* L.), in the United States

2. Details of proposed action

2.1 Purpose of the release(s)

Releases of *Spurgia esulae* will be used to initiate or augment populations at field insectary sites (FIS) in various states. Once these FIS populations are successfully established and are deemed sufficiently large, *Spurgia esulae* will be collected and distributed to leafy spurge-infested areas throughout the state.

Spurgia esulae attacks the meristematic tissues (buds) of leafy spurge shoots, causing the formation of a gall (Gagné 1990). This damage rarely kills spurge shoots, but typically prevents flowering and, hence, seed production. Galls may also serve to divert nutrients from other plant tissues (Weis *et al.* 1988).

Thus, the primary role of *Spurgia esulae* in the leafy spurge biocontrol program is to reduce seed production in spurge stands. A secondary role for this agent may lie in exerting a physiological stress on leafy spurge plants that could enhance the efficacy of other biological control agents.

2.2 Need for release

Leafy spurge is a perennial herbaceous plant native to Europe and Asia. Since its accidental introduction beginning in the nineteenth century (Dunn 1985), leafy spurge has become a widespread and economically-important weed in the northern United States and in Canada. The major economic impact of leafy spurge is based on reduced cattle production on infested rangelands (Leistritz *et al.*

1992). The weed also has an adverse ecological impact by displacing native plants (Belcher and Wilson 1989) and, perhaps, by degrading wildlife habitats (Wallace *et al*. 1992).

A variety of tactics may be employed in managing weedy plants. Chemical (herbicides) and cultural (e.g. sheep grazing, cultivation) control techniques may be effective against leafy spurge in some situations, but their widespread utilization is limited by logistical, economic, or environmental constraints. Biological control, however, may offer an opportunity for large-scale, cost-effective leafy spurge management, especially in remote areas and in low-value grazing lands.

2.3 Specific location of the rearing facility and release site(s)

Spurgia esulae galls, containing mature larvae or pupae, will be collected from an established field insectary site near Bozeman, MT. In 1995, material will be provided for field release in some or all of the following states: Colorado, Idaho, Iowa, Michigan, Minnesota, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wisconsin, and Wyoming. Releases may also be made in other states in 1995 and future years.

2.4 Number to be released

Generally, 50-100 galls, each containing 15-30 *Spurgia esulae* larvae or pupae, will be provided to each state in 1995. The exact number will be determined after assessing the *S. esulae* population at the Montana collection site in spring 1995.

2.5 Timing or release

Spurgia esulae galls will be collected in mid- to late June 1995, depending on local weather conditions. Field release in the various states will be accomplished within two days of collection in Montana.

2.6 Methods used for release

Releases of *Spurgia esulae* galls will be made at open (uncaged) field insectary sites.

3. Biology of target organism

3.1 Common name, scientific name, and taxonomic classification

Common name: Leafy spurge
Scientific name: *Euphorbia esula* L.

Phylum: *Magnoliophyta*
Class: *Magnoliopsida*
Subclass: *Rosidae*
Order: *Euphorbiales*
Family: ***Euphorbiaceae***
Subfamily: *Euphorbioideae*
Tribe: *Euphorbieae*
Subtribe: *Euphorbiinae*
Genus: ***Euphorbia***
Subgenus: *esula*
Section: *esula*
Subsection: *esulae*
Species: ***esula***

The taxonomic status of leafy spurge, and the family Euphorbiaceae in general, has not yet been fully resolved. There is a great deal of morphological and biochemical variation among Eurasian and introduced North American populations of *Euphorbia esula* (Crompton *et al*. 1990, Evans *et al*. 1991, Holden and Mahlberg 1992, Manners and Davis 1984). This has led to some classifications of the weed as a complex of numerous species and interspecific hybrids (Ebke and McCarty 1983, Radcliffe-Smith 1985). However, there is ample evidence that leafy spurge can be treated as a single, though highly variable, species (Crompton *et al*. 1990, Evans *et al*. 1991, Harvey *et al*. 1988), a classification that will be followed in this document.

3.2 General life history

Leafy spurge is a long-lived herbaceous perennial plant whose aboveground stems die back each fall but whose well-developed root system and adventitious buds persist from year to year (Best *et al*. 1980). Buds initiate elongation during the fall but remain below the soil surface throughout the winter (Messersmith *et al*. 1985). Bud elongation resumes in early spring and the aboveground portions of the plant (shoots) become apparent in April or May, depending on location.

Vegetative shoots develop rapidly and reach their full height in June or July. Mature stem heights are variable, depending on soil and weather conditions, but generally range from 0.25 to 1.5 m. Stems may be branched or unbranched. Leafy spurge leaves are usually green or grayish-green in color, linear or lanceolate in shape, and from 2-8 cm long and 2-10 mm wide (Best *et al*. 1980). Leaves are arranged alternately along the stem.

Leafy spurge possesses specialized, unisexual flowers in a compound umbellate arrangement (Selleck *et al*. 1962). On some shoots, flower buds begin to develop several weeks after the shoots first appear, with peak flowering occurring in June and July (Best *et al*. 1980). Flowers may also appear later during the growing season, depending on weather conditions (Raju 1985). Because of the sticky pollen, asynchrony in maturity of adjacent male and female flowers, and the presence of nectaries, leafy spurge appears to be pollinated primarily by insects (Best *et al*. 1980, Messersmith *et al*. 1985). Seeds develop and mature from July through September, and are then explosively expelled up to 5 m from the parent plant; generally, from 30-150 seeds are produced by each flowering shoot (Selleck *et al*. 1962). Leafy spurge seeds may be dispersed over longer distances by flowing water (Selleck *et al*. 1962), birds (Blockstein *et al*. 1987) or grazing mammals (Lacey *et al*. 1992). Spurge seeds are also transported by humans in gravel, soil, hay, or farm equipment (Messersmith *et al*. 1985).

Leafy spurge seeds usually germinate in the early spring (Best *et al* 1980). Though viability decreases over time, some dormant seeds may germinate after 10 or more years in the soil (Bowes and Thomas 1978, Selleck *et al*. 1962). Typically, spurge seedlings develop a single shoot during the first growing season but do not flower (Messersmith *et al*. 1985). Seedling shoots are usually shorter and less robust than those originating from root buds, reaching heights of 20 cm or less. During the initial growing season, seedlings begin to develop an extensive root system that may extend up to about 1 m and that possesses many root buds (Messersmith *et al*. 1985). In general, seedlings serve to initiate new leafy spurge patches; exposed mineral soil associated with disturbance (e.g. cultivation, trails, roads, overgrazing) seem best suited for leafy spurge seedling and, hence, patch establishment (Belcher and Wilson 1989). Only a small percentage of newly-germinated seedlings are able to survive in established patches (Best *et al*. 1980).

Established spurge patches possess a network of lateral and vertical roots that serve perenniating, reproductive, and nutrient and water storage functions (Stroh *et al*. 1990). Most of the root biomass is located in the upper 15 cm of the soil (Selleck *et al*. 1962), but some vertical roots may reach depths of 9 m or more (Best *et al*. 1980). Two types of adventitious buds are formed on the root system (Messersmith *et al*. 1985): **crown** buds are formed on the root crown, at the base of a current-year shoot, while **root**

buds may form almost anywhere along the lateral and vertical roots. Generally, one or more crown buds will elongate at the same location each year, while the number and location of elongating root buds varies greatly from year to year and from plant to plant (Messersmith *et al*. 1985). Root buds may be formed "spontaneously" or in response to root injury (Messersmith *et al*. 1985). Most root buds occur near the soil surface, but some may be found more than 3 m deep along vertical roots (Stroh *et al*. 1990).

Only a subset of crown and root buds formed in a given year actually produce aboveground shoots, through a system of hormonal control and, perhaps, competition for water and nutrients (Raju 1985). Removal of shoots (e.g. mowing or grazing) usually causes activation of some dormant crown and root buds, and the production of new shoots; new shoot density often exceeds that observed before the treatment (Messersmith *et al*. 1985). Leafy spurge root fragments as small as 2 cm long will produce new shoots and root systems and, hence, new plants, provided they remain buried in soil (Messersmith *et al*. 1985).

Established leafy spurge plants expand vegetatively, through elongation of the horizontal roots and the formation of adventitious buds (Best *et al*. 1980). As some of these buds produce shoots in subsequent years, new root crowns are formed. The root connections among the new root crowns and the parent root system eventually disintegrate, resulting in independent, "daughter" plants. Through lateral expansion of the root systems, leafy spurge patches expand up to about 1 m in radius each year (Selleck *et al*. 1962, Stroh *et al*. 1990). At a given location, the rate of radial increase in patch size remains fairly constant from year to year (Selleck *et al*. 1962).

3.3 Pest status

Leafy spurge occurs in at least 30 US states and nine Canadian provinces (Dunn 1979), but is a significant economic problem primarily in Minnesota, Montana, Nebraska, North Dakota, South Dakota, Wyoming, Alberta, Manitoba, and Saskatchewan. Currently, about 660,000 ha are infested in Montana, North Dakota, South Dakota, and Wyoming, and the affected area doubles in size about every 10 years (Leitch *et al*. 1994).

Leafy spurge, like other members of the Euphorbiaceae, contains a milky latex throughout all parts of the plant. This latex is composed of a complex of chemicals, including

a variety of terpenoid compounds (Mahlberg 1989). Some latex chemicals from leafy spurge have skin irritant and tumor-inducing properties in mammals (Seip and Hecker 1982, Upadhyay *et al*. 1978). Paradoxically, other compounds from *E. esula* latex may have antileukemic properties; plants in the family Euphorbiaceae have long been used to treat cancers and tumors in traditional medicine (Kupchan *et al*. 1975).

Due to its latex chemistry, leafy spurge can induce a variety of digestive maladies or, in sufficient quantities, may cause death when consumed by cattle (Kronberg *et al*. 1993). However, spurge is rarely eaten by cattle, who instead avoid spurge-infested pasture despite the presence of palatable grasses (Hein and Miller 1992, Lym and Kirby 1987). Significant (>50%) reductions in forage utilization by cattle result when leafy spurge achieves 10% or more of plant cover (Hein and Miller 1992). Interestingly, domestic sheep and goats are able to consume leafy spurge with no visible detrimental effects (Landgraf *et al*. 1984).

Leafy spurge is an aggressive competitor that, because of its expansive root system and dense shoot growth, is able to outcompete rangeland grasses and forbs for available water, nutrients, and light. In addition, leafy spurge appears to exert an allelopathic effect on other plants, possibly through chemicals leached from decomposing leaf, stem, and root tissues (Steenhagen and Zimdahl 1979). Generally, the abundance of grasses and other forbs is significantly reduced in established leafy spurge patches, and some species may disappear altogether (Belcher and Wilson 1989, Nowierski and Harvey 1989).

Leafy spurge infestations significantly reduce the abundance of native prairie plants (Belcher and Wilson 1989). This reduction in native plant diversity may have a negative impact on wildlife populations (Wallace *et al*. 1992).

The primary economic impacts of leafy spurge are based on reductions in available forage and, hence, reduced cattle production on infested rangeland. In Montana, North Dakota, South Dakota, and Wyoming, Leitch *et al*. (1994) estimate that direct and secondary losses due to lost cattle production approach $120 million a year. An additional $10 million in non-agricultural (e.g. recreational and watershed) losses (Wallace *et al*. 1992) bring the total losses due to leafy spurge to about $130 million annually in the four-state area (Leitch *et al*. 1994).

4. Biology of organism to be released

4.1 Common name, scientific name, and taxonomic classification

Common name: none
Scientific name: *Spurgia esulae* Gagné

Phylum: *Arthropoda*
Class: *Insecta*
Subclass: *Pterygota*
Division: *Endopterygota*
Order: ***Diptera***
Suborder: *Nematocera*
Superfamily: *Mycetophiloidea*
Family: ***Cecidomyiidae***
Subfamily: *Cecidomyiinae*
Supertribe: *Lasiopteridi*
Tribe: *Oligotrophini*
Genus: ***Spurgia***
Species: ***esulae***

4.2 Taxonomic specialist(s) who identified organism

The genus *Spurgia* and the species *S. esulae* were originally described by R.J. Gagné, USDA-ARS, Systematic Entomology Laboratory (SEL), based on European and introduced US specimens (Gagné 1990). Subsequent confirmation of *Spurgia esulae* from the Bozeman FIS (see **2.3**, above) has been made by Dr. Gagné.

4.3 Location of voucher specimens

Type material for *Spurgia esulae* is kept at the US National Museum of Natural History (USNM) in Washington, DC. Voucher specimens from later redistribution collections are kept at the SEL and USDA-APHIS Bozeman Biological Control Facility.

4.4 Natural geographic range of organism

Spurgia esulae is believed to occur throughout much of Europe, wherever its host plant (*Euphorbia esula*) is found (Pecora *et al*. 1991).

4.5 Location where organism was originally collected

Insects initially released in the United States were collected by USDA-ARS scientists near Pisa, in northern Italy.

4.6 General life history

Spurgia esulae overwinters in the soil as a mature larva (Pecora *et al*. 1991). Overwintered larvae pupate in the spring, and adults emerge from the soil from April to June,

depending on location. *S. esulae* adults are small (<2 mm) flies that probably live only two or three days under field conditions. However, adult females appear able to actively or passively (via wind dispersal) move at least 10 m from the pupation site (Hansen, unpubl. data). After mating. adult females deposit groups of orange-colored eggs on leafy spurge leaves, near the apical buds. Generally, female flies produce lay 20-150 eggs, in groups of 8-20 (Solinas and Pecora 1984).

After hatching, first-instar larvae migrate to leafy spurge buds, where they begin feeding on the meristematic tissue. Larval feeding induces hypertrophy in the bud tissues, causing the formation of a gall. *S. esulae*-induced galls are somewhat cabbage-like in appearance, and consist of a tight cluster of abnormal warty and flattened leafy spurge leaves among which are found the developing *S. esulae* larvae. Larvae are legless, orange in color, and complete three stadia (Solinas and Pecora 1984). Larval development generally requires 2-4 weeks, depending on local weather conditions.

Mature larvae of the final generation drop from the galls and burrow into the soil, where they spend the winter. During earlier generations, *Spurgia esulae* larvae construct white silken cocoons inside the gall, within which pupation occurs. The pupal stage lasts about a week, after which eclosed adult flies emerge from the galls.

Spurgia esulae is multivoltine, but the number of generations completed per year varies with location. *S. esulae* was reported to complete four or five generations in northern Italy (Pecora *et al*. 1991). In the US, three generations occur per year in southwestern Montana (Hansen, unpubl. data), while *S. esulae* completes four generations in eastern North Dakota (Nelson 1994).

After gall formation, leafy spurge buds lose their meristematic activity, so development of flower buds and further stem elongation are prevented. In addition, gall formation appears to disrupt apical dominance, which stimulates the formation of lateral branches on galled spurge stems. Buds on these lateral branches provide attack sites for subsequent *Spurgia esulae* generations (Solinas and Pecora 1984).

4.7 Host range in the field

Spurgia esulae appears to occur only on the various "forms" of leafy spurge, *Euphorbia esula*, in its native Europe

(Pecora *et al*. 1991). To date, introduced US populations of *S. esulae* have also been reported only from *E. esula*.

4.8 Host range in laboratory/greenhouse tests

Laboratory and garden plot experiments showed that *Spurgia esulae* will oviposit, and complete development, on *Euphorbia esula* from several European and US populations, and on several other *Euphorbia* species in the subgenus *Esula* (Pecora *et al*. 1991). Poinsettia (*E. pulcherrima*), an important horticultural plant, was not utilized by *S. esulae*.

The native North American spurges *Euphorbia incisa*, *E. palmeri*, *E. robusta*, and *E. spathulata* supported development under controlled conditions, but other native spurges in the subgenus *Esula* (the rare species *purpurea* and *E. telephoides*) were not suitable hosts (Pecora *et al*. 1991). It is not yet known if these host utilization patterns will be observed under field conditions in the US. In any event, *Spurgia esulae*'s host range appears restricted to leafy spurge and, potentially some, but not all, other native and introduced *Euphorbia* species in the subgenus *Esula*.

4.9 Specific references on the organism

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4.10 List of known parasitoids or predators of organism

Spurgia esulae larvae are reportedly parasitized by *Tetrasticus* spp. (Hymenoptera: Eulophidae) in Italy (Solinas and Pecora 1984). A native wasp, *Zatropis*

nigroaenus (Hymenoptera: Pteromalidae), parasitizes *S. esulae* in North Dakota (Lym and Carlson 1994), but has not yet been observed among Montana *S. esulae* populations (Hansen, unpubl. data). Other arthropods, including adult and nymphal thrips (Thysanoptera) and mites have been collected from *S. esulae* galls at the Bozeman FIS (see **2.3**, above), but they appear to commensals rather than predators.

5. Distribution of organism in the US

5.1 Current North American distribution

Spurgia esulae was approved for US release on May 16, 1985, under the obsolete name of *Bayeria capitigena*. During summer 1985, initial field releases were made at several Montana locations by USDA-ARS personnel. Through 1994, *Spurgia esulae* has been released in Colorado, Idaho, Iowa, Minnesota, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wisconsin, and Wyoming. Established populations are present in Montana, North Dakota, Oregon, and South Dakota, while the status of populations in the remaining states is not yet clear. The insect has not been released in Canada.

5.2 Expected North American range

There appear to be no climatic or ecological barriers to survival and establishment of *Spurgia esulae* in most or all of the spurge-infested areas of the US and, at least, in southern parts of Canada. Of course, the ultimate North American range of this insect will reflect the extent of human redistribution activities.

6. Expected environmental impact of proposed release(s)

6.1 Human impacts

Spurgia esulae releases should have no impact on humans or on private property, exclusive of impacts on leafy spurge infestations.

6.2 Direct impacts

Spurgia esulae will reduce flower and seed production by, and perhaps reduce the vigor of, leafy spurge plants. However, attacks by this insect should rarely, if ever, directly kill the weed. Thus, the primary role of this agent in leafy spurge control lies in reducing the seed pool available for long-range dispersal.

The host range of *Spurgia esulae* is limited to a subset of plant species in the subgenus *Esula* of the genus *Euphorbia*, including the target weed (leafy spurge). Under experimental conditions, *Spurgia esulae* has been shown to cause galls on several native *Euphorbia* species, though it is not yet known if these plants will be suitable hosts under field conditions. The two federally-protected native spurges (*Euphorbia garberi* and *E. deltiodes*; subgenus *Chamaesyce*) and two rare native spurges being considered for protection (*E. purpurea* and *E. telephiodes*) (Pemberton 1985) are **not** suitable hosts for *Spurgia esulae*.

6.3 Indirect effects

No native or exotic insects, birds, reptiles, or mammals are known to depend largely or exclusively on leafy spurge. Even if such a dependent relationship existed, *Spurgia esulae* would have an insignificant impact because it is usually incapable of killing spurge plants. Thus, *Spurgia esulae* release should have no adverse indirect impacts.

6.4 Methods to prevent undesired environmental effects

No undesired environmental effects are anticipated.

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