

A Report to TAG  
and an  
Environmental Assessment  
of  
***Minoa murinata***

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## Abstract

Leafy spurge is a long-lived herbaceous perennial weed that was first introduced into the United States circa 1827. Currently there are no satisfactory means of controlling leafy spurge, and it is left to spread unchecked and to displace native flora. Attempts have been made to control leafy spurge with herbicides, but they are only temporarily effective because they fail to destroy the roots. The moist parts of the leafy spurge infestations are particularly sensitive, as picloram, the most commonly used herbicide, is highly water soluble and leaches into streams and ponds.

*Minoa murinata* is a promising biocontrol agent. *M. murinata* has already been released in Canada and is showing signs of controlling leafy spurge remarkably well. Since it is already in Canada and because of its limited host range and habitat requirements, the release of *Minoa murinata* into the United States is recommended.

## Introduction

Leafy spurge is a noxious perennial weed on the Great Plains of the United States and the prairie provinces of Canada. It is a non-native plant and was not known in the United States until 1827 (Thompson, *et. al.*, 1990). Because it is an introduced plant, leafy spurge has no native natural enemies. The plant is primarily found in non-tilled agricultural land (pasture, rangeland, hayland, and idle cropland) but it is also found along roadsides, river banks, flood plains, ridges, and mountain slopes (Bangsund, and Leistriz, 1991). This noxious weed restricts native plant growth and is not eaten by cattle unless it is given to them in weedy hay or if no other forage is available (Rees and Spencer, 1991). Leafy spurge also produces a toxic latex. The latex causes scours and blisters in cattle, and in large amounts, death. In humans, it causes dermatitis and blisters, and overexposure may lead to blindness. For these reasons, leafy spurge is a serious problem for farmers and ranchers. The area of greatest infestation in North America is defined by a 1,200 mile-diameter circle centered near Wolf Point, Montana (Spencer, 1990). The circle encompasses parts of nine states and five Canadian provinces and covers nearly 2.5 million acres. The greatest infestations are located in Montana, North Dakota, South Dakota, and Wyoming. The total negative economic impact in the four states combined could reach over \$144 million annually by 1995 (Bangsund and Leistriz, 1991). Due to the cost of herbicides and the threat that they pose to the environment, an urgent need has developed to find alternative control methods. Biological control seems to be one answer. The Agriculture Research Service (USDA/ARS) has been researching more effective ways to control leafy spurge for almost twenty years. Nine insects, brought to the U.S. from the native lands of leafy spurge, have been released in the United States to control leafy spurge, and more are being studied for future release. Several of these biological control agents have already made significant impacts on the spread of leafy spurge. Unlike herbicides, biocontrol agents kill the spurge without causing harm to other plants or animals located in the release areas. In sites where leafy spurge flea beetles were released in 1989, 1990, and

1991, improvements can be readily observed. In the middle of many infestations where flea beetles have been released, large, clear, circular areas have appeared. These areas, called depressions, show the positive impact of biocontrol agents on leafy spurge infestations. Introduced biocontrol agents are increasing in numbers in the field. Local, state, and federal land owners are excited about this technological method of leafy spurge control. Some of these introduced biocontrol agents are now being released in thirteen states.

## **1. Proposed Release**

### **1.1. GOALS**

The main goal of the proposed release is the establishment of *M. murinata* for more effective control of leafy spurge, the reduction of herbicide usage in riparian conditions, and thus the reduction of the economic impact of leafy spurge.

### **1.2. PROCEDURES**

A site for release is first chosen based on three main groups of site characteristics. Once a site is chosen, the insects will be released into the area, and then monitored to determine their establishment, effectiveness and survival rates.

### **1.3. SUMMARY OF SITE CHARACTERISTICS**

A site is chosen based on three sets of parameters; physical, biological, and cultural.

- 1) Physical characteristics include soil texture, soil moisture, risk of flooding, topography, direction of slope, estimated bare ground at site, and annual precipitation.
- 2) Biological characteristics include weed density, whether the infestation is continuous or interrupted, the amount of ground area shaded by plants, typical mature weed height, trees or shrubs in the release site and surrounding area, amount of shade from shrubs and trees, and size of weed infestation.
- 3) Cultural characteristics are current land use, herbicides applied within the last two years, and weed treatments within the last 12 months.

## **2. Purpose and Need**

### **2.1. SIGNIFICANCE OF ACTION**

Leafy spurge is a noxious perennial weed of the Northern Great Plains of the United States. It is hardy, resists control, and forms dense stands that restrict native plant growth and grazing (Bangsund and Leistritz, 1991). Leafy spurge reproduces by both seeds and

vegetative root buds (Spencer, 1991) and therefore has an exceptional ability to thrive and spread. These characteristics have made leafy spurge a very serious problem for farmers and ranchers. The most serious infestations are located on the prairies where, because of its deep root system, it has become the dominant plant on the open sandy soils, displacing native flora and having a corresponding negative impact on native fauna. It also survives, however, on heavy moist soils and in shaded areas. Because of this and climatic reasons, biocontrol agents are the most successful means of controlling leafy spurge.

The toxic latex in leafy spurge also causes problems. This milky substance is poisonous to cattle and man. In cattle, the latex causes scours and blisters, and in large amounts death (Rees and Spencer, 1991). In humans it causes dermatitis, and blisters, and overexposure may lead to blindness. Thus, the continued spread of spurge into recreational areas is undesirable.

Leafy spurge also displaces native plants. The western prairie fringed orchid, *Platanthera praeclara* is one of these plants. It has received threatened status in the United States and it remains in danger of leafy spurge invasion (Gassman, 1990). *Platanthera praeclara* is not only forced out of its habitat by leafy spurge, but it is killed by the herbicides used to stop the spread of leafy spurge.

The proposed solution is to use biological control to limit the spread of leafy spurge. *Minoa murinata* would be used in combination with other biocontrol agents to achieve this control.

## 2.2. ALTERNATIVE TO PROPOSED SOLUTION

Leafy spurge can be controlled through the use of herbicides, but long-term control is very difficult to achieve. Herbicides commonly used in the control of leafy spurge are 2,4-D, picloram, and dicamba (Lym, 1991a). On non-arable land, picloram is the most persistent and effective herbicide available and retreatment may not be necessary for 3-5 years (Lym and Whitson, 1991). However, picloram is expensive, extremely persistent, mobile, and kills a broad spectrum of plants. Picloram is highly water soluble, leaches into streams and ponds, and has been known to kill trees. Because of this, the present large scale use of picloram is ecologically undesirable. The best chemical options remaining are 2, 4-D, and dicamba. However, these herbicides fail to kill the roots of established plants and have to be reapplied every 1-2 years (Lym and Whitson, 1991). Also, large amounts of dicamba harm native forage production. There is an urgent need to develop an alternative to the use of picloram and other herbicides to control the spread of leafy spurge on non-arable land. A much more economical and environmentally acceptable means of controlling this noxious weed would be through biological methods of control.

### 2.3. GOALS OF THE PROGRAM

The goal of this program is to successfully control leafy spurge with the geometrid moth *Minoa murinata*.

## 3. Description of Proposed Release Organism

### 3.1. TAXONOMY

Order: Lepidoptera  
Family: Geometridae  
Subfamily: Larentiinae  
Genus: *Minoa* Teitschke 1825  
Species: *M. murinata* (Scop.).

*M. murinata* is a small delicate grey-brown moth. It is the only geometrid with true larval verrucae and it is placed in a monotypic genus. The stock used in the study were collected from *E. cyparissias* near Rappoltstein, Austria (Harris, 1986).

### 3.2. DISTRIBUTION

The distribution of *M. murinata* is England north to York, and central and southern Europe east to Siberia (Harris, 1986). More than likely, the northern limit coincides with its host plant limits. However, the limit in the south is probably due to an intolerance to high temperatures since suitable spurges do occur further south (Harris, 1986). *M. murinata*, especially those of southern Europe, are often located in the mountains. Harris also states that in North America, the moth should be able to survive on spurge stands in Canada south to San Francisco in the west and Washington D.C. in the east (*op.cit.*). The endangered North American species of *Euphorbia* will not be affected, not only because of the host specificity of the moth, but because all of the endangered species are Southern U.S. species, and out of the predicted distribution of *M. murinata*.

### 3.3. ECOLOGY IN NATIVE REGION

The habitat of the moth is widely varied. It is the main species on cypress spurge on sunny, dry chalk soil on heath-steppes, plains and highlands, but it is also found on dry to moist sites in closed woods (Harris, 1986). The moths accept shaded sites. According to Harris, 1986, they emerge, mate, and complete their life cycles at 12° C. The larvae will tolerate prolonged periods at 4° C. Colonies in the laboratory declined and eventually died-out when kept at a constant temperature above 26° C. (Harris, 1986) This may explain the restriction of the moth to mountains and the cooler parts of the spurge zone in Europe.

### 3.4. BIOLOGICAL CHARACTERISTICS

The adult *M. murinata* feeds readily on a wick with 15% honey solution (Harris, 1986). It is active diurnally and flies easily with frequent pauses to alight. Oviposition begins within a day or two of mating. The eggs are a creamy yellow color and are laid on the underside of a spurge leaf in a line. An average line contained  $9.1 \pm 1.0$  (SE) eggs but some contained more than 30 eggs. The newly hatched larvae are white with a dark head capsule but usually by the last instar (4th) they are pinkish with irregular dark brown marks along the back and sides. However, the amount of pink and brown varies considerably and some mature larvae are whitish. All larval instars feed from the underside of the leaf hanging in a U shape. They tend to eat all of the leaves in the oviposition area except for the leaf bud which is not usually eaten. Harris, 1986, stated that restricted feeding on the tender expanding leaves and floral parts occurs on some spurges, but on leafy spurge, the mature foliage is consumed. If disturbed, the young instars drop off by a thread and the older instars curl and drop. Pupation occurs in the soil.

### 3.5. HOST RANGE

In most countries, *M. murinata* is only found on *E. cyparissias* (Harris, 1986) The species is common in Germany wherever *E. cyparissias* occurs and it only feeds on those plants (Harris, 1986). *E. amygdaloides* is its host in Britain, and there *M. murinata* feeds on the spurge's flowers and floral leaves. In captivity, however, it also thrives on *E. peplus* and *E. exigua*. Larvae occurred on all samples of *E. cyparissias* foliage imported from Austria with other biocontrol agents.

### 3.6. NON-TARGET HOST ORGANISMS

It should be noted that *M. murinata* does not attack crops. Its host range is limited to various types of spurge. Grasses, crops and other plants found in the release areas will not be affected.

## 4. Description of Target Organism

### 4.1. TAXONOMY

Order: Geraniales  
Family: Euphorbiaceae  
Genus: Euphorbia L.  
Subgenus: *Esula*  
Species: *E. esula-virgata* complex (2n=60); leafy spurge

Leafy spurge is an introduced species in North America. Native to the Caucasian region, *E. virgata* is a southeastern European-Asiatic species that occurs from eastern Austria and Czechoslovakia to central Asia. The taxonomic status of the introduced North American leafy spurge complex is in a state of confusion. In Europe, there are 105 native *Euphorbia* species in the subgenus *Esula*, the group to which leafy spurge belongs. In North America, there are only 21 native species in the subgenus *Esula* (Muemsher, 1940). Variations in the leafy spurge genotype in North America resulting from new gene combinations and natural selection and adaptation may affect biotic agents introduced from Eurasian areas where these genotypes do not occur. Even more perplexity is added when one considers that this weed may have been introduced from multiple sources throughout Eurasia (Rees and Spencer, 1991).

#### 4.2. PLANTS RELATED TO THE TARGET WEEDS

Host specificity tests with the candidate agent are used to determine whether or not it has a restricted host range. If the host range shows a predictable pattern then it means that the plants outside of the susceptible group are not at risk (Gassman, 1990). Plant species will only be attacked if

1. they occur inside of the climatic region and habitat required of the agent
2. they provide the right structures
3. they occur above a minimum threshold density

The purpose of biocontrol agents, such as the proposed *M. murinata*, is to reduce the host to a few scattered plants. Because of this we must be concerned with economic plants acceptable to oligophagous agents as they are often grown in large monocultures. A few scattered plants are generally not at risk unless they occur in the same habitat or close to a large infestation of the target species.

##### 4.2.1 Economically important species

The economically most important *Euphorbia* species in North America is *E. pulcherrima* Willd. (subgenus *Poinsettia*). It is a perennial which is propagated from cuttings as a Christmas pot plant. This trade has an annual crop value of 54 million dollars.

*E. polychroma* Kern. (subgenus *Esula*) is a novelty European perennial that in North America is mostly grown from seed as an annual bedding plant. It is not of major economic importance and scattered garden plants are not likely to be at risk from a biocontrol agent.

*E. oblongata* (subgenus *Esula*) is a European annual that has become a waif in California. It is not cultivated in North America and therefore does not require special consideration.

*E. antisiphilitica* Zuccar. (subgenus *Agaloma*) is a perennial that produces a high quality wax. It is the basis of a small industry in northern Mexico with an annual value of \$1 million. The plant is a tough xerophyte that produces only a few scale-like ephemeral

leaves. It does not survive in regions with winter frost and so occurs south of the distribution of leafy spurge.

#### 4.2.2. Native Species

Currently the main cause for concern over the introduction of agents for the biocontrol of leafy spurge is the native *Euphorbia* species, especially those in the subgenus *Esula*. The United States Endangered Species Act of 1973 requires that special consideration be given to species designated in the Federal Register as endangered (LE), or threatened (LT) before biocontrol agents can be released into the United States. Category 2 is an entry level and after investigation, the species is moved into Category 3 (not threatened or endangered) or to Category 1 (species for which there is substantial evidence to support biological susceptibility).

Three *Euphorbia* taxa are listed as endangered or threatened in the United States. Only three *Euphorbia* taxa are located on the United States mainland that are considered endangered or threatened; *E. deltoidea* ssp., *deltoidea*, and *E. garberi*. These three taxa are, however, native to Florida and are located outside of the predicted geographic range of *Minoa murinata*. Eighty percent of the taxa in category 1 (endangered) are Hawaiian and the remainder occupy habitats not suitable for *Minoa murinata*.

There are 21 Category 1 spurges in Hawaii which are not at risk to agents released on the mainland. There are also nine Category 1 spurges found on the continent (*E. hooveri*, and four varieties of *E. porterana*). All of these are in the subgenus *Chamaesyce* and are southern USA species. There are 9 species in Category 3 on the North American mainland (1 in the subgenus *Esula*, 6 in *Agaloma* and 2 in the subgenus *Chamaesyce*). However, only 2 of these are sympatric with leafy spurge. Lastly, there are 7 species in Category 2 (subgenus *Esula*, *E. purpurea*, and *E. telephioides*, and 5 in *Chamaesyce*). Of these, two are sympatric with leafy spurge: *E. purpurea* (subgenus *Esula*) and *E. fendleri* (subgenus *Chamaesyce*).

The number of American species included in the five subgenera of Euphorbia is:

- ◆ Agaloma: 26
- ◆ Chamaesyce: 58
- ◆ Esula: 21
- ◆ Poinsettia: 3
- ◆ Euphorbium: 0

According to this list, in terms of species numbers, the most important subgenus is *Chamaesyce*. This subgenus is also the most important in terms of rare species. However, all species (except 2) that are under legal review for legal protection are southern US species. Although it is preferable to test all rare plant species or those under review, only those plants which are likely to be at risk need to be tested. The plants that may be at risk are only those plants that occur in the habitats suitable for the beetle's survival.

*E. skottsbergi* var. *kalaeloana* is indigenous to the Hawaiian Islands and therefore not at risk to the proposed release.

Two species, *E. hooveri* and *E. purpurea* are not designated endangered or threatened but are listed as Category 1 and 2 respectively. Because of their listing as species being considered for designation of threatened, these species must also be reviewed.

*Euphorbia hooveri* is mainly found in subsaline rainpools in the Lower Sonoran Zone of Tulare and Tehama Co., in the Central Valley of California and is a species of hot, arid, inhospitable sites. However, *M. murinata* is primarily montane. In laboratory experiments, colonies of *murinata* do not survive prolonged periods above 26° C. Thus, even if the moth were to extend its limits hundreds of miles south of those predicted, one would expect it to remain on the Western side of the Coastal Range and not become established sympatrically with *E. hooveri*.

Not much reliable information is available on the second species, *E. purpurea*. Hence, it is listed as Category 2. However, in contrast to *E. hooveri*, *E. purpurea* is found in a wide variety of areas. It can be found from Ohio to Delaware, and south to North Carolina. The wide range of *E. purpurea* should decrease its vulnerability. It is a species of swampy woods and thickets, and these are not the habitats of leafy spurge or popular collecting sites. This may explain the lack of information available on *E. purpurea*.

*E. maculata* is a common weed of lawns, gardens, and waste ground. It is poisonous to livestock and can lead to photosensitization. It is a problem weed in other parts of the world where it has been introduced. Therefore, a reduction in its numbers would be welcomed.

The few isolated localities in which *E. platysperma* has only been recorded in a few isolated localities. It is a species mainly found in very arid portions of the Colorado and Sonoran Deserts. These areas are not habitats conducive to invasion or the establishment of *M. murinata*.

There is only one species in Section *Chamaesyce* which is endangered. There is no indication that the proposed release poses a risk to any of the species in this section. Six of the taxa (one endangered, one threatened, and four in category 1) are restricted to Southern Florida and Alabama. One, in Category 2, is restricted to the southeast coast of the U.S.. All seven are native to sand dunes. It is unlikely that the moth would extend into the geographic range of most of these species, and would not invade their habitats. The remaining two *Chamaesyce* taxa, *E. atrococca* and *E. remyi*, (Category 1) are Hawaiian species and thus are not in danger of agents released on the mainland.

There are no species of Sections *Poinsettia* or *Agaloma* which are endangered.

There are no "endangered" or "threatened" species in Section *Tithymalus*. *E. telephioides* is native to Florida and is a Category 2 taxon. *E. austrina*, also of southern Florida, is a 3B taxon. The south Texas *E. roemerana* has been found not to be endangered.

#### 4.3. DISTRIBUTION

In continental Europe, leafy spurge is found as far south as central Spain, Italy, and the Balkans, and extends eastward through central Russia into Siberia (Lym, 1991b). In North America, the distribution occurs primarily in the Northern Great Plains. Leafy spurge is practically absent south of 40 degrees north latitude, and almost no 'economic' or 'potentially economic' infestations are found east of the Mississippi River. The most widespread infestation in the U.S. occurs in Minnesota, but the weed problem is the most severe in North Dakota, followed closely by Montana. It is estimated that about 90% of the leafy spurge in North America may be found within 1000 km of Wolf Point, a small town in northeastern Montana (Spencer, 1990).

#### 4.4. ECOLOGY

Leafy spurge grows on many different types of terrain. It can be found on river banks, flood plains, grasslands, ridges, and mountain slopes, but it is mainly found in untilled, non-cropland areas such as pastures, rangeland, and roadsides (Lym, 1991b). It also grows in wide variety of environments including dry, subhumid, subtropic, and subartic (Lym, 1991b). For initial infestation, leafy spurge tends to occupy sites with a high sand content but once introduced into an area, the spurge appears to have no problems adapting and begins its invasion.

#### 4.5. BIOLOGICAL CHARACTERISTICS

Rees and Spencer (1991) state that leafy spurge is a herbaceous perennial that spreads by both roots and seeds. It is spread along roadsides by grading and gravelling and the seed itself can be thrown up to 5 meters by the explosive force of the capsule (Rees and Spencer, 1991). Long distance dispersal is by birds and other animals.

The maintenance of a spurge stand is by vegetative reproduction and seed is of little consequence (Gassmann, 1990). The role of seed is the establishment of new stands and the return of old stands after they have been killed by herbicide treatments (Gassmann, 1990). Seed reduction by a biocontrol agent would be beneficial but since spurge is also spread vegetatively on roads and other equipment, spurge is relatively seed independent.

#### 4.6. MORTALITY FACTORS

Leafy spurge is most sensitive to root damage (Gassmann, 1990). It is also sensitive to feeding on the stems and leaves. This feeding helps to reduce seed production and weakens the spurge's defense mechanisms, making it more vulnerable to native plant diseases. *M. murinata* should be an effective biocontrol agent since it attacks both the stem and the leaves of leafy spurge.

There are no known native predators or parasites of leafy spurge because it is not a plant species native to North America. The latex that spurge produces is a natural barrier that keeps most grazing animals away (Lym, 1991b). Cattle will usually not eat leafy spurge unless it is given in weedy hay or better forage is not available. Although sheep and goats will eat leafy spurge, they fail to completely kill leafy spurge because they do not destroy the roots. Only the upper seed producing area is eaten, and the spurge is still able to spread and grow again. The grasshopper is the only insect known to consume spurge but it only happens in times of drought (Gassmann, 1990). The only known organisms able to kill leafy spurge are those that have been introduced to do so.

## 5. Research in Support of Release

### 5.1. COUNTRY OF ORIGIN FIELD INVESTIGATIONS

No-choice feeding tests were conducted with newly hatched larvae and with third instar larvae that had been reared on leafy spurge. They were mainly tested in 8.5 cm diameter plastic containers covered with a screen. According to Harris, 1986, these containers were then placed over a growing branch of the test plant which was introduced through a slit in one side of the container. A few tests were run using cut foliage in Petri dishes. However, there was often high mortality of the control larvae in these tests. Because of this, the results of these tests were only used on plant species that were not available for retesting (Harris, 1986). In the later tests, unless the survival of the control larvae was 80% or better, the test was repeated.

The plants tested were selected to include economic species from a wide range of orders and families, a range of latex or rubber producing plants, plants that are eaten by insects such as *Apthona* spp. that have primarily speciated on the genus *Euphorbia*, and on a range of *Euphorbia* spp. representing several sections and subsections (Harris, 1986).

Feeding and development of *Minoa murinata* are confined to certain subsections of *Euphorbia*. There was only one non-*Euphorbia* genus on which any nibbling by first instar larvae was found and that was on *Helanthemum*. This was, however, according to Harris, 1986, only pinprick sized damage. The third instar larvae did a small amount of feeding on the flowers of *Pedilanthus macrocarpus* but they were unable to completely develop. These results show that the moth does not threaten any plants outside of the genus *Euphorbia*.

All of the species tested in the subsections Galarrhaei and Esulae supported the growth and development of both first and third instar larvae except for two closely related species, *E. characias* and *E. wulfeni*. *E. lathyris* and *E. mysinites* were not suitable for first instar larvae but they did support third instar larvae (Harris, 1986). This appears to be because both *E. lathyris* and *E. mysinites* have tough, drought resistant foliage and the first instar larvae were not strong enough to eat it. On the basis of these tests, most *Euphorbia* spp. in the section Tithymalus contain the chemical requirements necessary for feeding by *M. murinata* larvae, but any that have tough or hard foliage are not physically suitable for young instars. In the subsection *Esulae*, feeding in nature on *E. amygdaloides* is reported to be restricted to the flowers and floral bracts which are softer than the mature foliage. Harris, 1986, also stated that the plants used in these tests were not flowering and the first instar larvae had a high mortality and the third instar larvae that pupated were small.

In the section Chamaesycae, *E. maculata* supported good larval development but *E. serpyllifolia* was a poor host and supported the development of only one out of ten first instar larvae. One plant of *E. marginata* was accepted and supported larval development but all the others tested were rejected (Harris, 1986). None of the other species of *Euphorbia* tested were suitable for first instar larval development although *E. milii* did sustain a reduced amount of feeding that permitted some third instar larvae to reach pupation.

According to Harris, 1986, the feeding tests showed that most spurges in the subsections Galarrhaei and Esulae are suitable for larval development of *M. murinata*. All the field host records are also from these subsections. One species in the subsection Chamaesycae supported full larval development and another species did not. Apparently there is a considerable variation in the feeding inhibitors in this subsection and tests on more species would be needed to determine the suitability of the taxon as a whole. None of the other subsections of the genus *Euphorbia* were suitable for normal larval development and all other plant genera were outside its host range.

#### 5.4. PRESENT DISTRIBUTION

According to Peter Harris, 1992, *Minoa murinata* have been surviving in Saskatchewan, Canada in the open, in a field cage in Vegeville, Alberta, and also possibly in Manitoba. However, in a study conducted by Alec McClay, 1992, temperatures about 30° C are lethal to the eggs of *M. murinata*. In cages established by McClay one winter, the survival rate of the insects was marginal. This may affect the possibility of establishment and survival of *M. murinata* in several areas.

## 6. Environmental Consequences of Proposed Release

## 6.1. SITE DESCRIPTION

The proposed release site for *Minoa murinata* is located in Williams County, North Dakota, section 10, township 154N, range 96W. The site is at an altitude of 566.9 in a level, moderately drained area. It has an annual precipitation of 25-40 cm and there is a low to moderate risk of flooding. The soil consists of 16.5% sand, 38% silt, and 45.5% clay.

*A. cyparissiae* have been released in this area to control spurge and their progress is currently being monitored. The establishment of *M. murinata* should not interfere with *A. cyparissiae* and should not cause any problems with any of the insects, plants, or animals native to the area.

## 6.2. PHYSICAL ENVIRONMENTAL RISKS

- ◆ **Air** The establishment of *Minoa murinata* will pose no threat to air quality.
- ◆ **Water** *M. murinata* will not have any negative effect on water quality. In fact, it may indirectly help to improve the water quality by reducing the amount of herbicides used to control leafy spurge.
- ◆ **Land** *Minoa murinata* will not have any adverse effects on land quality. The value of spurge infested land should increase as biocontrol takes effect.

## 6.3. HUMAN HEALTH RISKS

The establishment of *M. murinata* will have no detrimental effects on humans. However, leafy spurge does have negative effects on human health. The latex produced by spurge causes dermatitis and may even cause blindness. Therefore, any reduction in the spread of leafy spurge will be beneficial to humans.

## 6.4. ECOLOGICAL IMPACTS

**Wildlife.....***Minoa murinata* will have no negative effect on wildlife. In fact, it will have a positive effect. By controlling leafy spurge, more diverse vegetation will result and that will be beneficial to all wildlife.

**Invertebrates.....**Native insects will not be threatened (by interference or exploitation) by *M. murinata*. Since leafy spurge is not a native plant species it is free of specialized native herbivores (Gassmann, 1990). Leafy spurge is seldom attacked by invertebrate phytophages except for grasshoppers in times of drought (Gassmann, 1990). Monocultures tend to decrease the diversity of plants and animals. Therefore, the reduction of spurge will increase plant diversity and the increased plant diversity will in turn increase the number of insect species.

**Domestic Animals.....***M. murinata* will not cause any adverse effects on domestic animals and livestock. On the contrary, the latex in leafy spurge gives cattle scours, mouth blisters and in large quantities can cause death. This causes the cattle to avoid grazing in areas with moderate to high spurge densities. The reduction of spurge will in fact cause a resurgence in vegetation for these animals.

**Pollinators.....**Spurge does produce abundant amounts of honey in open nectaries, but it is not regarded by beekeepers as an important honey producing plant. In fact, the replacement of vegetation may supply a more continuous flow of honey (Gassmann, 1990). Gassmann, 1990, also stated that the honey from some South Africa *Euphorbia* species is toxic and it is not known if this applies to leafy spurge honey.

**Other Biological Control Agents.....**The establishment of *M. murinata* should not cause any problems for any other previously established biological control agents.

**Threatened and Endangered Species.....**The establishment of *M. murinata* will have no negative effect on endangered or threatened plant species. In fact, at least one species will benefit. In the United States, the western prairie fringed orchid, *Platanthera praeclara*, was declared a threatened species partly because of its susceptibility to the herbicides used to control leafy spurge (Gassmann, 1990). The legally protected species are not at risk because of the limited climatic range of *M. murinata*.

## 6.5. POTENTIAL FOR DISPERSAL FROM THE RELEASE AREA

Because *Minoa murinata* is a moth, it is likely to travel larger distances from the release areas than other biocontrol agents. However, it will not enter areas that do not fit its climatic and habitat requirements.

## 7. Cummulative Impact

The establishment of *M. murinata* will complement the effect of the other biological agents released for the control of leafy spurge. Thus, a reduction of the populations of the weed is expected. This will allow many indirect beneficial economic and ecolgical impacts: Improved enviroments for native plants due to competition from leafy spurge, increased sustainable productivity on rangelands and pastures, reduction in the application of herbicides, and enhancement of recreational lands.

*M. murinata* will help to increase the plant diversity on a rather narrow range of sites currently dominated by leafy spurge. The main effect of *M. murinata* on wildlife, both vertebrate and invertebrate, will be to increase their diversity. Their increased diversity will be due to the larger diversification of plant life.

Effective spurge biocontrol will reduce the amount of herbicides used to control spurge and their contamination of ground water. Gassmann, 1990, states that pressure to

cultivate on light soils to control leafy spurge will also be reduced with the achievement of spurge biocontrol. This reduction of cultivation will help to decrease erosion and maintain a prairie habitat.

### 7.1. MITIGATIVE MEASURES

If for some reason it should become necessary to decrease the number of *M. murinata*, the method of control currently used by APHIS (Animal and Plant Health Inspection Service) against grasshoppers, could be used effectively. In general, the most satisfactory and consistent results are obtained by the use of ultra-low-volume (ULV) sprays. One treatment would not eradicate the insect. Instead, three separate treatments at a minimum should be used. There are many different insecticides that could be used, but the three that would probably work best are Malathion ULV, Carbaryl/Sevin-4-Oil, and Carbaryl/ULV. The same treatment methods and dosage that are currently used to control grasshoppers could also be used to control *M. murinata*.

<u>Insecticide</u>	<u>Dosage</u>	
	<u>Per hectare</u>	<u>Per acre</u>
Malathion ULV 91.0 -95.0% AI	428 ml ULV (0.65 Kg AI/hectare)	8.0 fluid oz. ULV (0.58 lb. AI/acre)
Carbaryl/ Sevin-4-Oil	1.46 liters total material [1.17 liters of formulation plus 292.23 ml diesel] (0.42 Kg AI/hectare)	20 fluid oz. Total material [16.0 oz. formulation plus 4.0 oz. diesel] (.5 lb. AI/acre)
Carbaryl/ULV	2.34 liters total material [876.90 ml of formulation [plus 219.22 ml of diesel] (0.42 Kg AI/hectare)	15.0 fluid oz. total material [12.0 oz. of formulation plus 3.0 diesel] oz. (0.375 lb. AI/acre)

## 8. Conclusion

*Minoa murinata* is one of the main agents attacking *E. cyparissias* in dry locations between the latitudes 40-60° N in western Europe and the leafy spurge of the U.S. is as good or better host than *E. cyparissias*. According to host records, it is restricted to a few species of *Euphorbia* in nature, and in feeding tests, it was shown that *M. murinata* is largely restricted to certain spurges in the subsections Galarrahaei and Esulae. However, not all of the spurges in these subsections are suitable. For example, some, like *E. characias*, were unacceptable because of feeding inhibitors or because the larvae were restricted to immature foliage on the spurges with hard or leathery leaves. Most members of Chamaesyce were unsuitable hosts. Only *E. maculata* supported larval development. The moth did not attack *E. lathyris* (Harris, 1986)

The oviposition tests that were run indicate that *M. murinata* favored spurges that were good larval hosts (Harris, 1986). They tended to avoid marginal hosts and even some plants that did support good larval growth. This may be the reason why *Minoa murinata* has never been reported on *E. epythimoides*, an ornamental common in Britain and a better host than *E. amygdaloides*. According to Harris, 1986, marginal hosts in the field will rarely be exposed to larval attack since oviposition preferences should be even more prominent in the field than in the laboratory.

*Minoa murinata* is confined to a zone north of latitude 40° N in the continental part of the Palearctic. This is apparently due to an intolerance to high summer temperatures (Harris, 1986). This restriction can be expected to be followed in North America and the moth will cover the main range of leafy spurge infestations in North America. All of the endangered native spurges are Southern U.S. species and are not within the climatic range of the moth. Thus, even if these spurges are acceptable to the moth, they will not be at risk (Harris, 1986).

*M. murinata* could be a valuable agent in the biocontrol of leafy spurge in the United States. It will help to increase the stress on the spurge and poses little threat to any economic or endangered native plants. The potential benefits in effecting some degree of control over the serious leafy spurge problem in North America far outweigh the potential risks to native and ornamental spurges. *M. murinata* is already released in Canada and will eventually make its way into the United States so release in the U.S. will only speed its imminent arrival. Therefore, the release of *Minoa murinata* in the United States is recommended.

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