A Report to TAG

and

An Environmental Assessment

of

Pegomya curticornis

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Abstract

Leafy spurge is a long-lived herbaceous perennial weed that was first introduced into the United States in 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. At this time, the most effective biocontrol agents for leafy spurge are those that attack its root system. *Pegomya curticornis* does this successfully. The proposed project is to control leafy spurge with the gall fly *Pegomya curticornis.*

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 (Bansgund, and Leistritz, 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 Leistritz, 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 goals of the proposed release are:

1. the establishment of *Pegomya curticornis* to more effectively control leafy spurge
2. to decrease the use of herbicides in riparian conditions,
3. to reduce the economic impact of leafy spurge,
4. to increase the number of introduced biotic agents for the contorl of leafy spurge to increase plant stressover wider ecological niches.

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.

- Physical: soil texture, soil moisture, risk of flooding, topography, direction of slope, estimated bare ground at site, annual precipitation
- Biological: 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, size of weed infestation
- Cultural: current land use, herbicides applied within the last two years, weed treatments within the last twelve 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. *Pegomya curticornis* would be used in combination with other biocontrol agents to achieve this control.

2.2. ALTERNATIVES TO PROPOSED ACTION

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 project is to successfully control leafy spurge with the anthomyiid gall fly *Pegomya curticornis*.

3. Description of Proposed Release Organism

3.1. TAXONOMY

Order:	Diptera
Family:	Anthomyiidae
Genus:	*Pegomya* Robineau-Desvoidy
Species:	*P. curticornis*

The genus *Pegomya* belongs to those in the family Anthomyiidae which cannot clearly be defined morphologically. It is therefore possible that not all the species presently included in the genus *Pegomya* are correctly placed . According to Andre Gassmann, 1987, at one time, *P. Agronomyza euphorbiae* Kieffer, *Pegomya* (Anthomyia) *Transversaloides* Schnabel, *Chortophila curticornis* Stein and *C. brevicornis* Zett. were believed to be synonyms of *P. argyrocephala.* However, slight differences in the male genetalia were later observed.

Recent close examination of lies, reared during 1983-86 at the European Station, CIBC from five *Euphorbia species*, by Dr. V. Michelsen, Zoological Museum Copenhagen, revealed that at least two of Hennig's "synonyms", *P. transversaloides* and *P. curicornis* refer to two different species (Gassmann, 1987).

3.2. DISTRIBUTION

At this time, *P. curticornis* has only been collected in Hungary. It is expected that *P. curticornis* is more widely distributed than presently known, but it seems that it is only locally attaining high enough population levels to be detected.

3.3. HOST RANGE

3.3.1. Investigations of Host Specificity and Larval Establishment

According to Gassmann, 1987, the majority of oviposition tests were made with *P. transversaloides.* The main reason was because flies reared from various spurges were believed, in the beginning, to be the same species, tentatively named *P. argyrocephala.* Another reason was that large numbers of *P. curticornis* were difficult to obtain. However, three *Pegomya* species were tested. Although this may seem like a generalization, it should not cause any problems. This is due to the fact that *P. transversaloides* has a slightly **wider** potential host range than both *P. virgata* and *P. curticornis.*

Pegomya large complete their development inside the shoot in which the eggs are laid. According to Gassmann, 1987, they never transfer to another shoot of the same plant or to a neighboring plant. For this reason, the investigation of th ehost specificity of *Pegomya* was mainly based on oviposition tests. Test plants on which oviposition occurred in the no-choice tests were later included in simultaneous choice tests (Gassmann, 1987). Between 3-4 test plant species and a control plant were offered to four females of *Pegomya* in cages (40 cm x 40 cm x 70 cm). The plants were regularly checked for oviposition and replaced by fresh plkants if necessary (*op. cit.*). The test plants were offered in varying combinations by fresh plants if

necessary. The test plants were offered in varying combinations and their position int he test cages was changed at each control.

The oviposition tests of *P. transversaloides* showed that oviposition, mostly by unmated females, occurred on ten species of *Euphorbia*, eight of which belong to the subsection Esulae (Gassmann, 1987). Gassmann, 1987, stated that establishment of a few larvae was observedon eight species, but only two of these supported larvae to pupation. He also stated that a single living larva was found on *E. segetalis* L. and *E. myrsinitis* L. three weeks after oviposition. It is almost certain, however, that these larvae would have been found dead if the shoots would have been disected at a later date. Outside the genus *Euphorbia* another eight species in the family Euphorbiaceae were tested. Oviposition occurred only once on *Ricinus communis* L., but none of the four larvae which hatched started feeding.

Outside the family Euphorbiaceae oviposition occured on *Linum usitatissimum*L., a plant morphologically similar to spurge (Gassmann, 1987). Although oviposition was observed in each of the sequential tests, only seven fertile eggs were laid on this plant and all larvae died before pupation.

In his report, Andre Gassmann, 1987, noted that cccasional ovipostion of a few eggs occurred on another five test plant species when these plants were first offered to flies which were apparently under oviposition stress. Again, most of these eggs were laid by unmated females, and the two larvae which hatched died without any feeding.

Occasional oviposition occurred on five *Euphorbia* species and *L. usitatissuimum*, but, with the exception of *E. peplus* L., was less frequent than in sequential choice tests. Complete development occurred only on the control and on Canadian leafy spurge (Gassmann, 1987). **It should be noted that no oviposition occurred on *E. amygdaloides*, *E. milii*, *R. communis*, and *Rosa* sp.**

In addition to the tests conducted with *P. transversaloides,* one sequential and three simultaneous choice oviposition tests were conducted with *P. curticornis*. Gassmann, 1987, stated that in the sequential choice test a few fertile eggs were laid on three *Euphorbia* species, of which *E. lathyrus* and *E. oblongata* were mined, but did not allow complete development. *E. lathyris* was also accepted for oviposition in the simultaneous choice tests, and one larva of *P. curticornis* pupated on this plant. However, this puparium was of abnormal shape and eventually died (Gassmann, 1987).

3.3.2. Host Plant Preference Test

In a first series of tests, the host plant preference of *P. curticornis* was studied in a multiple choice test with potted plants in cages (40 cm x 40 cm x 70 cm) in the greenhouse (Gassmann, 1987). Four plants were offered per cage (*E. cyparissias, E. virgata, E. lucida,* and Canadian leafy spurge) to two mated females. Nine replications wre conducted with *P. curticornis.* The plants were checked for oviposition daily or every second day and replaced by fresh plants when oviposition had occurred (*op. cit.).* All the plants were replaced by fresh ones every 4-6 days.

The tests were run until the females died. *P. curticornis* significantly preferred its field host plant, *E. lucida.*

3.3.3. Larval Establishment

Larval establishment was defined as the capability of newly hatched larvae to penetrate into the shoot and to mine (Gassmann, 1987). The percent larval establishment was based on total number of shoots with fertile eggs. Gassmann, 1987, found in the results of these tests that the initial larval establishment on the field host plant is not significantly different from that observed on Canadian leafy spurge, but no larval establishment occurred on the other European spurges offered. Larval survival tests showed that larval survival is closely linked with oviposition preference.

Based on these tests, it was concluded that *P. curticornis* has a narrow host range and should not cause any serious problems with any spurges other than leafy spurge.

3.4. NON-TARGET HOST ORGANISMS

It should be noted that *P. curticornis* 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

4.2.1. Economically Important Species

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 (Gassmann, 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 *P. curticornis,* 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.

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. antisyphilitica 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 *P. curticornis.* *P. curticornis* prefers a more continental type of climate. Eighty percent of the taxa in category 1 (endangered) are Hawaiian and the remainder occupy habitats not suitable for *P. curticornis.*

E. skottsbergi var. *kalaeloana* is indiginous 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, *P. curticornis* has a difficult time surviving in high temperatures and would therefore not establish itself in the areas sympatric with *E. hooveri.*

Not much reliable information is available on the second species, *E. purpurea.* Hence, it is listed as Catergory 2. However, in contrast to *E. hooveri, E. purpurea* is found in a wide variety of areas. It can be found from Ohio to Deleware, 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 <u>not</u> 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 condusive to invasion or the establishment of *P. curticornis.*

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 fly 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 IN NATIVE REGION

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

Gassmann, 1987, stated in his report that the puparia of *Pegomya* were transferred into winter storage in early fall. After emergence the flies were kept in cages (40 cm x 40 cm x 40 cm) in a greenhouse for a few days and then transferred to potted plants which were covered by a transparent one liter plastic cylinder closed with a gauze lid. The rearing containers were kept in the laboratory at about 20^0 C constant temperature to avoid overheating and condensation. Two pairs of flies were usually kept in each container. The flies were fed with three nutritive solutions (15% honey solution, milk with 10% honey and 5% pollen and a 2% yeast hydrolysate solution in distilled water) which were offered on suspended filter paper strips. The nutrient solutions were renewed every 2-3 days and the plants were sprayed with water twice a day (Gassmann, 1987).

Fresh plants were offered for oviposition every 2-4 days. Gassmann, 1987, stated that since the females insert the eggs between the developing leaves on the shoot tip, successful oviposition had to be checked by dissection. Because the eggs were extremely delicate and most of them were damaged during dissection, dissections were made 4-5 days after oviposition to allow the larvae to hatch and to mine into the shoots before dissection (*op. cit.*). Plants with infested shoots were kept in the laboratory for a few days and then transferred to the institute's garden.

Experiments were made to collect information on the temperature threshold for the termination of diapause and to determine the temperature threshold and degee-day accumulation required for the development of post-diapause puparia. The lower temperature threshold was determined by the x-intercept method of the linear regression. The number of degree-days above the base temperature required for completion of development was determined by taking the reciprocal of the slope of the linear regression (Gassmann, 1987).

Under semi-natural conditions in the institute's garden, emergence of *P. transversaloides* started at the end of March and reached its peak between 5 and 10 days after the onset of emergence. According to Gassmann, 1987, the first flies of *P. curticornis* emerged about one week after those of *P. transversaloides*. Average mortality rates of between 10 and 20% were observed. In Canada, a well established *P. curticornis* colony began emergence in mid April (McClay, 1992).

In the laboratory no development occurred at temperatures of 15°C. The development occurred at 5 and 10°C with mortality rates not significantly higher than those under field conditions (Gassmann, 1987). It would seem that *P. curticornis* requires higher temperatures in the spring for normal post-diapause development does *P. transversaloides*. Thus the flies from Hungary are adapted to a continental type of climate which may explain their absence from areas in central, western and northern Europe which have a more atlantic type of climate (*op. cit.*).

Gassmann, 1987, stated that under laboratory conditions the highest rates of successful mating (40-60%) were obtained when flies were kept after emergence gregariously in relatively big cages (40 x 40 x 70 cm) under semi-natural conditions in a unheated greenhouse. Although *P. curticornis* was rarely observed mating during the day time, mating occurred at rest and lasted a few minutes. Males are capable of mating with several females which themselves apparently only mate once, 24-72 hours after emergence (*op. cit.*).

Oviposition started 1-2 days after mating, (3-4 days after emergence) and continued until one day before the female died. Both mated and unmated females oviposited on potted plants in the laboratory. Females ready to oviposit protruded their long ovipositor and pushed it between the developing leaves or the closed floral bracts into the center of the shoot tip (Gassmann, 1987). Egg deposition was indicated by convulsive movements of the female abdomen. *P. curticornis* lays its oval-shaped whitish eggs in batches up to fifteen. According to Gassmann, 1987, the number of eggs laid per shoot tip is well-adapted to potential for larval development. The total number of eggs laid per female was significantly different for mated (average 41, range 11-56, N-10) and unmated (average 21.4, range 0-56, N-30). Thus, under laboratory conditions, only two thirds of the potential reproductive capacity could be realized.

Gassmann, 1987, stated that mated females lived on average 17.5 days (range 9-31) and males for 14.5 days (range 4-27). Temperature has an important effect on longevity. The flies lived longer at lower temperatures.

At 20°C the larvae hatched 3-3.5 days after oviposition. In the laboratory the first and second instars were each passed within 3-3.5 days on average, and all larvae reached the third instar within 9-11 days (Gassmann, 1987). Under field conditions, the third instar is reached within three weeks and development is completed within 60-80 days. Field observations in Hungary have shown that *P. curticornis* pupated in early July (*op. cit.*). The time of pupation was well correlated with emergence pattern in the spring.

Gassmann, 1987, noted that immediately after hatching the larvae mined into the pith and downwards to the shoot base which was reached within 25-30 days. Arriving at the shoot base, the larvae started to feed on the vascular bundles which provoked the formation of gall tissue accompanied by gall formation. In the laboratory, the first signs of gall development were observed 30-40 days after oviposition. In the field, *Pegomya* reached the shoot base on average by the end of May and fed on gall tissue for about one month (*op. cit.*). Only a single larva developed per shoot on *E. cyparissias* and *E. virgata*. Gassmann, 1987, stated that if several eggs were laid per shoot, normally only one larva survived direct larval combat, but occasionally all larvae were killed. He also stated that aggressive behavior of first instar larvae did not occur on *E. lucida* which supported the development of up to ten larvae per shoot. Generally, pupation

occurred in the gall, on average 10-15 mm long and 4-7 mm wide on *E. cyparissias* and *E. virgata*, but occasionally puparia were formed in the root collar or the rhizome. Pupation of *P. curticornis* on *E. lucida* occurred in the lower part of the shoot and the position of the puparia was indicated by slight lateral swellings. Gall formation did not occur in cases where larval feeding rate exceeded the production rate of gall tissue (*op. cit.*).

5.2. PRESENT DISTRIBUTION

At this time, *P. curticornis* has been released in three provinces in Canada. According to Peter Harris, 1992, they are thriving in Alberta, surviving in Manitoba, and there is a small population in Saskatichewan. Alec McClay, (October 1992), states that his insects are currently doing well in a field cage and he expects to release them into the open in 1993.

6. Environmental consequences of proposed release

6.1. SITE DESCRIPTION

Based on information from Alec McClay who has a fairly well-established site in Canada, the proposed release site for *Pegomya curticornis* is located in Ransom County, North Dakota, section 29, township 135N, range 53W. The site is located in a hilly, well-drained area with no risk of flooding. It has an annual precipitation of 25-40 cm and the leafy spurge infestation is continuous. There are no trees or shade in this area and the vegetative association is mixed grass. The soil is sandy, consisting of 93.7% sand, 2.5% silt, and 3.8% clay. There are no other biocontrol agents released in this area, and there is also no grazing, therefore, *P. curticornis* will not interfere with any of the insects, plants, or animals native to the area.

6.2. PHYSICAL ENVIRONMENTAL RISKS

- **Air**.....The release of *Pegomya curticornis* will have no effect on air quality.
- **Water**.....The establishment of *Pegomya curticornis* will have no negative effect on water quality. On the contrary, if the fly is effective enough, reduction of the use of herbicides will result, and this will be beneficial to water quality.
- **Land**.....*Pegomya curticornis* will have no detrimental effects on soil quality. In fact, the value of land currently infested by leafy spurge should increase as biocontrol takes effect.

6.3. HUMAN HEALTH RISK

Pegomya curticornis will not have any adverse effects on human health. 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**.....*P. curticornis* 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.
- **Insects**.....Native insects will not be threatened (by interference or exploitation) by *P. curticornis*. 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.
- **Endangered or threatened species** .....The establishment of *P. curticornis* 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 three legally protected species (*E. deltoidea*, *E. garberi* and *E. skottsbergii* var. *kalaeloana*) are not at risk because of the limited host range of *P. curticornis*and its climatic limitations.
- **Domestic animals and livestock**.....*P. curticornis* 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 (Lym, 1991b). 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 *Pegomya curticornis* should not cause any problems with other biological control agents.

6.5. POTENTIAL FOR DISPERSAL FROM RELEASE AREA

The potential dispersal from the release area is not well known at this time. In Europe, the fly has only been found in Hungary and is not thought to have spread into many other areas. This is probably due to the low amount of spurge in Europe and the habitat requirements of the fly. However, because it does fly quite actively, it is expected to spread quicker and somewhat farther than some of the other biocontrol agents currently released.

6.6. CUMULATIVE IMPACTS

The establishment of *P. curticornis* 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.

***P. curticornis* will help to increase the plant diversity on a rather narrow range of sites currently dominated by leafy spurge. The main effect of *P. curticornis* 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. Mitigative measures

If for some reason it should become necessary to decrease the number of *P. curticornis*, 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 *P. curticornis*.

	Dosage	
Insecticide	Per hectare	Per acre

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 oz. diesel] (0.375 lb. AI/acre)

8. Conclusion

The direct effect of *P. curticornis* on leafy spurge will be the reduction of the weed density and the return of a wide variety of native herbaceous plants. The forage value of spurge infested land and the attractiveness of parks and recreation areas will increase as biocontrol takes effect. Faunal diversity and food chains will be re-established in spurge areas under biocontrol. The successful spurge biocontrol will reduce the amount of herbicide used for its control and hence will lessen the contamination of ground water.

P. curticornis 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. *P. curticornis* 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 *P. curticornis* in the United States in recommended.

Works Cited

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92-08
Leafy Spurge

TAGIBCW #23 (88-6)

Pegomya curticornis (Stein) (Dipt.: Anthomyiidae)	From Europe (via Canada)	For leafy spurge (Euphorbia esula L.)

Proposal for release in the United States. Received in BCDC 9/1/88. (See TAGIBCW #3 for release of P. curticornis (=P. virgatae n.sp.) in Canada.)

Copy sent for comment to F. C. Thompson, SEL (taxonomist), 10/18/88.

TAG comments sent to TAG Chairman 10/6/88.

Letter expressing TAG recommendation for denial of permission for release and a request for more quarantine testing (at Bozeman, MT) prior to release, from TAG Chairman to researcher dated 4/3/89, received in BCDC 8/29/90 (from researcher); copies forwarded by BCDC to PPQ 8/31/90.

State (Montana) approval for quarantine importation obtained 4/19/89.

PPQ permit issued 5/3/89 (received in BCDC 9/12/90).

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE
BIOLOGICAL ASSESSMENT SUPPORT STAFF
HYATTSVILLE, MARYLAND 20782

APPLICATION AND PERMIT TO MOVE LIVE PLANT PESTS AND NOXIOUS WEEDS

SECTION A - TO BE COMPLETED BY THE APPLICANT

1. NAME AND ADDRESS (Include Zip Code)
Robert M. Nowierski
Entomology Research Laboratory
Montana State Univ.
Bozeman, MT 59717

OK 4-17-89 after quarantine

2. TELEPHONE NO. (406) 994-5080

1. TYPE OF PEST TO BE MOVED
☑ Arthropods ☐ Noxious Weeds
☐ Pathogens ☐ Other (Specify)

A. SCIENTIFIC NAMES OF PESTS TO BE MOVED	B. CLASSIFICATION (Order, Family, Other)	C. LIFE STAGES IF APPLICABLE	D. NUMBER OF SPECIMENS OR UNITS	E. SHIPPED FROM (Country or State)	F. ARE PESTS NOW IN U.S.	G. WHAT HOST MATERIAL WILL ACCOMPANY PEST?	H. USDA USE PEST CATEGORY
4. Pegamya curticornis	Diptera Anthomyiidae	pupae	500	Switzerland	No	Euphorbia esula roots (washed)	
5.							
6.							

7. DESTINATION Insect Quarantine Lab Montana State Univ., Bozeman, MT
8. PORT OF ARRIVAL New York
9. APPROXIMATE DATE OF ARRIVAL OR INTERSTATE MOVEMENT April / May / June / July '89
10. NO. OF SHIPMENTS 3
11. SUPPLIER Dr. Dieter Schroeder CIBC, Delemont, Switzerland
12. METHOD OF SHIPMENT ☐ Air Mail ☑ Air Freight ☐ Baggage ☐ Auto
13. INTENDED USE (Be specific) Pegamya curticornis will be received in quarantine for additional host plant testing. This fly is a promising biocontrol agent of leafy spurge, Euphorbia esula. Testing will be conducted by Dr. Robert M. Nowierski at MSU.
14. METHODS TO BE USED TO PREVENT PLANT PEST ESCAPE
Testing will be conducted inside insect cages in the Insect Quarantine Laboratory
15. METHOD OF FINAL DISPOSITION
Following host plant testing if this biocontrol agent is not approved for release by TAG all fly material and associated test plants will be autoclaved
16. I/We agree to comply with the safeguards printed on the reverse of this form, and understand that a permit may be subject to other conditions specified in Section B and C. SIGNATURE OF RESIDENT, APPLICANT OR AGENT Robert M. Nowierski
17. DATE 4.11.89

SECTION B - TO BE COMPLETED BY STATE OFFICIAL

18. STATUS ☒ Approve ☐ Disapprove ☐ Accept USDA Decision
19. CONDITIONS RECOMMENDED Close surveillance of release sites to insure host specificity
20. SIGNATURE
21. TITLE Entomologist STATE Montana
22. DATE 4/19/89

SECTION C - TO BE COMPLETED BY FEDERAL OFFICIAL

PERMIT
23. PERMIT NO. 890219

(Permit not valid unless signed by an authorized official of the Animal and Plant Health Inspection Service)

Under authority of the Federal Plant Pest Act of May 23, 1957 or the Federal Noxious Weed Act of 1974, permission is hereby granted to the applicant named above to move the pests described, except as deleted, subject to the conditions stated on, or attached to this application. *(See standard conditions on reverse side).*

1. Release into the U.S. is not permitted.
2. For quarantine containment only. To conduct additional host studies.
3. TAG recommendation into quarantine 4/3/89.

MT/NER/JR Coulson

24. SIGNATURE OF PLANT PROTECTION AND QUARANTINE OFFICIAL	25. DATE	26. LABELS ISSUED	27. VALID UNTIL
	5/3/89	20 PPQ 599	12/31/92

PPQ FORM 526 (SEP 81) *Previous edition may be used*

MONTANA STATE UNIVERSITY
Entomology Research Laboratory
Montana State University
Bozeman, Montana 59717
406-994-3860

April 11, 1989

Mr. Oran Roy Bjornson, Administrator
Mr. Will Kissinger
Plant Industry Division
Montana Department of Agriculture
Agriculture/Livestock Building
Capitol Station
Helena, MT 59620

Dear Gentlemen:

Please find enclosed APHIS permit form #526 for shipment of Pegomya curticornis (Stein) from Delemont, Switzerland by Dieter Schroeder (Commonwealth Institute of Biological Control) to the Insect Quarantine Laboratory at Bozeman, Montana. This anthomyiid fly species is a potential biological control agent of Leafy Spurge, Euphorbia esula. I am interested in obtaining this fly to test it in Quarantine on some additional euphorb species native to North America and ultimately to assess whether this fly would be safe to release in North America.

I should mention that permission to work on P. curticornis in Quarantine was recently granted by the Technical Advisory Group (TAG). Please see enclosed letter dated April 3, 1989.

Would you mind sending the extra copy of this letter on to Phil Lima when you send the 526 form to him? This may help expedite the process. We would greatly appreciate immediate processing if possible since the flies need to be collected from April through July in Europe. Thank you very much.

Sincerely,

Robert M. Nowierski

Robert M. Nowierski
Associate Professor of Entomology

Where Tradition Meets the Future
1889-1989
University of Idaho

April 3, 1989

Dr. Robert Nowierski
Biocontrol Facility
Forestry Science Lab
Montana State University
Bozeman, MT 59717

Dear Dr. Nowierski:

College of Agriculture
Department of Plant, Soil and Entomological Sciences
University of Idaho
Moscow, Idaho
83843 U.S.A.

208-885-6276
FAX 208-885-7760

The TAG committee reviews of your proposal to release Pegomya curticornis for biological control of Euphorbia esula were generally favorable, but one reviewer questioned the adequacy of the host range definition, the validity of the synonomy of P. virgatae with P. curticornis and its effect on host range interpretation, and the validity of the conception that the host range is extremely narrow. I concur with that reviewer that P. curticornis should be brought into quarantine at Bozeman for further host specificity testing before release.

Yours truly,

Robert H. Callihan
Associate Professor of Agronomy

bl:12273crs

cc: P. W. Lima

COMMONWEALTH of VIRGINIA

S. MASON CARBAUGH
COMMISSIONER

BILLY W. SOUTHALL
DIRECTOR

DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES
Division of Product and Industry Regulation
P. O. Box 1163, Richmond, Virginia 23209

September 21, 1988

Mr. Philip Lima, Executive Secretary
Technical Advisory Group on the
Introduction of Biological
Control of Weeds
USDA/APHIS-PQQ
6505 Belcrest Rd, Rm 669
Hyattsville, MD 20782

Dear Phil:

This is in reply to Dr. Robert M. Nowierski's request for approval to release Pegomya curticornis(= P. virgatae) in the United States for the control of leafy and cypress spurge.

I support the release of P. curticornis pending further information such as where and when will the release be made, and what is the monitoring protocol to determine if it attacks and/or becomes established on non target plants in the U.S.?

Sincerely,

Donald H. Kludy
State Entomologist & Chief
Bureau of Plant Protection
& Pesticide Regulation
804/786-3515

DHK/cbf

United States Department of Agriculture

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Bio-Control Facility
Forestry Sciences Lab.
Montana State University
Bozeman, Montana 59717

Subject: Review of the Petition to Release Pegomya curticornis for the Biological Control of leafy spurge, Euphorbia esula, in the United States

Date: September 29, 1988

To: Philip J. Lima
Executive Secretary, TAG
USDA, APHIS, PPQ
Federal Building
6505 Belcrest Road
Hyattsville, MD 20782

I have carefully reviewed the final screening report on the Pegomya argyrocephala complex relating to the proposed release of P. curticornis for biological control of leafy spurge in the United States. There are several problems with this proposal, particularly the paucity of information pertaining specifically to P. curticornis, the agent in question, to warrant its immediate field release without additional testing in quarantine.

In my opinion, the potential host range of P. curticornis was not adequately defined. According to the screening report, the most extensive host specificity investigations were made with P. transversaloides, not P. curticornis. To extrapolate this information from one species to another is inappropriate and may prove to be dangerous.

Also, there is some confusion as to the identity of the agent. In the cover letter of 18 August 1988, Dr. Nowierski equates P. virgatae as a synonym of P. curticornis, the candidate agent, yet A. Gassman treats these as separate species in his screening report. This makes the interpretation of the host range data difficult if not impossible. For example, P. virgatae developed normally on Canadian leafy spurge (Table 13) whereas P. curticornis did not develop on the target weed (Table 15). If P. virgatae is indeed a biotype of P. curticornis, then definitive evidence of this synonymy should have been provided to members of the TAG.

Furthermore, the so-called "extremely narrow host range of P. curticornis" is, in my opinion, doubtful as a result of the synonymy. If P. curticornis sensu lato develops on both E. lucida and E. virgata as well as Canadian leafy spurge, then its potential host range must be broader than previously thought and therefore warrants further testing to ensure it will not attack most North American native spurges and especially rare spurges under review.

I therefore recommend that P. curticornis be brought into quarantine at Bozeman, MT for additional host specificity testing of representative American Euphorbia species. The following Euphorbia species are currently endangered, threatened, or under review and are available through the Center for Plant Conservation, Jamaica Plain, MA:

E. purpurea (Raf.) Fern

E. telephioides Chapm.

E. roemerana Scheele

E. deltoidea ssp. deltoidea
Engelm. ex Chapm.

E. garberi Engelm. ex Chapm.

E. porterana Small

E. hooveri L. C. Wheeler

The following additional Euphorbia species are sympatric with leafy spurge and therefore have the potential to act as bridge species:

E. robusta (Engelm.) Small

E. spatulata Lam.

E. corollata L.

E. marginata Pursh.

JAMES P. CUDA, Ph.D., R.P.E.
Station Supervisor, Methods Development
Bio-Control Facility
USDA, APHIS, PPQ
Bozeman, Montana

Enclosure