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Investigations on Euzophera cinerosella (Zeller) (Lep.: Pyralidae), a possible agent for the biological control of the weed Artemisia absinthium L. (Compositae) in Canada

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The taxonomy, distribution, life-history and host plant relationship of the Pyralid *Euzophera cinerosella* (Zeller), an oligophagous, univoltine stem-and root-borer of *Artemisia absinthium* are described. Its actual and potential effectiveness as a phytophage of *A. absinthium* are discussed and it is shown that it possesses a number of biological and ecological characteristics which are desirable in candidate agents for the biological control of weeds. Field surveys in 4 countries and laboratory investigations show that the basis of host specificity in *E. cinerosella* includes a combination of chemical, structural and phenological requirements. These are only fully present in *A. absinthium* and partly so in some closely related species of *Artemisia*. Hence, the experimental investigation of the host specificity of *E. cinerosella* is recommended.

Artemisia absinthium (Absinthe), a weed native to Eurasia, was first recognized as a serious weed in Canada in 1954. It is found in all Canadian Provinces but is particularly abundant in the Prairie Provinces. It occurs along roadsides, in waste places, farmyards, pastures and cropland (Frankton & Mulligan, 1970). A literature review of the phytophagous insects associated with *A. absinthium* in Europe suggested that the Pyralid *Euzophera cinerosella* (Zeller), the larvae of which mine the stems and roots, is specific to *A. absinthium*. Field surveys during 1972-1975 in Austria, France, Germany and especially in the Swiss Valais revealed that *E. cinerosella* occurs in most populations of *A. absinthium* throughout its European range, that it causes serious damage to its host plant and that it has potential as a biological control agent. Consequently Dr. P. Harris, Regina, suggested an investigation of this species. Hence, the present study carried out at the European Station, CIBC, to investigate its biology and host specificity.

TAXONOMIC POSITION

According to the systematic revision of the palaearctic Phycitinae by Roesler (1973), the genus *Euzophera* (Zeller, 1867) comprises 44 species in the palaearctic region and members of the genus are known from all continents. Roesler subdivided the genus in 3 subgenera, *Euzophera* (42 species), *Quadrempista* (1 species) and *Cymbalorissa* (1 species). A detailed diagnosis of the genus *Euzophera* and a key for the identification of the species are given by Roesler (1973).

E. cinerosella (Zeller, 1839 as *Myelois cinerosella),* the type species of the genus, was described from specimens collected at Stettin, Poland. Roesler (loc. cit.) gives a full description of the adult.

Phycis incanella Eversmann, *Myelois artemisiella* Stainton and *Euzophera pimelcella* Zerny are synonyms.

GEOGRAPHIC DISTRIBUTION

Present knowledge suggests that the genus *Euzophera* originated in the east-mediterranean or west-asiatic region, where 24 species and one subspecies are found. Of these 17 are restricted to western Asia (Asia Minor, Middle East, Iran, Afganistan) and represent the largest group of species within a single geographic area. Another ten species and one subspecies are restricted to eastern Asia (Mongolia, China, Japan), two species to Central Asia, two to North Africa and four species and one subspecies to Europe (including the European part of the USSR). Seven species are more widely distributed, occurring in western Asia, in North Africa and in many parts of southern Europe. The number of species occurring in various parts of the Palaearctic is given in tabl. 1.

Table 1: The number of species of *Euzophera* known to occur in various parts of the palaearctic region

	No. species
Europe: *northern & central* parts	4
south-western parts (southern France, Spain, Portugal, Italy)	6
south-eastern parts (Hungary, Balkans, SE-Russia)	11
Anatolia, Syria, Palestine	15
Arabia (including Iraq)	9
Northern Africa (including Egypt & northern Sudan)	7
Iran & Armenia	17
Turkestan, Afganistan, Pakistan, Sikkim	13
Central Asia	4
Mongolia	5
China	5
Siberia	1
Japan	1

According to ROESLER (1973) there are two subspecies *E. cinerosella cinerosella* found in Europe east to Asia Minor and *E. c. politella* in Iran and Mongolia. In Europe, *E. cinerosella* has been found in England, Danmark, Germany, Poland, Czechoslovakia, southern France, Spain, Portugal, Italy, including Sicily, southern and eastern Switzerland, Austria, Hungary, Yugoslavia, Romania, Bulgaria, Greece, Turkey (Anatolia), Cyprus, and USSR (Ural Mountains, Kasan, Caucasus, Galicia). Outside Europe it occurs in Israel and the Lebanon.

The present observations and information from specialists indicates that *E. cinerosella* can be found almost everywhere in Europe where *Artemisia absinthium* occurs. However, it seems to be more common in areas with a continental climate and in western and southern Europe it is restricted to areas with low precipitation.

During the surveys and collections (1972–1975) *E. cinerosella* was found in the Valais and at various localities in the Tessin (Switzerland), the Aosta Valley (Italy), in Tyrol (Lower Austria), the Burgenland (Austria) and along the Adriatic coast of Yugoslavia. All collections were made in the Valais where *E. cinerosella* is common on south-facing slopes throughout the vine-growing area but is rare in the plains along the river Rhone.

HOST PLANTS

Records are available for only 6 species of the 44 palaearctic *Euzophera* (tabl. 2). According to ROESLER (1973) it can be expected that most species mine the bark and twigs of deciduous trees and shrubs. However, the available host plant records do not support this statement, but show that they are able to exploit a wide range of host plants, trees *(Fraxinus, Ulmus, Olea),* herbs *(Artemisia)* and annuals *(Solanum).* Also, there is great variation between the species as to the part of the host plant used as food (bark, wood of shoots and roots, fruit, leaves). One species is predacious on coccids. This wide range of host plants and feeding sites among *Euzophera* species is not necessarily an indication of general polyphagy. On the contrary it may be an indication of a process of specialization which is taking place within the genus. This view is supported by the known lifehistories as five of the six species, the host range and feeding habits of which are wellknown, are rather specific. The sixth, *E. bigella* ZELLER, seems to be polyphagous, but ROESLER (1973) states that it shows a remarkable morphological variation which suggests that an assemblage of several subspecies or even sibling species may be included under this name.

Table 2: Host plant records of palaearctic *Euzophera* species

pinguis HAWORTH	- in bark of *Fraxinus* (SCHUETZE, 1931; BEIRNE, 1952; HANNEMANN, 1964), in branches of *Olea europaea* L. (CHRETIEN, 1917; L'HOMME, 1935). Europe.
bigella ZELLER	- in bark of *Ulmus* (KRONE, 1904), *Salix* (KASY, 1954), in fruit of apple, apricot, walnut (PALMONI, 1969), apple, pomegranate, quince (KUZNETSOV, 1957). Noxious. Europe & Israel.
cinerosella ZELLER	- in roots (shoots) of *Artemisia absinthium* (BEIRNE, 1952; SCHUETZE, 1931). Europe.
cocciphaga HAMPSON	- feeding on coccid *Aspidoproctus xyliae* GR. (CLAUSEN, 1940). India.
osseatella (TREITSCHKE)	- in stems of Solanaceae, e.g. *Solanum villosum* MILL. (PALMONI, 1969) Israel, *S. Melongena* L. (ASSEM pers. record, cit. ROESLER, 1973) Egypt. Noxious.
fulginosella (HEINEMANN)	- in leaf-rolls of *Betula* (JAHR & ZINCK, 1961; HANNEMANN, 1964). Europe.

E. cinerosella is widely distributed and wellknown to specialists and amateur collectors. All available information indicates that it is restricted to *A. absinthium.* This is supported by the field surveys in the Alsace (France), Austria, southern Germany and Switzerland, during which *E. cinerosella* was found exclusively on *A. absinthium,* but not on *A. campestris* or *A. vulgaris* even in mixed stands of *A. absinthium* and *A. vulgaris* in eastern Austria and the Valais. Also not a single larva has been found on the nearby plants of the other two *Artemisia* species even when they were present at high density on *A. absinthium.* It may therefore be concluded that *E. cinerosella* lives monophagous on *A. absinthium.*

LIFE HISTORY

Material and Method

Between 1974–1976, the life history of *E. cinerosella* was studied in the area between Sierre and Visp, Valais (Switzerland), from where came all material for laboratory investigations at Delémont.

Root stocks of *A. absinthium* containing mature larvae and pupae were collected at the end of April or the beginning of May, shortly before emergence of the first adults so as to allow normal development under field conditions. These were put in a moderately moist soil-peat-mixture in emergence cages and kept at 23–25 °C at normal day-length. The emerging adults of *E. cinerosella* were used for life history studies. Oviposition and the establishment of first instar larvae were studied on potted plants in the laboratory and on plants growing in the garden of the laboratory. All laboratory investigations were supplemented by field observations in the Valais.

Emergence of E. cinerosella

In the laboratory, emergence took place over a two months period, beginning at the end of May or early June and ceasing at the end of July (tabl. 3). Both sexes emerged at the same rate throughout the emergence period so that the observed number of moths of each sex which emerged during 10-day periods did not significantly depart from the expected numbers, when tested with the x^2-test. Emergence in the field followed exactly the same pattern. Males and females were observed in the Valais and eastern Austria between the end of May and early August.

Table 3: Emergence of *Euzophera cinerosella* (Laboratory rearings)

Date collected	Period of emergence ♂♂	♀♀	Days ♂♂	♀♀
April 29-30, 1974	May 30-July 29	June 1-August 19	61	80*
May 6-7, 1975	June 6-July 28	June 6-July 22	53	47
May 11-12, 1976	May 29-July 27	June 5-July 27	60	53

*only 5 females emerged after the 56th day.

It has not been possible to identify reasons for this unusual emergence pattern; possibly phenological or physiological differences between individual plants or differences in microclimate are responsible. The usually high rate of attack seems to demonstrate that scattered emergence is rather an advantage than a handicap and may well be a special adaptation for the successful exploitation of the host plant.

Mating and oviposition

The females mated shortly after emergence, or at any rate within 24 hours. Males are able to mate several times, females apparently mate only once. Oviposition started the day after mating with up to 12 eggs laid per female during each of the first 4 days, thereafter the rate progressively decreased with increasing age. In a careful inspection of 200 shoots of *A. absinthium* collected in the Valais on July 4, 1974 most of the eggs were laid on the stems and leaves of the lower parts of the shoots but the total number of eggs was too small to conclude that the lower parts of the shoots are preferred. Therefore, 5 potted plants of *A. absinthium* with 44 shoots were put in cages to study oviposition of *E. cinerosella*. Of a total of 1249 eggs, 1152 were laid on the shoots and 97 on soil particles and the litter on top of the flower pots. The distribution at different height intervals above ground is shown in tabl. 4. Thus 74.5% of the eggs were found up to 10 cm above ground, and 90% of the eggs on the lower 20 cm of the shoots (tabl. 4). The basal parts of the shoots are therefore the preferred oviposition site. Although the majority of the eggs was found on the stems and on dead leaves, green leaves were equally favoured. The eggs were laid singly or in small batches (up to 6) on the surface of stems and leaves, preferentially in crevices, below scales and between the pinnae of folded dead leaves. On fresh leaves the eggs were often found in the angle between the pinnae. The egg period lasted 8 to 10 days.

Table 4: Distribution of eggs of *Euzophera cinerosella* on 44 shoots of 5 potted plants of *Artemisia absinthium*

	Height above ground (cm)					
	0–10	10–20	20–30	30–40	40–50	50–60
	110	–	–	–	–	–
	31	2	–	–	–	–
	110	45	60	8	–	–
	180	62	–	6	4	–
	428	76	18	1	5	6
Total	859	185	78	15	9	6
%	74.5	16.1	6.8	1.3	0.8	0.5

The eggs are oval in shape and somewhat flattened, length $\bar{x} = 0.61 \pm 0.02$ mm, width $\bar{x} = 0.38 \pm 0.01$ mm (No. = 50). The eggs are whitish when deposited and turn progressively reddish within 3 to 4 days. The chorion is sculptured with prominent ribs, the parts enclosed by the ribs have the shape of a maple leaf.

Longevity and egg production

Under laboratory conditions, when fed with a honey-sugar solution, males lived 2 weeks on average, females for 3 weeks (tabl. 5). The longevity of both sexes increased slightly during the first third of the emergency period and decreased thereafter but the different life spans shown in tabl. 5 for groups of males and females emerging at different times within the emergence period are not significantly different from the mean value (x^2-test).

Table 5: Longevity and egg production of *Euzophera cinerosella* in the laboratory in 1975

Emergence date	Average longevity days		Average No. eggs/female	No. eggs/ female/day	Eggs in dead ♀	
	♂♂	♀♀			No. per ♀	%
June 6–15	15 (4–24)	17 (4–21)	55	2.30	16.0	29
June 16–19	18.5 (16–24)	23 (19–25)	65	2.83	7.5	11
June 23–27	13 (9–15)	16 (10–22)	101	5.91	4.0	4
July 2-8	7 (2–13)	13 (5–18)	78	5.60	4.8	6
July 10–22	11	12	48.5	4.04	12.0	25

The average number of eggs laid per female increased from 55 at the beginning of June to 101 at the end of June and decreased to 48.5 towards the end of July. Females which emerged in August did not lay any eggs, even if they had mated. As can be seen from tabl. 5, the increase and decrease of egg production was not correlated with longevity, but due to differential fecundity. An additional indication of a differential fitness of females which emerged at different dates is given by the number of eggs which remained in the ovaries when the females had died. Thus the highest numbers were found in females which had issued at the beginning and at the end of the emergence period which lost about one quarter of their potential. Compared with around 5% for females which had emerged in the middle of the emergence period.

Hatching and larval development

In the laboratory the larvae hatched 8–10 days after oviposition. They left the eggs through a hole at the posterior end of the egg. The egg shell is not eaten, but larvae hatching on green leaves sometimes fed on the upper cuticule of the leaf. Larvae hatching on dry leaves or on the stem moved upwards to reach green leaves. Within 24 hours they bored into the base of the leaves, destroyed axillary bud and started mining downwards, feeding in the vascular tissue of the shoots. The first moult was observed within 6–10 days of hatching by which time the mines were 6 to 10 mm long.

Those larvae which had entered the shoots 10 to 12 cm above ground remained in their mines and progressed downwards into the root but those that had entered the shoots at greater distance (15–40 cm) from the root collar did not remain in their mines. They emerged as second or early third instars and re-entered the shoots near the root collar or within 10 cm above the root collar. Later instars mined below the bark of the lower part of the shoots and down into the roots, the outer parts were eaten before the larvae mined into the woody part of the roots. Only fifth and sixth instars were found in the roots. Pupation took place after hibernation in late spring of the following year in a loose white silken cocoon in a pupal cell in the upper part of the roots.

In the field in the Valais, the first larvae were found in early June. The great majority of the larvae hatched within 20 cm of the ground and entered the shoots close to the empty egg. The first four larval instars mined in the lower part of the shoots, sometimes circling them and destroying the larger portion of the root crown area. By the end of July all larvae had reached the fourth instar and by the end of August all had reached the fifth or sixth instar and were mining in the roots (of a sample collected on August 29, 1975, ⅓ were fifth and ⅔ sixth instar). They stopped feeding in late October and hibernated in their mines. In spring the larvae mined upwards and prepared their pupal cells. From mid-April onwards only praepupae were found. Pupation took place from early May onwards. Emergence began at the end of May and continued until the end of July.

Head capsule sizes of different instars of *E. cinerosella:* first 0.25 mm, second 0.36–0.39 mm, third 0.45–0.65 mm, fourth 0.71–1.00 mm, fifth 1.05–1.35 mm, sixth 1.40–1.60 mm.

Larval development on potted plants was slightly retarded, but followed that in nature. It is therefore of interest to note that in the laboratory the successful hatching rates of eggs laid at different times during the oviposition period were significantly different (x^2-test) (tabl. 6). If it is decided to liberate *E. cinerosella* in Canada, females emerging during the third to fifth week after the onset of emergence should be liberated in preference, because they seem to be the fittest: they lay more eggs (tabl. 5) with a higher fertility (tabl. 6).

Table 6: Hatching rates of *Euzophera cinerosella* in relation to the emergence dates of females in 1975

Emergence date of females	No. eggs	No. hatched	% hatched
June 6–13	397	199	50
June 15–20	520	386	74
June 23–July 7	897	552	62
July 10–22	615	255	41

The larval population in the field

The abundance of *E. cinerosella* at three sites in the Valais was studied: at the bottom of the Rhone Valley, where *A. absinthium* was abundant on alluvial deposits of sand and gravel on waste places, abandoned gravel pits and road sites (e.g. near Visp, 650 m NN); at the foot of south-facing slopes, where *Artemisia* grows on the banks of small streams and foot-paths (e.g. near Raron, 720 m NN); and on south-facing slopes about 100–150 m above the valley bottom, where *Artemisia* grows on waste land, uncultivated patches and road-sides in between vineyards (e.g. near Salgesch, 800–850 m NN).

Table 7: Frequency distribution of *Euzophera cinerosella* larvae in 50 root stocks of *Artemisia absinthium* near Salgesch, Valais (root stocks collected August 8, 1973 and August 27, 1975).

No. root stocks	No. larvae	No. root stocks	No. larvae
22	0	2	7
6	1	1	8
5	2	1	9
4	3	2	10
1	4	2	14
2	5	1	21
1	6		

During 1973–1976, the percentage of root stocks attacked by *E. cinerosella* remained constantly below 5% at the bottom of the valley, but was constantly above 50% on the slopes. In certain places between 80% and 100% of the *Artemisia* plants were continuously attacked. The infested root stocks contained between 1 and 21 larvae (tabl. 7). The age and size of the root stocks and the number of larvae found in them was not correlated. It seems that certain plants are preferred for oviposition, but the criteria on which this preferrence is based remain unknown. At the main observation area near Salgesch, the density of *E. cinerosella* decreased from 2.45 larvae per root stock in 1973 to 0.59 larvae in 1976 (tabl. 8).

Table 8: Abundance of *Euzophera cinerosella* in field collected root stocks of *Artemisia absinthium* near Salgesch (Valais)

Date collected	No. root stocks	No. larvae	Average larvae root stock
August 8, 1973	40	98	2.45
May 1-17, 1974	264	403	1.53
May 6-7, 1975	170	210	1.24
May 11-12, 1976	200	117	0.59

MORTALITY FACTORS

Mortality of the egg stage has not been studied in the field, but occasional observations show that a certain percentage of the eggs does not develop as has been observed in the laboratory (tabl. 6). Apart from a differential egg mortality within each generation, an increasing egg mortality was observed in our laboratory breedings: 10% in 1974, 43% in 1975 and 71% in 1976. It would seem that the increased egg mortality was the result of a degeneration of the field population, because each sample comprised field collected praepupae and pupae which were reared to the adult under exactly the same laboratory conditions.

The extent of mortality of newly hatched larvae in the field could not be studied. Ants were observed to prey on these larvae and may be of some importance on host plants on which aphid colonies are visited by ants. In the laboratory it was observed that a certain percentage of the newly hatched larvae was too weak to enter the shoot and died (6.6% in 1975 and 10.8% in 1976).

The Tachinid *Bithia jacentkovskyi* VILLEN. is the most important larval parasite of *E. cinerosella* in the Valais, accounting for up to 90% of the total parasitized (tabl. 9). Two additional parasites, a *Campoplex* and a *Braconid,* the identification of which is pending, are of little importance. No pupal parasites were found. Predation on larvae and pupae within the root stocks has not been observed. No diseased larvae or pupae were found. Between 1973 and 1976, the winter mortality of larvae remained below 10%. Part of this mortality was caused by drought which killed plants in autumn and these dried up during winter. In heavily attacked root stocks some of the larvae died from starvation. In a few cases larvae of *E. cinerosella* were killed by the larva of the Cerambycid *Phytoecia julii* MULSANT, which occurred in low numbers in some of the attacked root stocks.

Table 9: Parasitism of the larvae of *Euzophera cinerosella* in the Valais

Year	No. hosts	Total parasitism		*Bithia jacentkovskyi*		Others	
		No.	%	No.	%	No.	%
1974	403	182	45	153	84	29	16
1975	210	115	55	105	91	10	9
1976	117	27	23	26	96	1	4

The fact that a single parasite species is responsible for the major proportion of the total mortality is of great significance in view of the anticipated release of *E. cinerosella* in Canada. *B. jacentkovskyi* is most certainly a specialized parasite of *E. cinerosella.* The fly has so far only been collected at sites where *A. absinthium* is present and the high rates of parasitization observed in the Valais demonstrate that *B. jacentkovskyi* is well synchronized with its host. Of the 14 palaearctic species of *Bithia* the hosts of 4 species are known and they are all Lepidoptera mining in roots of herbaceous plants. No species of *Bithia* is known to occur in Canada. The only closely related Tachinid, *Neofischeria flava* TOWNSEND, is recorded from Connecticut and the Atlantic region of North America. It can therefore be expected that *E. cinerosella* would not be attacked by a specialized Tachinid after its release in Canada and should become even more abundant than in Europe.

EFFECT ON THE HOST PLANT

The larvae of *E. cinerosella* damage *A. absinthium* in three different ways, the type of damage being related to the developmental stages of the larvae. In nature, the damage caused by first and second instars is insignificant, although they destroy a certain number of leaves and buds.

Third and fourth instar larvae mine the cambium and vascular system in the lower part of the shoots and the root collar area. Shoots of 2–4 mm diameter are often completely circled and die. Shoots of larger diameter wilt and dry up prematurely if a large part of the vascular system is destroyed which usually happens when two or more larvae mine the same shoot. In both instances the plant loses a certain proportion of its assimilating surface and no viable seeds are produced on the attacked shoots. At high rates of attack, e.g. 10 to 20 larvae of *E. cinerosella* per plant, between 10 to 15 shoots can be destroyed on a single plant that is between 30% and 100% depending on the size of the plant. Counts of live and dead shoots made at the end of August near Sierre revealed that between 4% and 51% (average 26%) of the shoots had been killed by the feeding of third and fourth instar larvae.

The greatest damage is caused by the root mining of fifth and sixth instar larvae. At first they mine superficially in the cambium and vascular system of the root producing irregular mines of varying diameter, which are enlarged to patches of different sizes so that large parts of the cortical tissue are destroyed when several larvae feed in the same root. Later in the season, at the end of August or in early September, the larvae enter the woody central part of the root where a single larva can produce a mine 14–20 cm long before it returns to the cortical tissue to prepare the pupal cell close to the soil surface.

Table 10: Frequency of different degrees of damage caused by larval feeding of *Euzophera cinerosella* on root stocks of *Artemisia absinthium* near Sierre (Valais)

Year	Rate of attack(%)	No. root stocks	Damage class (%) I	II	III	IV
1973	78	40	29	29	32	10
1974	81	264	31	23	24	23
1975	77	78	38	30	32	0
1976	90	159	14	29	24	33

I = Little damage; newly attacked
II = medium damage; 2–3 years of attack, or more than 3 larvae
III = severe damage; several years of attack, or many larvae
IV = roots dying or dead after several years of attack.

In the Valais the rate of attack varied between 77% and 90%. On dissection of the root stocks, various degrees of damage were observed (tabl. 10). In the first year damage was usually limited except where the roots were small and/or attacked by several larvae. Larval feeding during 2–3 years caused severe damage on smaller and medium sized root stocks and moderate damage on large root stocks. Even with moderate damage the number of shoots is reduced and the remaining shoots are shorter and produce less seeds, compared to healthy plants of comparable age and size. After 4–5 years of attack all or the major part of the root tissue is destroyed and even very large root stocks dry up and die.

The most severe damage was observed near Raron (Valais). In 1973, an isolated group of 60 large plants was found with an average of 40 shoots between 60–100 cm long. The volume of the root stocks varied between 200 and 400 m^3. All the roots were attacked by more than 5 larvae of *E. cinerosella* and small numbers of *Phytoecia julii*. In 1975, all 60 plants had died. On dissection it was found that the roots had been completely destroyed by larval feeding of *E. cinerosella*, and to a lesser extent *P. julii*.

POTENTIAL CONTROL VALUE

In the following discussion the scoring system developed by HARRIS (1973) is used to assess the potential control value of *E. cinerosella*.

a) *Host specificity: E. cinerosella* is an monophagous species Score : 1

b) *Direct damage inflicted:* The larval feeding of *E. cinerosella* destroys large parts of the vascular system of *A. absinthium* and reduces seed production Score : 5

c) *Indirect damage inflicted:* The feeding of *E. cinerosella* on healthy plants of *A. absinthium* conditions the plants for the attack by the Cerambycid *P. julii,* which destroys remaining root tissue and speeds up the die-back of large plants Score : 1

d) *Phenology of attack:* Prolonged period of feeding covering the growing season and increasing the susceptibility of attacked plant to drought Score : 0

e) *Number of generation: E. cinerosella* is univoltine Score : 0

f) *Fecundity:* Average egg number remains below or reaches just 100 Score : 0

g) *Extrinsic mortality factors:* Up to 55% of the larvae of *E. cinerosella* were parasitized, and between 84% and 96% of the total parasitism was caused by a specialized Tachinid which does not occur in North Amercia Score : 4

h) *Feeding behavior:* Up to 21 larvae of *E. cinerosella* were found in a single root stock. Several larvae may occur in small roots and destroy them completely during one season Score : 2

i) *Compatibility with other control agents:* The feeding of *E. cinerosella* will hardly effect any leaf feeder, will have only limited effect on seed feeders, like the Tephritid *Oxyna parietana* L. or the Noctuid *Cucullia argentea* HUFN., and apparently conditions *A. absinthium* for the attack of *P. julii* Score : 2

j) *Distribution: E. cinerosella* exists everywhere in Europe where *A. absinthium* is found and apparently covers the full range of the target weed Score : 6

k) *Evidence of effectiveness as a control agent: E. cinerosella* controls its host in certain parts of the native habitat in spite of high rates of parasitism by a specialized parasite Score : 4

l) *Size of agent:* The dry weight of the full grown insects is less than 5 mg Score : 0

The total of score of *E. cinerosella* in HARRI's system is 29 which is close to the high score of *Chrysolina hyperici* (HARRIS, 1973) and indicates that *E. cinerosella* has a number of characteristics which are highly desirable in biological weed control, particularly for warm sub-continental and continental climates.

CONCLUSIONS

The investigations in the Valais, Switzerland, have clearly shown that *E. cinerosella* has a great potential as a biological control agent of *A. absinthium.* In Europe it causes considerable plant mortality in spite of high rates of larval parasitism by the specialized parasite *B. jacentkovskyi.* The rate of larval parasitism is expected to be much lower in North America where a specialized Tachinid closely related to *Bithia* does not seem to occur. It can therefore be expected that *E. cinerosella* could become quite abundant and could cause serious damage on *A. absinthium* after its successful establishment in Canada.

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