Biological Control of Buckthorns (*Rhamnus cathartica* and *Frangula alnus*)

Report 2002-2003

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With contribution from J. Nicke

CABI Bioscience
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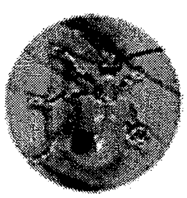
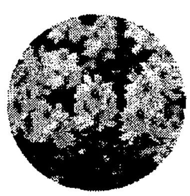

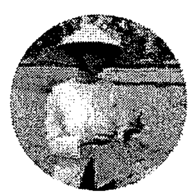
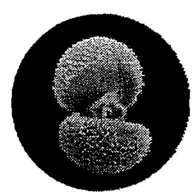

Consultant's Report

CABI Ref: XB0101
Issued March 2004

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Recommended citation:
Gassmann, A., Tosevski, I., Kiefer, B., Rheinhold, T. and G. Maia (2004). Biological Control of Buckthorns (*Rhamnus cathartica* and *Frangula alnus*). Annual Report 2002-03. Unpublished Report, CABI Bioscience Switzerland Centre, Delémont, Switzerland.

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Summary

Field surveys carried out in 2002-03 in some 75 sites in Austria, Germany, Italy, Czech Republic, Serbia and Switzerland resulted in the collection of some 800 arthropod samples collected on *Rhamnus cathartica*, *Frangula alnus*, *R. saxatilis* and *R. alpina*.

The complex of specialized arthropods is richer on *R. cathartica* than on *F. alnus*. Several species associated with *R. cathartica* have never been recorded on *F. alnus*: the leaf mining moths *Calybites quadrisignella*, *Stigmella catharticella*, and *S. rhamnella*, the root-boring moth *Synanthedon stomoxiformis,* the leaf feeding moth *Sorhagenia lophyrella* and the jumping plant-lice *Cacopsylla rhamnicolla* and *Trichochermes walkeri*.

Other species have been reared only very occasionaly from *F. alnus*. This is the case with the defoliating moths *Philereme vetulata, P. transversata* and *Triphosa dubitata*. A few species have been equally recorded on the two target buckthorn species, i.e. the leaf mining moth *Bucculatrix frangutella*, the shoot-tip mining moth *Sorhagenia janiszewskae* and the stem-boring beetle *Oberea pedemontana*.

In contrast, few species are exclusively associated with *F. alnus*, e.g. the leafhopper *Zygina suavis* and probably the fruit gall midges *Contarinia rhamni* and *Dasyneura frangulae.* Two other species, the defoliating Lepidoptera *Gonepteryx rhamni* and *Ancylis apicella*, prefer *F. alnus* to *R. cathartica*.

Several insects associated with *R. cathartica* have also been recorded on other buckthorn species, but not or only rarely on *F. alnus* (e.g. *Sorhagenia lophyrella*, *Stigmella rhamnella*, *Philereme vetulata* and *Triphosa dubitata*). This suggests rejection of *F. alnus* by these species, which has also been observed in sites where *R. cathartica* and *F. alnus* co-occur. Of the four buckthorn species which have been covered in our surveys in Europe, *F. alnus* is the only species which prefers moist habitats and acid soils. This suggests that habitat preference may have played a role in the evolutionary history of host plant preference of several insect species.

Host specificity, frequency of occurrence and estimates of relative abundance indicate that the jumping plant lices *Trichochermes walkeri* and *Trioza rhamni* are most consistently represented in the specific arthropod community associated with *R. cathartica* in Europe. Though less frequent or less abundant, the defoliators *Philereme vetulata* and *Triphosa dubitata* are also representative of the associated fauna of common buckthorn in its native range. *Sorhagenia janiszewskae* equally represent *R. cathartica* and *F. alnus*. *Frangula alnus* is well represented by *Gonepteryx rhamni* and *Zygina suavis.*

The frequency of occurrence and abundance was low for several species of interest, e.g. *Ancylis derasana*, *Philereme transversata*, *Calybites quadrisignella* and *Stigmella* spp. Other species were found only in a few sites where they were often common on both target buckthorns, e.g. *Oberea pedemontana* and *Bucculatrix frangutella*.

Work carried out in 2002-03 has allowed us to determine potential collection sites and best collection time for most of the promising biological control agents of buckthorns. A database has been developed with information on collection sites, the target trees and their natural enemies. Field observations and preliminary biological studies on a dozen species have elucidated biological features for a few key species and also highlighted some potential problems for the rearing of other species. Preliminary screening tests with neonate larvae have allowed two leaf feeding tortricids, *Ancylis apicella* and *A. derasana*, to be discarded from the prime list of potential biological control agents.

Dr. Luke Skinner, Minnesota Department of Natural Resources, project manager of this project, visited the CABI Bioscience Switzerland Centre, 14-21 June 2003. Several field sites were visited in Germany and Switzerland, the project was reviewed in detail and priorities agreed for 2004-2005. Insect species have been prioritised for host specificity studies according to their food niche, period of attack, potential availability and potential specificity. Most of these species are associated specifically with *R. cathartica*. These are: the leaf gall psylloid *Trichochermes walkeri*, the leaf feeding geometrid *Philereme vetulata* and the root-boring sesiid *Synanthedon stomoxiformis*. The other species, the shoot-tip mining cosmopterygid *Sorhagenia janiszewskae* and the stem boring cerambycid *Oberea pedemontana*, are associated with both *R. cathartica* and *F. alnus*.

Based on surveys completed in 2002 and 2003, new emphasis will be put on field surveys of flower and fruit/seed feeding insects. The study and distribution of potential natural enemies of *Rhamnus* spp. in Europe will be continued.

1 Background

In 2001, an assessment was made by Gassmann et al. (2001) of the potential for further work on biological control of buckthorns on behalf of the Minnesota State Department of Natural Resources, based on work carried out by our centre in the 1960s (the former Commonwealth Institute of Biological Control), and subsequent literature. Due to changes in the nomenclature of a large number of arthropod species, and the publication of several books, reviews and articles in the last 30 years, a full updated literature review has been carried out by the mean of entomological books, papers and the databases CABPEST, BIOSIS and AGRICOLA. Entomological taxonomic books which did not have plant indexes have been scanned completely in order to find insect species associated with buckthorns. The findings of the work carried out in the 1960s has been re-assessed in the light of the increasing importance of the issue of non-target impacts of biological control agents. About a dozen species of potential arthropod biological control agents and several pathogen biological control agents were prioritised for further study, which will initially focus on arthropod biological control agents and test plant species in the genera *Rhamnus* and *Frangula* and family Rhamnaceae.

2 Introduction

Rhamnus cathartica and *R. frangula* were described by Linnaeus in 1753. In 1754, Miller described the genus *Frangula*, and in 1768, the species *Frangula alnus*. The author name for *Frangula alnus* is cited as either Miller or P. Miller. For many years glossy buckthorn has gone under the name *Rhamnus frangula*. A more recent tendency has been to recognize this species under its newer generic name *Frangula*. The recognition of this genus as a separate entity from the genus *Rhamnus* is based on such differences as the presence of bisexual flowers instead of unisexual flowers, flower parts in 5s, as opposed to 4s, and on the basis of seed characteristics. In this report, we used the same nomenclature as in the PLANTS Database (USDA / NRCS 2001), i.e. *Rhamnus cathartica* L. for common buckthorn and *Frangula alnus* P. Miller for glossy buckthorn.

Both species have become invasive in North America. *Rhamnus cathartica* was introduced to North America as an ornamental shrub in the mid 1800s and was originally used for hedges, farm shelter belts, and widlife habitats (Gale 2001). It has spread extensively since then and has a range currently bound by Nova Scotia, Canada, in the northeast, Saskatchewan, Canada in the northwest, northeastern Kansas, USA in the southwest, and North Carolina, USA in the southeast (Gale 2001). The PLANTS database (USDA / NRCS 2001) indicates the presence of *R. cathartica* in 27 US states, including California in the west. Common buckthorn invades mainly woodlands and savannas, although it may also be found in prairies and open fields.

Rhamnus cathartica is a Eurasian species with some sub-mediterranean characteristics (Rameau *et al.* 1989). It is found throughout Europe, northwards to 61¡ 45 N in Sweden, but absent from most parts of Scandinavia and the Iberian Peninsula, and from the extreme south (Tutin 1968; Anonymous 2001a) (see also Fig. 1, under http://linnaeus.nrm.se/flora/). *Rhamnus cathartica* is also present in European Russia, in south-western Siberia and in the northern Caucasus (Anonymous 2001a). *Rhamnus cathartica* is not recorded in Armenia

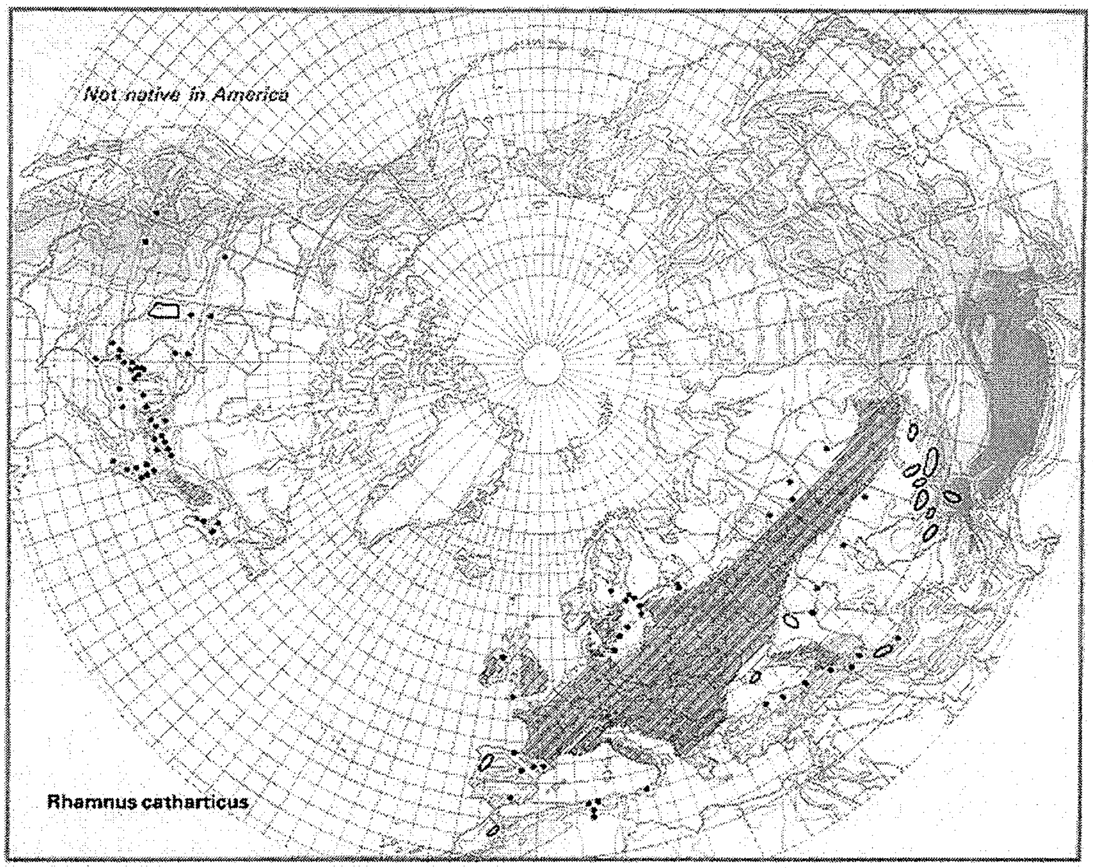


Fig. 1 Distribution of *Rhamnus cathartica*

(G. Fayvush, pers.com. 2001) or Pakistan (A. Poswal, pers. com. 2001), but the species does occur in the Province of Xinjiang in China (D. Jianqing, pers. com. 2001). In Europe, *R. cathartica* prefers mesic to mesic-dry warm open or half-shaded habitats. It grows best in calcareous alkaline or neutral soils but it can also be found occasionally in humid or swampy areas.

Frangula alnus was imported to North America prior to the 1900s as horticultural stock for landscape plantings and has become naturalized in the northeastern US and southeastern Canada (Haber 1997a). Currently, *F. alnus* occurs from

Nova Scotia to Manitoba, south to Minnesota, Illinois, New Jersey and Tennessee (Converse 2001). *Frangula alnus* is recorded in 23 states in the US (USDA / NRCS 2001). It is present in most central and north-eastern US states. *Frangula alnus* is most problematic in fens and other wetlands but also can invade uplands and sandy soil forests.

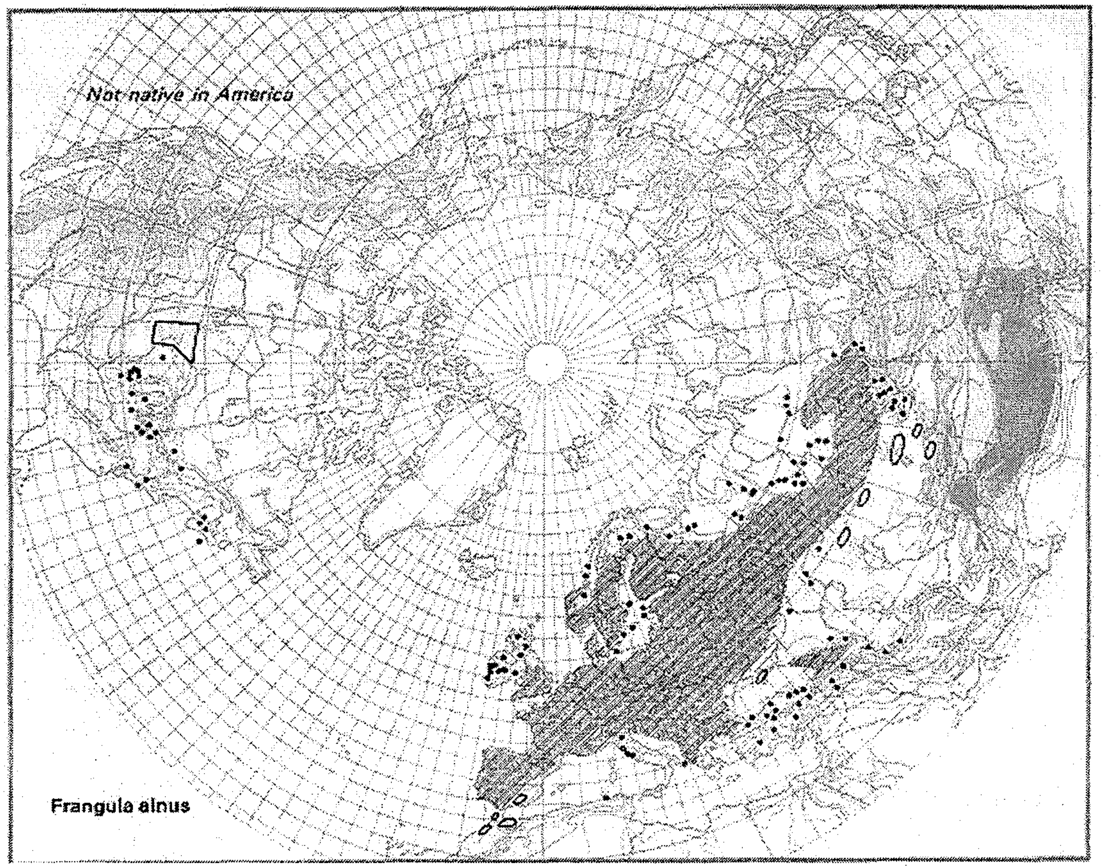


Fig. 2 Distribution of *Frangula alnus*

Frangula alnus is an Euro-siberian and sub-oceanic species. It is found in most parts of Europe, except the extreme north and part of the Mediterranean region (Tutin 1968; Scamoni 1985; Rameau *et al.* 1989; Anonymous 2001 b) (see also Fig. 2, under http://linnaeus.nrm.se/flora/). The northern-most locality for *F. alnus* in Norway is at 65¡ 13 N, 12¡ 46 E (Moe 1984). The altitudinal limit for the species in Norway is at 870m in SW Norway, where the present tree line is at 950 m; and at 941 m in southeastern parts of Norway where the present tree line is around 1100m (Moe 1984). *Frangula alnus* is also present in European Russia, in south-western Siberia and in the northern Caucasus (Anonymous 2001b). It is not known in Armenia (G. Fayvush, pers.com. 2001) or Pakistan (A. Poswal, pers. com. 2001), but the species occurs in the Province of Xinjiang in

China (D. Jianqing, pers. com. 2001). *Frangula alnus* has a slightly wider distribution than *R. cathartica* extending from northern Scandinavia in the boreal zone up to the Iberian Peninsula and a southernmost enclave in western North Africa (Medan 1994). *Frangula alnus* grows in various open to half shaded habitats. It prefers mesic to mesic-moist acid soils but it can also be found occasionally in dry calcareous stands.

The overall goal of the work carried out in 2002-03 was 1) to find *Rhamnus* spp. sites in Europe, 2) to study the distribution of potential natural enemies of *Rhamnus* spp. in Europe, i.e. to locate and further collect potential natural enemies of *R. cathartica* and *F. alnus*, 3) to carry out preliminary studies on the biology of a few species depending on their availability and 4) to further assess the suitability of potential biological control agents of buckthorns in order to start preliminary host range studies in 2004.

3 Material and Methods

Several entomologists and botanists throughout Europe were contacted in early 2002 in order to have better and quicker access to buckthorns and their potential natural enemies. Surveys were focussed on previously studied areas where a number of potential bioagents had been found in the 1960s, i.e. eastern Austria, Yugoslavia and to a much smaller extent in Germany, Switzerland and Southern France. From previous work and the extensive literature survey it was questionable whether many new potentially specific arthropods could be found during the surveys. However, surveys were extended to some other areas in Western Europe such as southern Switzerland and northern Italy in order to locate the cerambycid *Oberea pedemontana*, a species that had not been found during work carried out in the 1960s.

Extensive surveys on *Rhamnus* spp. of varying duration have been carried out in Switzerland, Germany, Italy, the Czech Republic, Yugoslavia and Austria. When possible, a particular area was sampled at least twice during the season. Several agents had been pre-selected as likely to be suitably host-specific and greater effort was put towards finding exploitable populations of these species. These efforts were continued in 2003, and the best time for collections was established for several species. Flower and fruit feeding arthropods were not surveyed during the first two years of the project because of the difficulty of having potted buckthorn trees at the flowering stage in the earliest phase of the project.

Relative population estimates of potential biological control agents of buckthorns were assessed using mainly visual inspection followed by capture by hand. Irrespective of the host plant or habitat, it was difficult to devise an all-species method, as the more mobile arthropods have a greater tendency to escape, small species are more easily missed, and large or firmly attached species are more difficult to remove. Capture by hand was preferred to beating (using a 115 by 80 cm white beating tray) since most potential agents feed inside plant tissue (leaf galls, leaf mines, leaf webs, leaf rolls). In the future, the relative abundance of only a few species, e.g. *Gonepteryx rhamni* and *Triphosa dubitata*, could be perhaps be assessed using a beating tray. With the exception of the stem-boring cerambycid *Oberea pedemontana*, there were no potential beetles feeding on buckthorn that would justify the extensive use of a beating tray. Therefore over 95% of the insects have been collected by hand. Pheromones traps were used to detect the presence of the root-boring moth *Synanthedon stomoxiformis*.

Time spent at each site was recorded to determine a catch per unit of time/effort, i.e. to determine the number of species of interest and specimens caught per site per unit effort. It should be realized, however, that a catch per unit of time is only indicative, given the variety of situations encountered, e.g. the highly variable size of the sampled areas, the variable number of trees per sampled area, their distribution, size and accessibility. The large number of organisms sampled, changes in the dispersion patterns of targeted organisms, and uncertainty regarding some identifications (e.g. when larvae did not emerge) also increases the difficulty to determine a comparable catch per unit of time. In addition, timing of sampling is also obviously of critical importance to assess species relative abundance. In Europe, buckthorns are a normal component of the vegetation and, unlike many ruderal or grassland weeds, they are difficult to detect from far away even at the flowering or fruiting stage. This means that a lot of time has always been spent to find the target plants even in the best sites. At some sites, the time to find the target plants was greater than the time spent collecting, and not all insect species were equally sampled. This is because, once a given species had been collected in sufficient numbers, the visual inspection was focussed on other less available species.

No whole plant sampling could be devised because of the variety of arthropods, food niches involved and the difficulty in reaching large parts of the trees in most situations. In this work, the sampling unit is the whole habitat/site. An attempt is made to determine relative population estimates for the most promising bioagents based on field observations, the time spent at the site, the approximate number of trees checked, the number of larvae or galls collected and the number of adults emerged. These estimates should be interpreted with much caution for the reasons mentionned above. Sampling methods and sampling units could be developed only when the research is focussed at the species level. Best collection sites for future work can be further assessed using the size of the sampled area and the potential number of plants available at the sampled area.

Representativeness indicates how the potential control agents are representative of the plant with which it is associated (i.e. on which buckthorn species is the insect most likely found). It is assessed using the frequency of occurrence of the arthropods on the various species of buckthorn sampled.

A voucher collection has been made of representative samples of each insect species of potential interest for biological control of buckthorns. A subsample has been identified by taxonomist experts or by the authors of this report. The name of the taxonomist for each species is given in section 5.

The climate graphs of the main collection areas are represented in Appendix 1. The climate graphs from Europe can be compared with those of a few locations in Minnesota (Appendix 2).

4 Results

4.1 Ecology of *Rhamnus cathartica* and *Frangula alnus*

Thanks to the information provided by local botanists and entomologists, good buckthorn areas were quickly located in 2002. In total, some 150 visits were made to 75 buckthorn sites for a total of some 65 days spent in the field in 2002-03.

Rhamnus cathartica has been found mainly along forest margins and hedges in mesic to mesic-dry conditions. The largest populations were found in the humid sub-continental type of climate of eastern Austria (e.g. Appendix 1, climate graph from WienerNeustadt and Melk) and to a lesser extend in the Upper Rhine Valley in south-western Germany (e.g. Basel climate graph). In the lowland in eastern Austria, *R. cathartica* can form large continuous stands along forest margins. The species appears less common in the sub-oceanic type of climate of western Switzerland (e.g. Geneva diagram) or in the Jura mountains (e.g. Del mont and La Chaux-de-Fonds climate graphs) or the Mediterranean climate of the northern Adriatic coast in Italy (e.g. Venice climate graph). *Rhamnus cathartica* has been found at elevations between 0 and 880 m above sea level but it is known to occur up to 1500 m (Rameau *et al.* 1989).

Frangula alnus has been found almost exclusively in peat bogs and open acidiphilous forests. It was found only very occasionally in calcareous drier stands. The largest populations of *F. alnus* were observed in northern Germany (e.g. Bielefeld climate graph), in the Black Forest in southern Germany (e.g. Hochenschwand and Donaueschingen climate graphs), in North-eastern Austria (e.g. Zwettel and Dobersberg climat graphs) and to a lesser extent in south-western Switzerland (Geneva) and the northern Adriatic coast (Venice). Large populations have also been observed along the Atlantic coast in south-western France. it was uncommon in drier areas in subcontinental areas (e.g. eastern Austria) or the Rhine Valley in Germany. In general, the large-scale climate types seem to play a much smaller role in the distribution of common and glossy buckthorns than local conditions and soil type.

Rhamnus cathartica and *Frangula alnus* were found together in only 15 collection sites/areas out of a total of some 75 sites visited (Table 1). At 7 sites, one species was much less common than the other, while in 4 sites both were uncommon (<10 individuals). The two species were thought to be equally abundant in two large mesic-dry riparian pine forests on the Adriatic coast in northern Italy, as well as in two sites in North-Eastern Austria. *R. cathartica* and *F. alnus* trees were found growing contiguously only very occasionally. In summary, the two target species grow in different habitats and co-occurrence at a small habitat scale is relatively rare.

Table 1: Number of sites discovered and sampled in 2002-03 (Austria, Germany, Italy, Czech Republik and Switzerland)

Number of sites with:

R. cathartica	*F. alnus*	*R.c. + F.a.*	*R. alpina*	*R.a. + R.c.*	*R. saxatilis*	*R.s. + R.c.*
27	27	15	1	1	1	3

Rhamnus alpina is a rather thermophilous and heliophylous submediterranean montaneous pioneer species which grows in open woods, on dry calcareous rocky soils. It is likely to be sympatric with *R. cathartica* in slightly more organic and moister soil conditions.

Rhamnus saxatilis is an heliophylous to half-shade submediterranean, perialpine European species growing in warm dry conditions and rocky calcareous soils. It appears to be an uncommon species in the areas surveyed. *Rhamnus saxatilis* and *R. cathartica* can grow sympatrically in slightly more organic soils.

4.2 Representativeness and abundance of arthropods found on *Rhamnus* spp.

Almost 300 and 500 field samples from Austria, Germany, Italy, Czech Republik and Switzerland have been treated separately in 2002 and 2003 respectively. A database (using MS Access) has been created containing information on the target trees and their natural enemies, plant and insect phenology, type of damage, GPS coordinates, and site elevation. Appendix 3 gives an overview of the locations surveyed, location and habitat characteristics, buckthorn species and insect species collected. Appendix 3 also gives the climate graphs of neighbouring or similar locations.

The frequency of occurrence of the arthropods found on *R. cathartica*, *R.alpina*, *R. saxatilis* and *F. alnus* is presented in Table 2 together with the data by Malicky *et al.* (1970).

Table 2: Frequency of occurrence of buckthorn insects in 2002-03 (Italy, Austria, Switzerland, Germany and the Czech Rep.)
Records from (Malicky et al. 1970)
(Only insects closely associated with buckthorns have been listed. The percentage of sites of that plant at which the species was found is shown in brackets).

	Rhamnus cathartica	*Frangula alnus*	*R. alpina*	*R. saxatilis*
# of sites sampled°:	46 (%)	42 (%)	2 (%)	4 (%)
# of sites with°:				
LEPIDOPTERA°:				
Bucculatricidae°:				
Bucculatrix frangutella	5 (10.9)	5 (11.9)	2 (100)	-
Bucculatrix frangutella	44 (20.6)	11 (13.3)	1.0 (20.0)	-
Cosmopterigidae°:				
Sorhagenia janiszewskae	13 (28.3)	12 (28.6)	1°? (50.0)	-
Sorhagenia janiszewskae	9 (4.2)	14 (16.9)	2 (40)	-
Sorhagenia lophyrella	27 (12.6)	-	-	13 (43.3)
Gracillariidae°:				
Calybites quadrisignella	3 (6.5)	-	-	-
Calybites quadrisignella	10 (4.7)	-	-	-
Nepticulidae°:				
Stigmella sp.	1 (2.2)			2 (50)
Stigmella catharticella	1 (2.2)	-	-	-
Stigmella catharticella	25 (11.7)	-	-	-
Stigmella rhamnella	1 (2.2)	-	1 (50.0)	-
Stigmella rhamnella	2 (0.9)	-	-	-
Pyralidae°:				
Acrobasis romanella	1 (2.8)			
Acrobasis romanella [1)]	-	-	-	-
Trachycera (*Eurhodope*) *legatea*	3 (1.4)	-	-	12 (40.0)
Pieridae°:				
Gonepteryx rhamni	7 (15.2)	22 (52.4)	2 (100.0)	-
Gonepteryx rhamni [2)]	18 (8.4)	22 (26.5)	-	-
Geometridae°:				
Philereme vetulata	10 (21.7)	1 (2.4)	-	-
Philereme vetulata	68 (31.8)	-	1,0 (20.0)	
Philereme transversata	4 (8.7)	-	-	-
Philereme transversata [3)]	38 (17.8)	1 (1.2)	-	2 (6.7)
Triphosa dubitata	23 (50.0)	-	1 (50.0)	-
Triphosa dubitata [3)]	42 (19.6)	3 (3.6)	3 (60.0)	-
Tortricidae°:				
Ancylis apicella	5 (10.9)	7 (16.7)	1 (50.0)	-
Ancylis apicella [1)]	2 (0.9)	2 (2.4)	-	1 (3.3)
Ancylis derasana	6 (13.0)	3 (7.1)	-	-
Ancylis derasana	9 (4.2)	-	-	-

	Rhamnus cathartica	Frangula alnus	R. alpina	R. saxatilis
HOMOPTERA				
Psyllidae°:				
Cacopsylla rhamnicola	5 (10.9)	-	-	-
Cacopsylla rhamnicola	6 (2.8)	-	-	-
Triozidae°:				
Trichochermes walkeri	40 (87.0)	-	-	-
Trichodermes walkeri	67 (16.8)	-	-	-
Trioza rhamni	36 (78.3)	-	-	-
Trioza rhamni	36 (16.8)	1 (1.2)	3.0 (60.0)	-
Cicadellidae°:				
Zygina suavis	-	5 (11.9)	-	-
COLEOPTERA				
Cerambycidae°:				
Oberea pedemontana	2 (4.3)	2 (4.8)	-	-
ACARI				
Eriophyidae				
Aceria annulata°?	7 (15.2)	-	-	-
Calepitrimerus rhamni	-	-	1 (50.0)	-

1) Also recorded on *Rhamnus alaternus*
2) Also recorded on *R. orbiculata* and *Frangula rupestris*
3) Also recorded on *R. orbiculata*

The complex of specific insect species is richer on *R. cathartica* than on *F. alnus* (Table 2). Several species associated with *R. cathartica* have never been recorded on *F. alnus*, i.e. *Sorhagenia lophyrella*, *Calybites quadrisignella*, *Stigmella catharticella*, *S. rhamnella*, *Cacopsylla rhamnicolla*, *Trichochermes walkeri* and *Synanthedon stomoxiformis*. The reverse is not true with the noticeable exception of *Zygina suavis*. Other species have been reared only very occasionaly from *F. alnus*. This is the case of *Philereme vetulata* (one single specimen reared from glossy buckthorn at a site where both buckthorns co-occur and where *F. alnus* dominates), and *P. transversata*, *Triphosa dubitata* and *Trioza rhamni* records from Malicky *et al.* (1970). A few species have been equally recorded on the two target buckthorn species, i.e. *Bucculatrix frangutella*, *Sorhagenia janiszewskae* and *Oberea pedemontana*. Two species only, *Gonepteryx rhamni* and *Ancylis apicella*, prefer *F. alnus* to *R. cathartica*. The picture is the same when only sites where both buckthorns co-occur are considered (Table 3).

Several insects associated with *R. cathartica* have also been recorded on other buckthorn species, but not or only rarely on *F. alnus*, e.g. *Sorhagenia lophyrella*, *Stigmella rhamnella*, *Philereme vetulata*, *Triphosa dubitata*, *Trioza rhamni* (Table 2). This suggests a strong rejection of *F. alnus* by these species. This hypothesis is reinforced by their close association with *Rhamnus cathartica* at sites where both buckthorn species co-occur (Table 3).

Other species, such as *Calybites quadrisignella*, *Stigmella catharticella*, *Cacopsylla rhamnicola* and *Trichochermes walkeri* are probably specific to *R. cathartica* in Europe. *Zygina suavis* is the only species found specific to *F. alnus,* although the gall midges *Contarinia rhamni* and *Dasyneura frangulae* are probably also specific.

Habitat preference has probably played a role in the evolutionary history of host plant preference of several insect species. For example, in Great Britain, *Stigmella catharticella* and *Philereme vetulata* are typical species for scrubland on calcareous soils (Heath 1976). Of the four buckthorn species we surveyed in Europe, *F. alnus* is the only species that prefers moist habitats and acid soils. It is therefore not surprising that these species have hardly been recorded on *F. alnus* in continental Europe. During evolutionary time, several insect species seem to have developed a preference for buckthorn species growing in mesic to dry habitats and on basic to neutral soils, and thus reject *F. alnus*. Host range tests should demonstrate whether *F. alnus* is suitable for larval development of these insects.

The relative population estimates (rare, relatively uncommon, common, abundant) given in Appendix 3 are based on field observations, time spent at site (and not time spent to find this particular species), the number of trees sampled and the number of specimen reared (see Appendix 4-15). These estimates should therefore be interpreted with caution. It should be noted also that relative population estimates do not necessarily reflect the potential availability of a particular species for biological studies. At some sites, high populations of a particular species were recorded on a small host population. At other sites, uncommon species were sampled on a few trees of a much bigger buckthorn population.

Trichochermes walkeri and *Trioza rhamni* best represent the specific arthropod community associated with *R. cathartica* in Europe. *Trichodermes walkeri* occurs in over 80% of all *R. cathartica* sites and it is common in 40 % of the sites where it has been found. *Trioza rhamni* occurs in nearly 80% of all *R. cathartica* sites and it is common or abundant in 30% of them. *Philereme vetulata* and *Triphosa dubitata* are also representative of common buckthorn in Europe. *Triphosa dubitata* was found in 50 % of all *R. cathartica* sites surveyed but it was rare or relatively uncommon in most of these. The frequency of occurrence of *Philereme vetulata* on *R. cathartica* was about 20% only but it was common or abundant in 65% of the sites where it has been found.

Sorhagenia janiszewskae is equally representative of *R. cathartica* and *F. alnus*. The frequency of occurrence was nearly 30% on both buckthorn species and the species was common or abundant at 50% of the sites of both species.

Frangula alnus is best represented by *Gonepteryx rhamni* and *Zygina suavis*. The frequency of occurrence of *G. rhamni* on *F. alnus* is over 50%, but the species is rare or relatively uncommon at 70% of sites. These numbers should be considered cautiously since not all *Gonepteryx* larvae were collected in 2003 since the species was not selected for further studies. *Ancylis apicella* is a good representative species of *F. alnus* with a frequency of occurrence of nearly 17% as compared to 11% on *R. cathartica*. The species was rare or relatively uncommon on nearly all buckthorn sites.

The frequency of occurrence and abundance was low for all other species of interest, e.g. *A. derasana*, *P. transversata*, *Calybites quadrisignella* and *Stigmella* spp. Two species were found only at a few sites but were often common when found, i.e. *O. pedemontana* and *B. frangutella*. The frequency of occurrence would probably be higher for species such as *Cacopsylla rhamnicola* and *Zygina suavis* if the surveys had focused more on these species.

Almost all species recorded on *R. cathartica*, *R. alpina* and *R. saxatilis* in the 1960s have been found during the surveys carried out in 2002-03. Exceptions are: one rare leaf sap sucker, *Heterocordylus erythrophtalmus* (Miridae) and the relatively common leaf roller *Sorhagenia lophyllera*. According to Malicky and Sobhian (1971), mature larvae of *S. lophyllera* are found mainly in early May, but pupation, which takes place in the soil, can occur by the end of April. Surveys in most localities were therefore made too late to find this species at the larval stage. Although adults of *S. lophyllera* can be found until July-August and the species hibernates as eggs, neither adults nor eggs were found.

The leaf feeding moth *Trachycera legatea* (=*Eurhodope legatella* in Malicky *et al.* (1970) was not found in 2002-03. It is possible however, that some of the empty leaf webs found on *R. saxatilis* in Austria belong to this species. According to Hannemann (1964), the larvae of *T. legatea* live from September until June, and pupation occurs probably in the litter in the field. This species is however not a high priority potential agent since larvae were found mainly on *R. saxatilis* so far and feeding tests made with medium-sized larvae showed that all *Rhamnus* species tested were accepted (Malicky *et al.* 1970).

Another oligophagous pyralid moth, *Acrobasis romanella*, has been found on *R. cathartica* at only one site in Italy. This species had been previously recorded exclusively on *R. alaternus* in north eastern Spain (Malicky *et al.* 1970). *Acrobasis romanella* is likely to be a Mediterranean or sub-Mediterranean species since it is also not recorded in Great Britain (Goater 1986) or in Germany (Hannemann 1964). Its potential host range remains unknown.

Because flowers and berries were not sampled, species like *Hysterosia sodaliana* (Lep., Tortricidae), *Sorhagenia rhamniella* (Lep., Cosmopterigidae) and the gall midges *Wachtiella krumbholzi*, *Contarinia rhamni* and *Dasyneura frangulae* (Dipt., Cecidomyiidae) were not recorded.

Of the list of potential biological control agents compiled by Gassmann *et al.* (2001), a few species have not been discovered by Malicky *et al.* (1970) or on these surveys. Several of these species are associated with the reproductive organs of buckthorn. On *F. alnus*: the flower gall formers *Contarinia rhamni* (Dipt., Cecidomyiidae) and *Dasyneura frangulae* (Dipt., Cecidomyiidae), and the mirid *Lygocoris rhamnicolla*; on *R. cathartica*: the fruit gall former *Wachtiella krumbholzi*, the two leaf gall former *Aphis mammulata* (Hom., Aphididae) and *Aceria rhamni* (Acari, Eriophyidae), the free living mite *Tetra rhamni* and the leaf-miner *Bucculatrix rhamniella* (Lep., Bucculatricidae).

Table 3°: Co-occurrence of buckthorns arthopods in sympatric sites with *R. cathartica* and *F. alnus*

Site #	Relative size of buckthorn populations	*R. cathartica*	*F. alnus*
CH3	*R. cath.* << *F. alnus*	-	*Gonepteryx rhamni*
		Philereme transversata	-
		Philereme vetulata	-
		Sorhagenia jasniszewskae ?	*S. jasniszewskae*
		Trichodermes walkeri	-
		Trioza rhamni	-
		T. dubitata	-
CH7	Both rare	*Trichodermes walkeri*	-
		Trioza rhamni	-
		Triphosa dubitata	*Zygina suavis*
CH13	*R. cath.* < F. alnus	*Gonepteryx rhamni*	*G. rhamni*
		Philereme vetulata	*P. vetulata* (1 specimen)
		-	*Sorhagenia jasniszewskae*
		Triphosa dubitata	-
		Trichodermes walkeri	-
D8	*R. cath* >> *F. alnus*	*Ancylis°apicella*	*A. apicella*
		Ancylis derasana	-
		Bucculatrix frangutella°	-
		Cacopsylla rhamnicola	-
		Philereme transversata	
		Trichodermes walkeri	-
		Trioza rhamni	-
		Triphosa dubitata	
		-	*Gonepteryx rhamni*
D20	*R. cath* >>> *F. alnus*	*Ancylis apicella*	-
		A. derasana	-
		Bucculatrix frangutella	-
		Calybites quadrisignella	-
		Gonepteryx rhamni	-
		Philereme vetulata	-
		P. transversata	-
		Stigmella rhamnella	-
		Trichochermes walkeri	-
		Trioza rhamni	-

Site #	Relative size of buckthorn populations	*R. cathartica*	*F. alnus*
A2	Both rare	*Trioza rhamni*	-
A19	*R.cath.* >> *F. alnus*	*Aceria annulata* ?	-
		Ancylis derasana	-
		Calybites quadrisignella	-
		Sorhagenia janiszewskae	*S. jasniszewskae*
		Trichodermes walkeri	-
		Trioza rhamni	-
		Triphosa dubitata	-
A34	Both rare	*Trichodermes walkeri*	-
		Trioza rhamni	-
A35	*R. cath* << *F. alnus*	-	*Gonepteryx rhamni*
		Philereme vetulata	-
		-	*Sorhagenia janiszewskae*
		Trichodermes walkeri	-
		Trioza rhamni	-
		-	*Zygina suavis*
A37	*R. cath* << *F. alnus*	-	*Gonepteryx rhamni*
		-	*Sorhagenia janiszewskae*
		Trichodermes walkeri	-
		Trioza rhamni	-
A38	*R. cath.* = *F. alnus*	-	*Gonepteryx rhamni*
		Philereme vetulata	-
		Trichodermes walkeri	-
		Trioza rhamni	-
A39	*R. cath.* = *F. alnus*	*Gonepteryx rhamni*	*Gonepteryx rhamni*
		Philereme vetulata	
		Trichodermes walkeri	
		Trioza rhamni	
A44	Both rare	*Gonepteryx rhamni*	-
		Trichodermes walkeri	-
		Trioza rhamni	-
I1 + I2	*R. cath.* = *F. alnus*	*Ancylis*° sp.	*A. apicella*
		Oberea pedemontana	*O. pedemontana*
		-	*Gonepteryx rhamni*
		S. jasniszewskae°?	*S. jasniszewskae*°?

Country codes: A - Austria; CH - Switzerland; D - Germany; I - Italy

Five new species have been discovered in 2002-03: *Oberea pedemontana* (Col., Cerambycidae) on *R. cathartica* and *F. alnus*, *Synanthedon stomoxiformis* (Lep., Sesiidae), *Aceria annulata* (Acari°: Eriophyiidae; identification to be confirmed), *Cacopsylla rhamnicolla* (Hom., Psyllidae) on *R. cathartica*, and *Zygina suavis* (Hom., Cicadellidae) on *F. alnus*, the later species being mentioned in none of the papers related to biological control of buckthorns, but is recorded in xx. No undescribed species or new associations have been discovered on European buckthorns.

4.3 Work in Yugoslavia

Work in Yugoslavia has focussed on the identification of collection sites for *S. stomoxiformis* and *O. pedemontana*, and the collection and shipment in 2003 of 100 *Ancylis* larvae to Switzerland (Table 4). Two sites with *R. cathartica*, and one each with *R. alpina*, *R. saxatilis* and *F. alnus* were found in the surroundings of Beograd in June and July 2002-03. Two field trips carried out in autumn 2004 at Banat, North east of Belgrade resulted in the discovery of five *R. cathartica* sites with populations of *Synanthedon stomoxiformis* and *Oberea pedemontana.*

Table 4: Field records of buckthorn insects found in 2002-03 in Yugoslavia

	Rhamnus cathartica	***Frangula alnus***	***R. saxatilis***	***R. falax***
# of sites sampled	7	1	1	1
LEPIDOPTERA:				
Sesiidae:				
Synanthedon stomoxyformis	+	-	-	-
Nepticulidae:				
Stigmella sp.	-	-	+	-
Tortricidae:				
Ancylis apicella	+	+	-	-
Ancylis derasana	+	-	-	-
COLEOPTERA:				
Cerambycidae:				
Oberea pedemontana	+	+	-	
HOMOPTERA:				
Triozidae:				
Trichodermes walkeri	+	-	-	-
ACARI:				
Eriophyidae:				
Calepitrimerus rhamni	-	-	-	+

4.4 Work at Bielefeld in Northern Germany (Jessica Nicke)

This work was carried out by Jessica Nicke at the University of Bielefeld in northern Germany in the context of a Diplom Arbeit supervised by Drs. M. Tschirnhaus and T. Steinlein.

Four study sites have been selected with good populations of *F. alnus*. *Rhamnus cathartica* is not present in this area. Plant density has been assessed at each site and soil has been analysed. At each site, ten *F. alnus* trees have been randomly selected and arthropod sampled using a beating tray of 120 x 80 cm. In addition, the trees have been visually inspected and leaf mines collected or insects collected by hand or with an aspirator. One Malaise trap has been set up at each site.

The thesis will be completed in 2004 and a summary prepared in due course. Preliminary data for insect families sampled with the beating tray are presented in Table 5. Only those families including one or more species associated with *F. alnus* are included. However, some new candidate biological control agent may appear in the enormous amount of arthropods collected (as perhaps in the Anthomyiid family).

The cecidomyiids may belong to the gall forming species, *Contarinia rhamni* or *Dasyneura frangulae*. In contrast, no anthomyiid species is known from *F. alnus*. If the Cicadellidae species is *Zyganis suavis*, this would indicate that it is more common in Northern Europe than in southern Germany or Switzerland. Few Triozidae (*Trioza rhamni* ?) have been recorded confirming the low occurrence of species in this family on *F. alnus*. The psyllid could be *Cacopsylla rhamnicolla* which appears to be well distributed in Northern Europe (Ossiannilson 1992).

The ecological data will allow assessment of the extent such data are relevant in explaining the diversity of the arthropod fauna on *F. alnus* and could be extended to other areas in Europe.

Table 5: Synopsis of the specialised insect fauna on *Frangula alnus* in the area of Bielefeld (Germany) in 2002

Insect families	**Bielefeld — D6**				**Bielefeld — D3**				**Bielefeld — D7**				**Bielefeld — D2**			
	End May	End June	End July	End Aug	Mid June	Mid July	Mid Aug.	Mid Sept	End May	Early July	Early Aug.	Early Sept.	End May	End June	End July	End Aug.
Lepidoptera larvae	+++	+++	+++	+++	+++	+++	+++	++	+++	+	++	+++	+++	+++	+++	+++
Diptera°;°: Cecidomyiidae	+	+	++	+	-	+	+	+	-	+	++	+	+	+++	+	+
Diptera°: Antomyiidae	+	-	-	+	+	+	+	+	-	-	+	-	-	-	+	-
Homoptera°: Cicadellidae	++	+	+++	+++	-	++	+++	+++	+	+	+++	+++	+	++	+++	+++
Triozidae	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-
Psyllidae	-	-	-	-	-	+	+	-	+	+	-	-	-	+	-	-

+ = 1 - 5 specimens
++ = 6 - 10 specimens
+++ = > 10 specimens

5 Observations on individual potential arthropod biological control agents

5.1 Lepidoptera

5.1.1 *Bucculatrix frangutella* (Lep., Bucculatricidae) (Det. Z. Lastuvka)

The frequency of occurrence was about 10% both on *R. cathartica* and *F. alnus* but the species may prefer *R. alpina* in some areas like the Jura mountains. The highest populations were found on *R. alpina* in Switzerland and *F. alnus* in southern Germany. Some plants were heavily attacked, and several larvae could be found on a single leaf. All sites and host species included, some 140 mining or free-living larvae were collected from late July to early August 2002 and kept in ventilated plastic boxes in an outdoor shelter. The formation of a brownish, rippled cocoon where pupation occurs, took place from late August to early September. Adult emergence occurred in late May-early June the following year (Appendix 4; Fig 3). The species breeds easily in cages in the laboratory. Pictures are shown in Appendix 16.

Malicky *et al.* (1970) recorded *B. frangutella* from *R. cathartica*, *F. alnus* and on one occasion from *R. alpina.* Feeding tests with mature field collected larvae indicate some consistent feeding on the North American buckthorn *Rhamnus purchiana* (Malicky *et al.* 1970). However, it is likely that oviposition and larval development tests with neonate larvae would demonstrate a narrower host range for *B. frangutella*.

The biology of *B. frangutella* is described by Malicky *et al.* (1965) and Heath and Emmet (1985). *Bucculatrix frangutella* is univoltine and in Great Britain the adult appears from June to mid-July. Imagos were caught during our surveys in late May in Austria and late June in the Swiss Jura. The adult is active in evening sunshine around its foodplants where it lays its eggs on the underside of the leaves. The larvae are found from August to September in Great Britain. First larval damage looks like a small dark spot on the leaf; the larvae then mine a tightly wound spiral around the eggshell, in which the larva feeds venter upwards (Heath and Emmet 1985). This part of the mine is conspicuously stained blackish violet. The last part of the mine straightens, and here the staining is absent. Then, the larva leaves the mine and moults in a flat white web (Malicky *et al.* 1965). Feeding is resumed on the under side of the leaves. When young, the larvae leave the upper epidermis undamaged causing transparent spots. The fourth larval instar eats out large holes in the leaf. Pupation occurs in a brownish, rippled cocoon on the upper or lower leaf surface.

Although locally quite common, *Bucculatrix frangutella* has not been selected for biological control of buckthorns because it appears relatively late in the season and because of a potential lack of specificity.

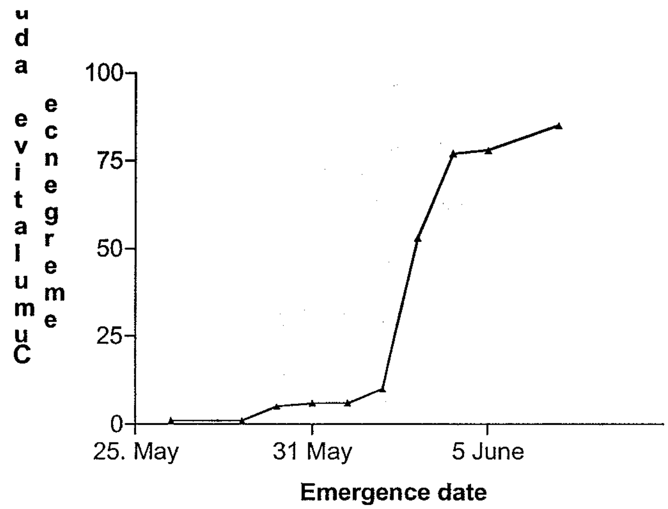


Fig 3. Emergence of *Bucculatrix frangutella* in 2003

5.1.2 *Sorhagenia janiszewskae* (Lep., Cosmopterigidae) (Det. R. Bryner)

Collection and adult emergence: The larvae of *S. janiszewskae* mine in the current year s shoots of buckthorns. The frequency of occurrence was close to 30% on both *R. cathartica* and *F. alnus* (Table 2). The species was common or abundant in 50% of either *R. cathartica* or *F. alnus* sites (Appendix 3). The geographical distribution of the moth is somewhat intriguing as no mined shoot-tips were found in southern Germany and in the upper Rhine Valley even though *R. cathartica* and *F. alnus* trees from 13 sites were carefully checked. Moreover, the occurrence of *S. janiszewskae* on *R. cathartica* in Geneva where it is abundant on *F. alnus* still needs to be confirmed. The frequency of occurrence of *S. janiszewskae* on *R. cathartica* and *F. alnus* was much higher in 2002-03 than in the 1960s perhaps because special attention was given to this species. The occurrence of the moth on *R. alpina* in the Swiss Jura needs to be confirmed but the moth was recorded on *R. alpina* in Eastern Austria (Malicky and Sobhian 1971). No evidence of the presence of *S. janiszewskae* was found in Northern Italy. According to (Malicky and Sobhian 1971), *S. janiszewskae* was never found south of the Alps. No attacked shoot-tip was found on *R. saxatilis* in any of the four sites inspected.

All field collected shoot-tips were kept in ventilated containers under an outdoor rain-shelter. As larvae leave their hosts to pupate in the soil, boxes were filled with soil and some soft paper to allow pupation.

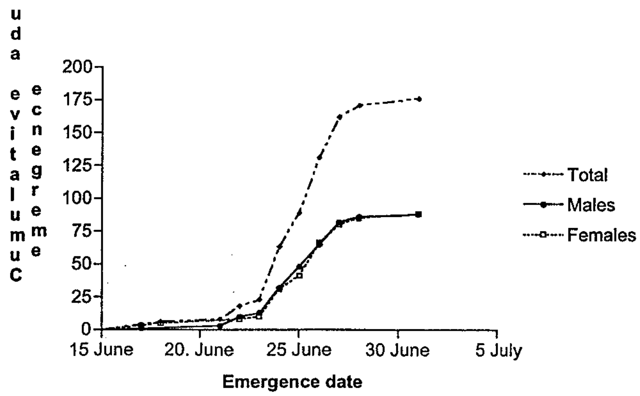


Fig 4a. Emergence of *S. janiszewskae* from *F. alnus* in Switzerland (2003)

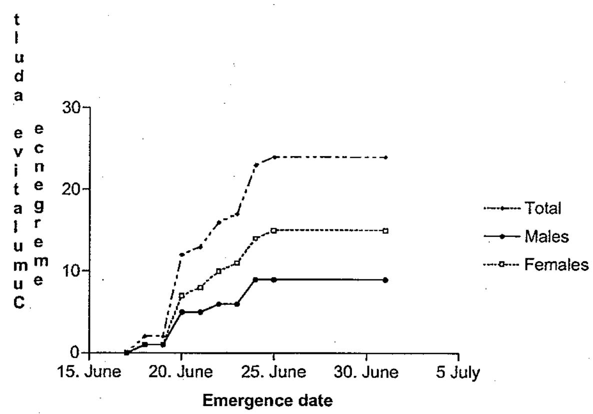


Fig 4b. Emergence of *S. janiszewskae* from *F. alnus* in Austria (2003)

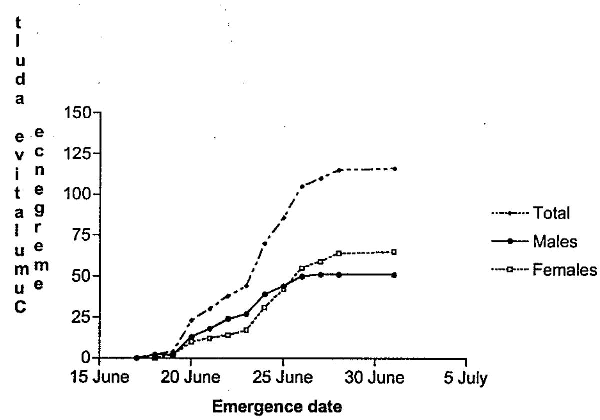


Fig 4c. Emergence of *S. janiszewskae* from *R. cathartica* in Austria (2003)

Only few adults emerged in 2002 from 150 attacked shoot-tips collected from *R. cathartica* and 230 collected from *F. alnus*. Upon dissection, it was found that most of the shoots were mined and empty. Collections were therefore carried out two weeks earlier in 2003 resulting in good adult emergence (Appendix 5; Fig 4).

The material collected from *R. cathartica* and *F. alnus* from different geographical areas was kept separately in case further studies would reveal the existence of different races. In 2003, all moths emerged between 17-30 June. There were no differences in phenology between the two host plants (Fig 4). The peak of emergence of *S. janiszewskae* from *F. alnus* in Switzerland was 5 days later than that from *F. alnus* in Austria.

<u>Rearing of adults</u>: The adults reared from *R. cathartica* and *F. alnus* were kept separately in 58 x 46 x 46 cm cages or ventilated plastic cylinders (height 25 cm, diameter 11 cm) with either potted buckthorn or twigs. Slightly moist sphagnum moss and corrugated cardboard for the moths to hide and honey-watered paper was provided to a variable number of *S. janiszewskae* in each container. Honey-water was changed every 2-3 days. The cages and containers were stored either outside beneath a tarpaulin, protected from rain and sun, or in an incubator at long daylight conditions (16/8h) and 15-16…C. Other containers were placed in an outdoor shelter, in an underground shelter or at 8-10¡C without illumination. In 2003, some 25 cages were used for a total of about 300 adult moths. None of the moth survived the summer; all were dead by mid-September. Thus, none of the rearing conditions proved to be better than the others, but adult longevity was slightly prolonged at 10¡C. All cages and cylinders were regularly checked for eggs but no eggs were found. This suggests that *S. janiszewskae* overwinters as an adult as suggested by Malicky and Sobhian (1971).

<u>Discussion:</u> All adult moths emerged from *R. cathartica* and *F. alnus* were identified as *S. janiszewskae*. According to Malicky *et al* (1970), this species also attacks *R. alpina*. *Sorhagenia janiszewskae* was common on *R. cathartica* in eastern Austria where the host plant is common as well and on *F. alnus* in south-western Switzerland (Geneva) where *F. alnus* also forms large stands in open forests. The occurrence of the moth on *R. cathartica* and *R. alpina* in Western Europe (i.e. Jura mountains in Switzerland, southern Germany, Italy) needs to be confirmed. Quite surprisingly, *S. janiszewskae* was not found on *F. alnus* in southern Germany although this species is common and forms locally large stands.

The information collected in 2002-03 indicates that mature larvae of *S. janiszewskae* leave the shoots between mid-May and early June. Adults emerged mid June to early July. Adult emergence in 2002-03 was about 2 weeks earlier than that observed by Malicky and Sobhian (1971) in the 1960s, which explains why collections of the moth in eastern Austria were made slightly too late in 2002. There is only one larva per mine/shoot-tip. The mine is 3-5 cm long. A small hole usually with some visible external frass indicates that the larva has already left the infested shoot-tip to pupate in the soil. Pupation takes two weeks. The species overwinters as adult. Pictures are shown in Appendix 17.

Obviously, the largest constraint for future work is successful adult aestivation and overwintering. The overwintering ecology of *S. janiszewskae* needs to be clarified to ensure good adult survival for future work.

Sorhagenia janiszewskae is one of the very few internal feeders on buckthorns. It seems also to be specific enough to deserve further attention and to be targeted for preliminary host range testing. Mass collection of larvae will be continued in 2004 and attempts to capture adults will be made in mid April in Switzerland in order to carry out preliminary oviposition tests.

5.1.3 *Calybites quadrisignella* (Lep., Gracillariidae) (Det. R. Bryner)

Larvae of *Calybites quadrisignella* were found on *R. cathartica* in only two sites in Austria and one site in Germany (Appendix 6). Larva were kept individually in ventilated plastic boxes with single leaves or small branches with moist paper, and stored in an outdoor shelter. A few days following the collection, some of the larvae had left their leaf-mines, and started to roll a leaf where feeding was resumed. Pupae were found either in the rolled leaves or outside in the rearing container. Six adults emerged between July 2 and 22, 2002 from the material collected in Austria in late May 2002. From 4 larvae collected in Germany on 26 June 02, two adults emerged in late May 2003. *Calybites quadrisignella* is usually bivoltine in central Europe and overwinters at the pupal stage. Pictures are presented in Appendix 18.

Calybites quadrisignella was recorded exclusively on *R. cathartica* by Malicky *et al.* (1970). Schuetze (1931, cited in Malicky *et al.* (1970)) recorded the species also on *F. alnus*.

Calybites quadrisignella seems to be a rare species as indicated by a low frequency of occurrence. However, this moth is, together with *Stigmella catharticella*, the most specific leaf miner on *R. cathartica*. Further attention should be put on this species once suitable collection areas have been found.

5.1.4 *Stigmella catharticella* and *S. rhamnella* (Lep., Nepticulidae) (Det. Z. Latuvska)

Leaves mined by *Stigmella* spp. were rare and difficult to find. Most leaf-mines were empty when collected, but were kept for a tentative identification based on the shape of the leaf-mine. The few empty leaf-mines collected on *R. saxatilis* at two sites in Austria belong probably to *S. catharticella*. In Yugoslavia, the leaf mines found on *R. saxatilis* also resemble those of *S. catharticella*. However, the identification based on the shape of the leaf mines is sometimes uncertain. All three adults emerged from *R. alpina* and *R. cathartica* were *S. rhamnella*

(Appendix 7). The best collection site (*S. rhamnella*?) was found on *R. cathartica* in southern Germany.

According to Lastuvka and Lastuvka (1997), *S. catharticella* can only be found on *R. cathartica*, while *S. rhamnella* is known from *R. cathartica*, *R. saxatilis*, *R. alpina* and *R. pumilus*. In Austria, *Stigmella catharticella* and *S. rhamnella* were found exclusively on *R. cathartica* by Malicky *et al.* (1970).

The eggs of *S. catharticella* are laid on the underside of a leaf of *R. cathartica*, generally close to a vein. The larvae feed within a characteristic serpentine mine. The mine is at first slender, more or less straight and completely filled with cloudy frass. Later, the mine broadens and progresses in a series of S -turns, generally leaving a narrow strip of uneaten leaf between each transverse; here the frass appears darker green and neatly coiled or dispersed, seldom showing clear margins. Then, in the final phase the frass is black and is placed as an irregular central line (Emmet 1976, cited in Puplesis (1994)). The first part of the mine by *S. rhamnella* consists of a number of confluent semicircles around the egg site, and then widens into a blotch or false-blotch. The frass is greenish, almost completely filling two-thirds of the track. The frass is scattered in the last part of the mine but margins are devoid of frass (Johansson et al. 1990 cited in Puplesis (1994)). The mines of *S. catharticella* and *S. rhamnella* are very different from those of *Bucculatrix frangutella* and can also be distinguished from those of *C. quadrisignella.* The majority of the leaf mines collected on *R. cathartica* probably belong to *S. catharticella* although the only emerged adult belongs to *S. rhamnella*. Pictures are presented in Appendix 18.

The absence of metallic lustre and unicoloured forewing distinguishes *S. rhamnella* from many species of the group (Puplesis 1994). *Stigmella catharticella* is recognizable by a white tornal spot on the forewing.

The life cycle of *S. catharticella* is bivoltine in Great Britain and in Central Europe. Adults fly from May to June and from July to August and the larvae feed in late June and July and again from September to October (Heath 1976; Puplesis 1994). The cocoon is pale brownish or ochreous. The geographical distribution of *S. catharticella* includes central-northern Europe, and Eastern Europe including the southern Urals.

Stigmella rhamnella is a bivoltine species. Larvae of *S. rhamnella* are found in September and possibly also in summer (Puplesis 1994). The cocoon is brown. The geographical distribution of *S. rhamnella* includes central and southern Europe.

Of the two species, *S. catharticella* is the most promising because of its high host specificity. Future collections should focus in Eastern Europe where the species seems to be more common. The best collection time for *S. catharticella* still need to be determined. Because it is a bivoltine species, *S. catharticella* could be preferred to *C. quadrasignella* although the second generation occurs late in the season and is unlikely to cause much damage to the host tree.

5.1.5 *Gonepteryx rhamni* (Lep., Pieridae)

Gonepteryx rhamni is one of the best representative buckthorn insects in all areas surveyed in Europe. The species has a strong preference for *F. alnus* and perhaps *R. alpina* (Tables 2, 3). The frequency of occurrence was over 50% on *F. alnus* as compared to 15% on *R. cathartica*. More surveys would need to be carried out on *R. alpina* to ascertain the frequency of occurrence of *G. rhamni* on this species. Plant abundance may play a role in host selection in sympatric stands with *R. cathartica* and *F. alnus*. Field surveys carried out by Malicky *et al.* (1970) also showed a clear preference for *F. alnus* over *R. cathartica*. Other field records are *R. orbiculata* in south-western Yugoslavia and *F. rupestris* in Yugoslavia (Malicky *et al.* 1970).

Following collection the larvae were reared in ventilated plastic boxes containing moist paper and leaves of buckthorn. In 2003, pupation occurred in the first half of June and adult emergence in the second half of June (Appendix 8). The phenology of *G. rhamni* was delayed by about 10 days in 2002.

Adults of both sexes hibernate within the shrub and herbaceous vegetation in forests. Mating and oviposition occurs in early spring the following year. The larvae, feeding on the leaves, may be found from May to early July. Larvae are well camouflaged because of their uniformly green colour and their resting position in the middle-rib of the leaf. For pupation the larva leaves the feeding site and fixes itself in a characteristic position on a twig or a stem of the host tree. The pupation period lasts about 2 weeks. Emergence of adults occurs mainly from mid-June to late August. Larval parasitism by *Apanteles* sp. (Hym., Braconidae), *Compsilura concinnata* Meig. and *Eucarcelia excisa* Fall. (Dipt., Tachinidae) can be high (Malicky *et al.* 1970). Pictures are presented in Appendix 19.

Some authors recorded *G. rhamni* not only from *Rhamnus* spp. but also from other plant genera such as *Prunus*, *Ligustrum*, *Vaccinium* or *Quercus*. However, these records are doubtful since larval feeding tests with medium-sized field collected larvae showed that *G. rhamni* complete larval development on all *Rhamnus* and *Frangula* species but not on any other species offered (Malicky *et al.* 1970).

It is likely that oviposition and larval development tests with neonate larvae would demonstrate a slightly narrower host range of *G. rhamni*. However, *G. rhamni* is a low priority species for the biological control of *F. alnus* because of a potential lack of specificity.

5.1.6 *Phileremne vetulata* (Lep., Geometridae) (Det. M.J.W. Cock)

Phileremne vetulata is closely associated with *R. cathartica* in Europe. Although the frequency of occurrence of this species on *R. cathartica* is only about 20%, populations are usually common or abundant where they occur (Table 2). One record has been made on *R. alpina* (Malicky *et al.* 1965) and a single specimen has been reared from *F. alnus*.

Phileremne vetulata has been found mainly in southern Switzerland (Geneva) and eastern Austria. The species is apparently less common in southern Germany or in the Swiss Jura. Best collection time for the larvae of *P. vetulata* is the end of April to early May. Pupation occurs during the second half of May and the adults emerge during the first two weeks of June (Appendix 9; Fig 5). As already underlined in the case of *Sorhagenia janiszewskae*, it is likely that the phenology of *P. vetulata* in 2002-03 in eastern Austria was about two weeks earlier than in the 1960s where adult emergence of *P. vetulata* was recorded in early July (Malicky *et al.* 1965) .

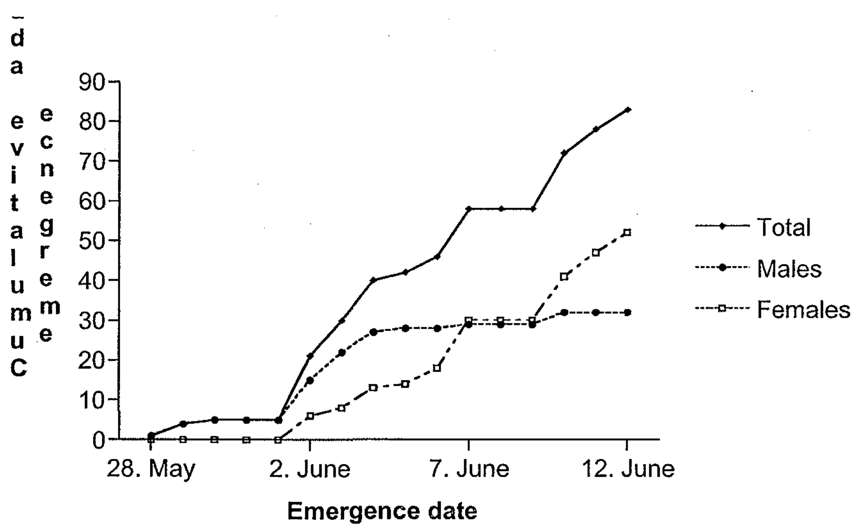


Fig 5. Emergence of *Phileremne vetulata* in 2003

Following collection, larvae were reared in ventilated plastic boxes, where leaves were kept fresh with moist paper. The adults mate and oviposit easily in cages (about 50x50x60 cm) stored outside beneath a tarpaulin or in cardboard cylinders (height 27 cm, diameter 10 cm) kept in an outdoor shelter. No plant material is necessary in the rearing cages since all eggs are laid on the bottom of the rearing cages. In 2003, 6 rearing cages and 12 cardboard boxes were set up with a total of 51 females and 38 males. Oviposition started 5-8 days later and lasted about one week. A total of 1816 eggs was obtained (mean=36 eggs). Four individually reared females laid an average of 53 eggs (range: 2-100).

Larvae of *P. vetulata* feed within rolled leaves. The early larval instars are of a uniformly brown colour and the late instars are dorsally black with two white longitudinal lines. In personal records longitudinal lines were mainly orange or red. Larval development lasts about 5 weeks and the larvae moved from one leaf to another. Pupation takes place within the leaf roll. The adults which have nocturnal habits fly in June and July (Malicky *et al.* 1970). *Philereme vetulata* is univoltine and hibernates in the egg stage on the bark of its host plant. Pictures are presented in Appendix 20

Philereme vetulata is exclusively associated with *R. cathartica* with the exception of one record on *R. alpina* (Malicky *et al.* 1965) and one specimen reared from *F. alnus*. Larval feeding tests with medium-size field collected larvae showed a marked preference for *R. cathartica* (and *R. alpina*) over *Frangula alnus*, *R. saxatilis* and *R. alaternus*. Some nibbling only was observed on *R. purshiana* (Malicky and Sobhian 1971). Screening tests with neonate larvae are likely to show an even more specific host range. *Philereme vetulata* appears to be the most specific geometrid species and one of the most specific defoliators on *R. cathartica*. Mass collections of larvae of *P. vetulata* are planned in 2004. Some 1000 fertile eggs are being kept in an outdoor shelter and will be used in spring 2004 for mass rearing and preliminary screening tests.

5.1.7 *Philereme transversata* (Lep., Geometridae) (Det. M.J.W. Cock)

Philereme transversata is a rare species on *R. carhartica* in the areas surveyed and only five adults were reared in 2002-03 (Appendix 10). The phenology of *P. tranversata* is the same as that of *P. vetulata*.

Philereme transversata is reported to be common all over Europe (Carter 1987). Larvae form leaf webs on *R. cathartica*. Pupation takes place in the soil, even though a personal record shows that pupation can also take place inside the leaf web. *Philereme transversata* fly in July, and oviposition occurs in August. The species hibernates in the egg stage. Egg hatching occurs in April-May. The larva has a typical brown structure on the last segments.

According to Malicky *et al.* (1965), the larvae of *P. transversata* feed on the leaves of buckthorn, but unlike *P. vetulata*, do not web the leaves together. This information thus differs from the larval feeding mode described by Carter (1987) for *P. transversata*. *Philereme transversata* was occasionally found on *R. saxatilis*, *R. orbiculata* and *F. alnus* (Malicky *et al.* 1970). The species is believed to be uncommon in eastern Austria.

Larval feeding tests with medium-size field collected larvae of *P. transversata* showed intensive feeding on all *Rhamnus* and *Frangula* species tested (Malicky *et al.* 1970). Thus, this species appears to be slightly less specific than *P. vetulata* but it should be kept in mind that medium-size field collected larvae were used for both species.

No further work is planned with this species unless a good population is discovered.

5.1.8 *Triphosa dubitata* (Lep., Geometridae) (Det. M.J.W. Cock)

Triphosa dubitata has a high frequency of occurrence on common buckthorn since it was found in 50% of all *R. cathartica* sites surveyed but it was rare or relatively uncommon in a majority of the sites (Table 2; Appendix 11). *Triphosa dubitata* was found in small numbers in nearly all surveyed areas in Austria, Germany, Switzerland and the Czech Republic. The species clearly prefers *R. cathartica* and *R. alpina*. These results are in agreement with those of Malicky *et al.* (1970) who also found *Triphosa dubitata* occasionally on *F. alnus* and *R. orbicaluta*.

According to Carter (1987), the host plants of *Triphosa dubitata* are *R. cathartica*, *F. alnus* but also *Prunus padus*. *Frangula alnus* and *R. alpina* were accepted in feeding tests with medium-size field collected larvae but the native North American *F. purshiana* and two species of *Prunus* were rejected (Malicky and Sobhian 1971). Preliminary no-choice larval feeding tests have been carried out in 2003 with *R. caroliniana* and *R. cathartica* (see section 6). None of the five young field collected *T. dubitata* larvae fed and survived on the native North American *R. caroliniana.* In contrast, four adults have been reared from *R. cathartica*. As for *P. vetulata*, it is likely that oviposition tests and larval feeding tests with neonate larvae will demonstrate a more specific host range.

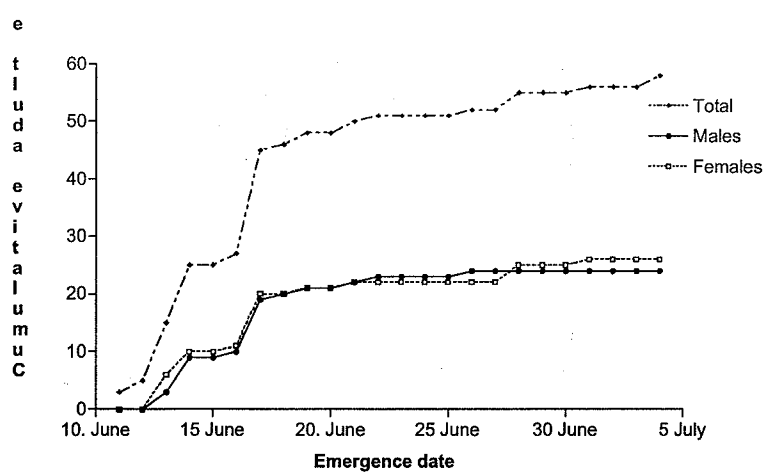


Fig 6. Emergence of *Triphosa dubitata* from *R. cathartica* in 2003

Following collection, larvae were reared in ventilated plastic boxes, where leaves were kept fresh with moist paper. Some 60 adults were reared in 2003 (Fig 6). The adults were split into four cages (about 50x50x60 cm) stored outside beneath a tarpaulin. Buckthorn twigs, wrapped paper towels, and pieces of cardboard were placed in the cages to provide resting sites and shelters for the adults. Water and honey water was provided to the moths in small cups that were changed 2-3 times per week. The survival rate was very good for the first month but then decreased. All adults were dead by mid-September. Pictures are shown in Appendix 21.

Triphosa dubitata overwinters as an adult in natural caves (Cherix 1976). According to Malicky *et al.* (1970), mainly females hibernate, but occasionally males also. All the hibernating females dissected by Malicky *et al.* (1970) showed sperma in their receptacula, and viable eggs were laid in the following spring demonstrating that females mated prior to hibernation. The ovaries of the females of *T. dubitata* develop in early spring. Eggs and first instar larvae can be found in late April. The average larval period lasts about 4 to 5 weeks. Larvae of *T. dubitata* can be identified by their green colour with four white stripes. They feed on the leaves of their host-plants, within a shelter of loosely spun leaves. The larvae leave their host and form a cocoon in the soil litter to pupate. Pupation takes place from the end of May until the end of July and takes about 3 weeks. Adults emerge in July and August.

Triphosa dubitata has not been selected for biological control because of the difficulty to aestivate and hibernate the adults until the following season. However, additional material will be collected in 2004 and reared to the adult stage. Adults will be kept for three weeks at natural temperature before being stored in cold temperature simulating the temperature found in natural caves. Attempts will be made to collect eggs during early season surveys and preliminary screening tests carried out with critical plant species.

5.1.9 *Ancylis apicella* (Lep., Tortricidae) (Det. M. Cock)

Ancylis apicella is a good representative species of *F. alnus* with a frequency of occurrence of 16.7 as compared to 10.9 on *R. cathartica* (Table 2). The species was usually rare or relatively uncommon at nearly all buckthorn sites (Appendix 12). *Ancylis apicella* was found in most major areas surveyed except in southern Switzerland (Geneva). Malicky *et al.* (1970) recorded *A. apicella* on *R. cathartica*, *R. saxatilis*, *R. alaternus* and *F. alnus.*

Larvae were collected from early May to late July. They were reared with buckthorn leaves in ventilated plastic boxes and stored in an outdoor shelter. Pupation occurred from early June to mid August. Adults from field collected larvae emerged mainly in June-July (Fig 7). A few larvae collected in late June and in July 2002 emerged only in 2003. Adults breed easily in captivity. 2-4 pairs were kept each on potted buckthorn covered by a gauze bag and stored outside beneath a tarpaulin. Most adults were dead 10 days after set up and eggs and larvae were found on the leaves. Eggs were usually laid on the lower leaf surface close to the veins. Development time from egg to adult takes 4-5 weeks in the laboratory.

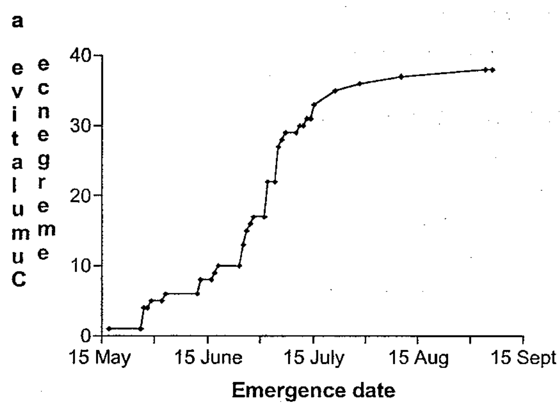


Fig 7. Emergence of *Ancylis apicella* from field collected larvae in 2003

Ancylis apicella is bivoltine. In Great Britain, the pupae are found in April and early July (Bradley *et al.* 1979). Early larval instars develop within a folded leaf, later spinning two leaves flatly together, eating parenchyma and blanching the leaves in irregular patches. Larvae develop singly. *Ancylis apicella* overwinters as larvae in a silk web. Pictures are presented in Appendix 22.

Preliminary no choice tests with neonate larvae indicate that the larval host range of *A. ancylis* is restricted to species in the genus *Rhamnus* in no-choice conditions (see section 6). In the field, *A. apicella* has been recorded on *R. cathartica*, *R. saxatilis*, *R. alaternus* and *Frangula alnus*, but rarely on *R. alpina*. Given the results of the no-choice larval host range tests and field records, *Ancylis apicella* has been excluded from the prime list of potential biological control agents for exotic buckthorn species in North America.

5.1.10 *Ancylis derasana* (Lep., Tortricidae) (Det. M.J.W. Cock)

Ancylis derasana was found in Austria and Germany only. Unlike *A. apicella*, *A. derasana* prefers *R. cathartica* to *F. alnus* (Table 2). The species was usually rare or relatively uncommon in most collection sites, exept in Serbia (Table 2; Appendix 13). *Ancylis derasana* and *A. apicella* co-occur on *R. cathartica* in Austria, southern Germany and Serbia where *A. derasana* was more common than *A. apicella* in the study sites. On some trees, over 50% of the leaves were rolled and damaged by *Ancylis* spp. Malicky *et al.* (1970) recorded *A. derasana* exclusively from *R. cathartica.* According to Sobhian *et al.* (1964), the biology of *A. derasana* and *A. apicella* are very similar. Both species are bivoltine.

Larvae were collected from mid-May until early July. For rearing, the larvae were kept with buckthorn leaves in ventilated plastic boxes and stored in an outdoor shelter. Pupation occurred in June-July. Adults from field-collected larvae emerged from the end of June until August. Twelve males and 14 females emerged from the 2003 collections. One larva collected in late June 2002 emerged only in late May 2003. Adults breed easily in captivity. Two pairs were kept each on four potted buckthorn covered by a gauze bag and stored outside beneath a tarpaulin. All adults were dead 10 days after set up and eggs and larvae were found on the leaves. A total of 300 eggs were obtained in three valid cages, i.e some 50 eggs per female. Eggs were usually laid on the lower leaf surface close to the veins. Development time from egg to adult takes 4-5 weeks in the laboratory. A few adults emerged from laboratory reared larvae by late August - early September and bred. The newly hatched larvae were not able to reach the mature larval stage before winter and died. Pictures are presented in Appendix 22.

Preliminary no choice tests with neonate larvae indicate that *F. alnus* and to a lesser extent *R. caroliniana* are less suitable hosts than *R. cathartica*, *R. alnifolia* and *R. alpina* (see section 6). Given the results of these preliminary no-choice larval host range tests, *Ancylis derasana* has not been selected as a candidate biological control agent for exotic buckthorn species in North America. In the field, *A. derasana* has been recorded exclusively on *R. cathartica* and *F. alnus*. This suggests that the realized (ecological) host range of *A. derasana* is more restricted than the physiological (larval) host range. Oviposition preference tests would be needed to assess the adult host range of *A. derasana* in North America.

5.1.11 *Synanthedon stomoxiformis* (Lep., Sesiidae) (Det. I. Tosevski)

The buckthorn clearwing moth *Synanthedon stomoxyformis* is widely distributed in the Palaeartic, from south-eastern Spain (ssp. *riefensthahli*), France, northern Italy across Central Europe to Turkey, Transcaucasia and Siberia (ssp. *amasina*). The species has a preference for *R. cathartica* but it can sometimes be found on *F. alnus*. According to P hringer *et al.* (1998) and Spatenka et al (1999), *Sorbus aria* (Rosaceae) and more rarely *Corylus avelana* (Corylaceae) are alternative hosts in upper Austria.

Synanthedon stomoxiformis is a relatively common species at several sites in the Deliblastiki Pesak region in Serbia where its presence has been confirmed by the use of pheromone lures (Appendix 23). Larvae have a biennial life cycle. The first year is spent in a shallow tunnel in the stem base or root, and during the second year, the larvae move down, boring into the roots. In autumn, the larva build above the ground a long and visible reddish exit tube made out of scraps, sawdust and silk. Pupation occurs by May the following year in the top of the exit tube. Several larvae can be found in the roots of a single *Rhamnus* tree. The adults emerge between late May-July. The adults feed on flower nectar before mating.

Trees showing the reddish exit tubes of *S. stomoxyformis* were marked to facilitate the collection of mature larvae/pupae in spring 2004. Rearing methods will be developed in 2004 and preliminary screening tests will be carried out. It is also planned to catch fertile females for oviposition and larval transfers.

5.2 Homoptera

5.2.1 *Trichochermes walkeri* (Hom., Psylloida: Triozidae) (Det. A. Gassmann)

Leaf-margin galls of *T. walkeri* were found exclusively on *Rhamnus cathartica*. *Trichochermes walkeri* best represents the specific arthropod community associated with *R. cathartica* in Europe. *Trichodermes walkeri* occurs in over 80% of all *R. cathartica* sites and it is common in 40% of the sites where it has been found (Table 2; Appendix 3). *Trichochermes walkeri* was found in all areas surveyed in 2002-03 except in Italy, where surveys were probably carried out too early to detect the galls (Appendix 14). The galls of *T. walkeri* seem to be aggregated on either tree, while within a tree they appear to have a more normal distribution.

<u>Biology of *T. walkeri*</u>: According to McLean (1993), *T. walkeri* has one generation per year. Adults emerge in August and the period of adult activity takes places from August to November. *Trichochermes walkeri* females lay small orange eggs on *R. cathartica* twigs during autumn. The nymphs hatch in spring from overwintering eggs. First-instar nymphs migrate to the leaves, feed on leaf margins and induce rolling of the leaf margin. By the end of May the nymph is enclosed in a small leaf roll, which grows bigger and thicker within the following weeks. Nymphal development takes place within the leaf gall. Pictures are shown in Appendix 24.

Nymphal development and adult emergence of *T. walkeri* were followed from May until late August by regular gall sampling at sites in south-western Germany (Rhine Valley) and in the Jura mountains in Switzerland. By mid-May, in the lowland in Europe, galls contain mainly L1 nymphs (Appendix 12). By mid-June, galls contain usually a majority of L2 nymphs, the first L3 nymphs can be found in the galls. By mid-July the majority of the nymphs consists of L3 nymphs. The first L4 nymphs appear in early-mid July and the first L5 nymphs by mid to late July. L1 to L4 nymphs are flat and orange. The head and thorax of the 5^{th} instar nymph are yellow or greenish-yellow; the abdomen is light green. The antennae are 8-segmented, and the eyes well developed. Width of the head of the four and fifth nymphal instar is similar (Fig 8). The adults do not emerge out of the galls but the L5 nymphs as was observed both in the laboratory and in the field. Empty galls can be found from the end of July. Adult emergence occurs in August. Newly emerged adults are green. Within one day, the adults turn reddish-brown, with dark brown markings, the forewings with a brown pattern.

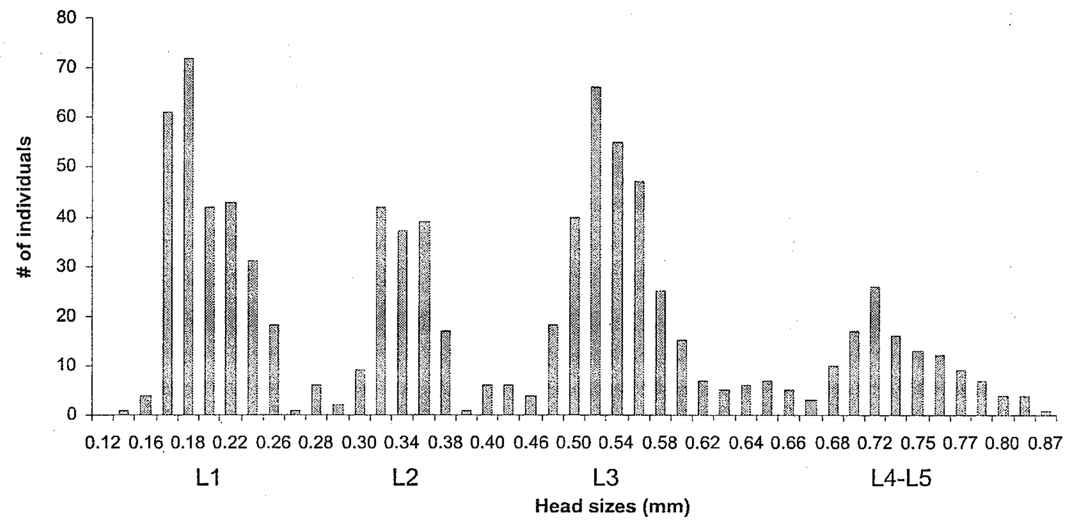


Fig.8. Nymphal head size of *Trichochermes walkeri*

About 70% of the galls are inhabited by one single nymph. Less than 10% of the galls contained between 3 to 5 nymphs. Immature stages of *T. walkeri* produce abundant waxy filaments and honeydew spheres in the galls. Early instar nymphs are vulnerable and dependent on living host tissue. Over 30% nymphal mortality was observed one week after galls were collected. Nymphal mortality increased to 70% two weeks after collection.

A total of 342 adults (155 females and 187 males) of *T. walkeri* emerged from some 2673 full galls (i.e. 12.8%) collected between August 5-19, 2002 in southern Germany and Switzerland. In 2003, only 13 adults emerged from a total of 4500 galls collected between July 22 and August 13 in southern Germany (Appendix 12). In the 2002 Annual Report, we wrote that adult emergence was likely to be a difficult step in the rearing of *T. walkeri*. This has been confirmed in 2003. As larvae will not feed on cut plant material, the galls have to be collected after larval feeding is resumed, and just before the L5 nymphs leave the galls. Determination of the nymphal instars and the observation of the first empty galls in the field are therefore crucial for mass collections. In 2002, a number of dead last instar nymphs were found in the rearing boxes perhaps because of a lack of moisture. In 2003, the main problem was apparently that the nymphs did not leave the galls and died. No dead adults could be found in the galls. One of the reasons could be the very hot and dry 2003 summer in particular in the main area of collection of *T. walkeri* in southern Germany. These unusual summer weather conditions may have resulted in abnormal gall conditions for *T. walkeri*.

Oviposition of T. walkeri: In 2002, 5 pairs of freshly emerged adults of *T. walkeri* were placed in rearing cylinders (10cm in diameter and 26cm in height) containing a cut branch of *R. cathartica* inserted into a cup filled with water, or on a potted plant covered by a gauze bag. Cut shoots were changed regularly, before they started to dry out. Altogether over 30 rearing cages were set up. In the beginning, different rearing conditions were compared. Seven randomly selected cylinders were stored in a long-day (16:8) incubator at 15ßC and another eight cylinders were stored in the laboratory at room temperature. The remaining cylinders and cages were kept outside beneath a tarpaulin, protected from rain and sun.

Mating was observed as early as 8 August 2002, 3 days after emergence of the first adults. The first eggs were seen on 30 August, 2002, two weeks after adult emergence. Within the following 4 weeks, with a peak between September 8-19 2002, some 2000 eggs were laid on common buckthorn, 800 of which were on potted plants. Adult mortality was higher within the first days under lab conditions and eggs were rarely found in cylinders stored in the incubator or in the laboratory. In summary, little oviposition occurred when the adults were kept in the laboratory or in an incubator at 15 ¡C and a 16:8 hour light regime. Best oviposition was obtained when the adults were kept in an outdoor shelter. Mating was observed once within three days after adult emergence but oviposition starts only 2-3 weeks after adult emergence. Adults can live more than six weeks in outdoor conditions and over two months in the laboratory.

In cages, eggs were laid between the leaf bud and the twig where they are probably protected from adverse weather conditions. The quality of the leaf bud (shape, size) seems to play a role in the oviposition behaviour. In captivity, several eggs were laid on both sides of one leaf bud.

Oviposition behaviour in the field: Oviposition behaviour under field conditions was investigated in early October at one site at Del mont, Switzerland. Four branches of 1.0 to 1.5 m length were randomly cut and the number of eggs counted. Leaf buds were divided into two categories: a) those sub-opposite buds growing at the leaf base of one year old branches (buds-A), and b) the apical leaf buds growing on small 3-4 cm lateral sub-opposite twigs (buds-B). A total of 264 buds-A and 125 buds-B were counted for a total of 118 eggs of *T. walkeri*. Thus, 77% of the eggs were laid on buds type-A while only 23% were laid on buds type-B. Single eggs were laid on 57 buds type-A and two eggs each on 17 buds type-A, i.e. 28% of the buds-A hosted eggs of *T. walkeri*. Nine individual eggs were laid on buds type-B or their twigs. Two to five eggs were found on seven buds-B or their twigs. Hence, just 13% of buds-B had eggs. Of the four branches sampled, one branch had only two eggs while the other three had an average of

39 eggs (range = 28-57). Therefore, *T. walkeri* prefers to oviposit on a certain type of leaf bud and there is usually only one egg laid per bud.

Nymphal and gall development: Potted plants infested by eggs of *T. walkeri* were kept in outdoor conditions until the following year to follow nymphal and gall development. Viable eggs were observed on the plants by mid-April 2003 although it was very difficult to re-count precisely the number of eggs. Fifty galls were produced on the plants by mid-July 2003 (Table 6). It was observed that galls are induced on the expanding leaves at the latest in late April-early May. Neonate nymphs can crawl more than 20 cm to reach a leaf bud. Thus, it will be possible to carry out oviposition tests in autumn and to follow nymphal and gall development the following year. In 2004, the oviposition areas will be marked to allow a more precise count of the eggs and a re-count of viable eggs the following spring.

Table 6. Oviposition and gall development by *T. walkeri* (2002-03)

Cage no.	Oviposition Control date (2002)	Approximative no. of eggs laid in 2002	No. of galls (July 2003)
Cage 22	9 Sept	20	1 gall
Cage 13	12 Sept	60	8 galls
Cage 17	16 Sept	15	3 galls
Cage 21	16 Sept	40	3 galls
Cage 27	16 Sept	?	5 galls
Cage 14	18 Sept	40	10 galls
Cage 17	25 Sept	30	1 gall
Cage 30	28 Sept	70	13 galls
Cage 33	28 Oct	25	2 galls
Cage 28	25 Sept	30	4 galls

Nymphal transfer: One of the problems with *T. walkeri* is that the host range has to be studied using potted plants. As mentioned above, it can be difficult to count precisely the number of eggs laid in autumn on large potted plants and to follow the fate of the eggs the following spring. Therefore, nymphal transfer was tested in early May 2003. Some 15 L1 nymphs from young field collected galls were transferred onto the leaves of each of 20 potted common buckthorn. In July, 14 galls only had developed on the test plants. Fifteen L2 nymphs transferred onto each of three potted buckthorns did not result in develoment of any galls. From these results, it is concluded that nymphal transfer may not give conclusive results if used for the study of the host range of *T. walkeri*. However, nymphal transfer will be repeated in 2004 to ascertain definitely the suitability of the method.

<u>Discussion</u>: *Trichochermes walkeri* was present in 80% of all *R. cathartica* sites surveyed and common in most of them. Galls on *Rhamnus* species other than *R. cathartica* were never observed. Though Hodkinson and White (1979) mentioned *R. alpina* and *F. alnus* as host-plants of *T. walkeri*, these results are doubtful and were never confirmed by other studies. McLean (1993) examined a *F. alnus* bush, standing right beside a highly attacked *R. cathartica* bush, over ten years but never found a single *T. walkeri* gall. *Trichochermes walkeri* is the most specific biological control agent found on *R. cathartica*. The insect also probably causes a severe stress on those buckthorns trees that are heavily attacked. This species has been selected for biological control of *R. cathartica*. Adult rearing from mature galls is the most critical step for successful screening tests of *T. walkeri*. In 2004, an effort will be made to find new collection sites in cooler areas as it was observed that good adult emergence was obtained in 2002 from galls collected in the Jura mountains. Also, an effort will be made to collect last instar nymphs or adults if this method is more cost effective. Oviposition tests will be started in autumn 2004.

5.2.2 *Trioza rhamni* (Hom., Psylloida: Triozidae) (Det. A. Gassmann)

Nymphs of the jumping plantlice *Trioza rhamni* were found at nearly 80% of all *Rhamnus cathartica* sites surveyed (Table 2). *Trioza rhamni* was common or abundant in 30% of these sites (Appendix 3). Small sample of nymphs were collected at several sites in three different countries (Switzerland, Austria and Germany) in order to determine the nymphal development stages at the time of collection. Regular visits and mass collections were made at one site in southern Germany from mid-June to the end of June. No work has been carried out on this species in 2003.

<u>Biology of *T. rhamni*</u>: The biology of *T. rhamni* has been briefly described by Ossiannilson (1992). After mating in spring, the females lay eggs singly on the underside of young leaves of *Rhamnus*. A pit-gall, which looks like a small bump on the upper leaf surface, develops around each egg. Egg hatching takes place a few days later. The first instar nymph remains in the gall, but after each moult the nymph then moves to another feeding site on the leaf. This univoltine species overwinters as adults. Teneral adults are light yellow. In mature individuals the vertex is black, lateral margins yellow to reddish-brown; the thorax is dark chocolate-brown, laterally orange-coloured or reddish-brown (Ossiannilson 1992).

Pit galls were visible at the time of the first collection in southern Switzerland (Geneva) in mid-May 2002 (Appendix 15). Eggs and first nymphal instars were found in pit galls. No nymphs were seen crawling on the leaves. Only L5 nymphs were found after mid-June 2002 and the pit galls were hardly visible. In eastern

Austria, the majority of L5 nymphs were collected on leaves by the end of May. In mid-June 2002, mass collections of mature nymphs were carried out in southern Germany. Adult emergence started a few days after the collections. Only very few nymphs were still present in late June and pit galls were hardly visible.

Nymphal development was delayed in the upland of the Jura mountains (850m) as compared to the lowland in Germany or Switzerland where most adults had already emerged. By late June, second and third nymphal instars were still present but there was a majority of last nymphal instars (58%). Pictures are shown in Appendix 25.

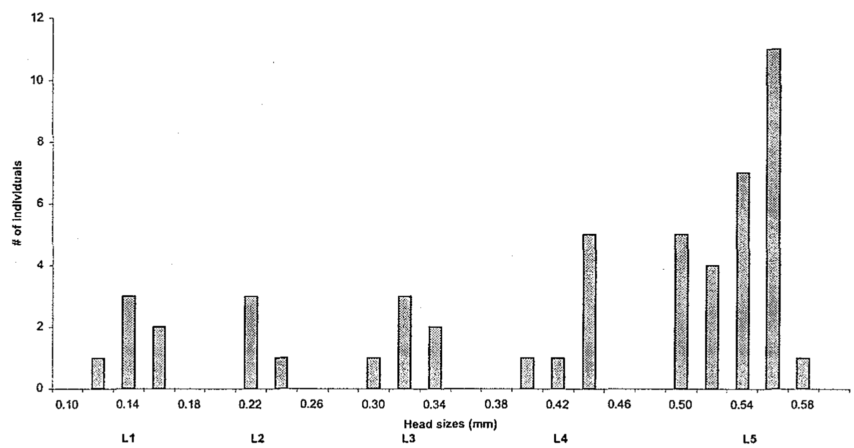


Fig 9 Nymphal head size of *Trioza rhamni* (Ntot = 51)

Development from egg to adult takes about 5 to 6 weeks under field conditions. There are five nymphal instars (Fig 9). Fifth instar nymphs are light green. All adults from material collected in Austria and southern Germany emerged between 9 and 23 June, 2002. It was observed that newly emerged adults started feeding just beside the last nymphal moult. Immature nymphs usually died shortly after they were collected.

<u>Adult survival and rearing of *T. rhamni* adults</u>: Three cages (58 x 46 x 46 cm) were filled with two potted *R. cathartica*, moist sphagnum moss, moist paper and cardboard boxes for the adults to hide. The cages were set up between June 17 and 21 with about 150 newly emerged adults each. One cage was kept in an outdoor plastic tunnel and the other two cages were stored beneath a large tarpaulin in a partly shaded site in the Centre s garden. Because the weather was very hot during the period of the test, two cages were partly covered with a moist piece of cloth. Many adults were observed to feed on buckthorn leaves during the

first days of the test, but the adult mortality increased very quickly in all three cages. All adults were dead by the end of July. A plastic cylinder (height 25 cm; diameter 11 cm) containing a branch of *R. cathartica*, moist paper and a piece of cardboard was kept from June 20 onwards with 20 *T. rhamni* in an incubator at 15 – 1 ¡C and 16/8h light regime. Adult survival was better under these conditions, but still, all adults died within three months.

Discussion: Literature and personal field records indicate that *Trioza rhamni* is exclusively associated with *R. cathartica.* In our opinion, records of *T. rhamni* from *R. alpina* (Malicky *et al.* 1970) need to be confirmed. A conspicuous leaf gall was found on *R. alpina* which is maybe induced by *Trioza kiefferi* (Buhr 1965).

The species is known from Austria, the Czech Republic, Germany, Great Britain, Hungary, Poland, Romania, Spain, Switzerland, the European part of the former USSR and the Caucasus (Ossiannilson 1992). *Trioza rhamni* is thus common in Europe and seems to be locally abundant, e.g. in the upper Rhine Valley. Immature nymphs are difficult to rear on cut leaves. Our field surveys indicate that the best time for collection of mature nymphs in Germany and Switzerland is during the first half of June. Problems, however, are anticipated in overwintering the adults since it has been impossible to keep adults alive in cages in outdoor natural conditions for more than a few weeks. As for the *Sorhagenia* species best results have been obtained in an incubator at 15 – 1 ¡C.

Trioza rhamni is specific to *R. cathartica* but the direct damage inflicted to the host plant is negligible, though this situation might change when the species undergoes permanent outbreak. Indeed, several Triozidae species are known as serious pests (e.g. *T. erytreae*, *T. perseae*). However, it is proposed to defer further study of this species to a second or later phase of the project if rearing methods can be developed and perhaps in relation to potential disease transmission.

5.2.3 *Cacopsylla rhamnicolla* (Hom., Psyllidae) (Det. P. Lauterer)

A small number of adults of *Cacopsylla rhamnicola* were found on *R. cathartica* at one site in Austria and one in Germany in 2002. In late April 2003, a few adults and numerous eggs and larvae were observed in the young folded leaves and inflorescence of *R. cathartica* at two sites in Switzerland and southern Germany. Thus, *C. rhamnicola* is probably much more common than previously thought. It is known in Europe from Britain to Romania and from Spain to southern Sweden. *Cacopsylla rhamnicolla* has also been recorded in European Russia, the Caucasus up to Central Asia and Mongolia (Ossiannilson 1992). *Cacopsylla rhamnicolla* is unvoltine, hibernating as an adult, probably on conifers. In Fennoscandinavia, the first teneral adults were found by the end of June. Eggs are laid in the inflorescences and on the young folded leaves (Ossiannilson 1992).

The species is specific to *R. cathartica*. *Cacopsylla rhamnicolla* however, has not been selected because of the lack of visible damage on the attacked trees, although this would deserve more attention. As for *Trioza rhamni*, this species could be considered in a second or later phase of the project if rearing methods can be developed and perhaps in relation to potential disease transmission.

5.2.4 *Zygina suavis* (Hom., Cicadellidae; Typhlocybinae) (Det. P. Lauterer)

Fifth instar nymphs of this leafhopper were found on *F. alnus* at one site in southern Germany on 23 July 2002. Numerous adults have collected on *F. alnus* in the Jura mountains in Switzerland on 19 August 2002 and 19 June 2003 (Appendix 23). Adults have also been recorded in mid-May 2003 in eastern Austria, and in early July 2003 in Northern Germany where the species seems to be very common. The observations made in the field and the literature indicate that *Z. suavis* has two generations (Ossiannilson 1981). According to Lauterer (pers. com. 2002), *Z. suavis* is a common species on *F. alnus* which is occasionally found on *R. cathartica* as well.

The *Z. suavis* subfamily Typhlocybinae is a large group of Cicadellidae that includes several pest species in the genera *Empoasca*, *Erythroneura* and *Typhlocyba*. In 1999, the cicadellid *Zygina* sp., was approved for release in Australia for the biological control of bridal creeper (*Myrsiphyllum asparagoides*) http://www.ento.csiro.au/bridalcreeper/. It is now widely distributed in southern Australia.

Cicadellidae cause several major types of injury to the plants. Some species remove excessive amounts of sap and reduce or destroy the chlorophyll in the leaves; others interfere with the normal physiology of the plant, for example by mechanically plugging the vascular bundles in the leaves. Some species cause stunting and leaf curling that results from the inhibition of growth on the underside of the leaves where the leafhoppers feed. Many species of leafhoppers act as vectors of organisms that cause plant diseases, e.g. viruses, bacteria or phytoplasma. *Zygina suavis* appears to be an important potential biological control agent for *F. alnus* for which few specialized herbivores have been recorded.

5.3 Coleoptera

5.3.1 *Oberea pedemontana* (Col., Cerambycidae) (Det. A. Gassmann)

Oberea pedemontana was found only in Northern Italy and Serbia (Tables 2; 4). Stems or branches of buckthorns showing obvious damage due to *O. pedemontana* were collected in 2002 in two contiguous sites near Ravenna, Italy. Altogether, 28 infested stem pieces or branches were collected on *R. cathartica* and 39 on *F. alnus*. For rearing, stem pieces from the two different host trees were set up in separate large plant pots with soil, and stored in 4 different cages in an outdoor shelter.

Adult emergence: Only one adult emerged on June 12, 2002 from the *R. cathartica* material. Dissection in late August 2002 revealed three dead larvae, and five living larvae. Fresh and old frass was found in all but four stems. Four adults of *O. pedemontana* emerged from *F. alnus* in mid-June 2002. From May 17 to June 20, 2002, 32 parasitoids emerged from the same material. In late August 2002, one dead pupa, two dead larvae and three living larvae as well as several parasitoid cocoons were found when the stems were dissected. Fresh and old frass was observed in all but seven stems. Pictures are shown in Appendix 26.

Rearing of Oberea pedemontana: Four adults were sexed when they were found mating in the laboratory. On June 27, 2002, these two pairs were placed in a 120cm x 45cm x 45 cm cage with one 1.5m *Frangula alnus* plant and held in an outdoor shelter. Mating was observed again the same day. One month later, the tree trunk and even thin branches were covered with scores, indicating oviposition. By mid-August all four adults were dead. In late August 2002, frass was observed around the scores indicating that larvae were mining the plant. Two adults emerged late June 2003. The plants will be placed in a cage in early May 2004 to record further adult emergence.

Discussion: According to Baronio *et al.* (1988), *O. pedemontana* in Italy has a three-year biological cycle on *F. alnus*. Eggs are laid in the branch phelloderm. Upon hatching, the larvae bore down a gallery along the central branch axis, keeping it open laterally in the initial segment. Both the opened and closed parts of the gallery are extended thereafter. The larva removes frass and powdery borings from the lower part of the gallery by pressing them to the upper part, including the open later extension. Before the onset of every winter, the larva retires to a section of the gallery that is plugged at either end by pieces of wood fibre. Here, the larva is turned upwards, i.e. upside down with respect to the feeding position. Feeding activity resumes about mid-April onwards, and the mature larvae pupate from the third week in April. The fully grown larva prepares the adult s emergence path by ascending the gallery up to the initial part, which is still blocked with frass and powdery borings and retunnelling through them as far as the base of the opening. The larva then goes down and pupates near the bottom of the gallery. Adult emergence begins by mid-May. Data collected in 2002 confirm that *O. pedemontana* needs more than one year to complete larval development. Baronio *et al.* (1988) reported a larval parasitism rate of 54% by *Billaea irrorata* Meig. (Dipt., Tachinidae) and *Dolichomitus messor* (Gravenhorst) (Hym., Ichneumonidae). Our data from 2002 indicates a total larval parasitism rate of 63%.

Oberea pedemontana is mainly found around the Adriatic Sea. The beetle has been recorded in Italy and Yugoslavia, and to a lesser extent in Austria, Hungary, Bulgaria, Rumania and perhaps in Turkey (Baronio *et al.* 1988 and references therein). In Italy, *O. pedemontana* had not yet been found on *Rhamnus cathartica* but only on *Frangula alnus*. In Yugoslavia, *O. pedemontana* is reported causing extensive damage to *R. cathartica* (Lekic and Mihajlovic 1976). The beetle has been found at several *R. cathartica* and *F. alnus* sites in Serbia during limited surveys carried out in 2002-03. The beetle has also been reported from *R. alpina* (Sama 1988) and from *Lonicera* species (Horion 1974; Demelt and Franz 1990). However, according to Frisch (1992), the record of *O. pedemontana* on *Lonicera* is probably due to the fact that *Lonicera* can occur in mixed stands with *F. alnus* and therefore adults of *O. pedemontana* were shaken off from these bushes. Contarini and Garagnani (1980) observed beetles infesting *F. alnus* and avoiding adjacent *R. cathartica* bushes.

Oberea pedemontana is the only specialized beetle recorded on buckthorns in Europe. It is also one of the very few internal feeders. Therefore, it has been selected for host specificity studies. Work in 2004 will be focused in Yugoslavia because of the high parasitism rate of the Italian populations.

5.4 Acari

Several microscopic mites such as *Aceria rhamni*, *A. annulata* and *Tetra rhamni*, as well as undescribed species, have been recorded on buckthorns (Buhr 1965). Neither the free living eriophyid mite. *Tetra rhamni,* nor the gall-forming species, *Aceria rhamni,* were found on *R. cathartica* and *F. alnus* in surveys. Abnormal hairyness on the underside of *R. cathartica* leaves has been found at several sites in Austria in late May and in southern Germany (Appendix 23). These leaf deformations occur in the form of mats of nutritive hairs called erineum (Meyer 1987) and could be induced by *Aceria annulata* or an undescribed mite (Buhr 1965). In the case of an erineum on *Acer campestre*, these hairs arise after brief induction by feeding of the mite (Meyer 1987). No mites have been observed in situ on such erinea on *R. cathartica*. Dense mats of hairs have not been found on *F. alnus* but such leaf deformations of unknown (acarian) origin are also described for *F. alnus* in the Netherlands and in Sweden (Buhr 1965).

In Yugoslavia, the eriopyid mite *Calepitrimerus rhamni* has been discovered on *R. alpina* ssp. *falax*. Damage by *C. rhamni* has also been observed on *R. alpina* in Switzerland. *Calepitrimerus rhamni* is also associated with *F. alnus* (Petanovic pers. com.).

In 2004, more efforts will be made in the search for microscopic mites associated with *R. cathartica* and *F. alnus*.

6 Preliminary host range studies

6.1 *Triphosa dubitata*

In Europe, *T. dubitata* has been recorded on *R. cathartica*, *R. alpina* and occasionally on *F. alnus* and *R. orbiculata.* A small number of no-choice larval development tests were carried out with larvae collected in Switzerland.

Five young field collected larvae were offerred *R. cathartica* and *R. caroliniana* in individual Petri dishes (10cm diam.) kept in an outdoor shelter. The larvae were checked and food changed 2-3 times per week.

No larvae fed and survived on the native North American *R. caroliniana.* In contrast, four adults were reared from *R. cathartica* (Table 7).

Table 7 Preliminary larval host range of *Triphosa dubitata* in no-choice conditions (test started 2 May 2003)

Host plant	# replicate	# pupae obtained	Time to pupation (days–SD)(N)	Larval survival (days–SD)(N)
Rhamnus cathartica	5	4	26 –1.2 (4)	22 (1)
R. caroliniana (NA)	5	0	-	3–1.4 (5)

6.2 *Ancylis apicella*

In the field, *A. apicella* has been recorded on *R. cathartica*, *R. saxatilis*, *R. alaternus* and *Frangula alnus*, but rarely on *R. alpina.* A small number of no-choice larval development tests were carried out with larvae bred from material collected in Germany and Serbia.

One neonate larva was offered one of four buckthorn species in ten replicates in individual Petri dishes (10cm diam.) kept in an outdoor shelter. The larvae were checked and food changed 2-3 times per week.

Larval survival appears to be slightly higher on *R. cathartica* and *R. alnifolium* than on *R. caroliniana* and *R. alpina* (Table 8). Time to pupation was significantly longer on *R. alpina* than on the other buckthorn species (Tukey test, $P < 0.005$). There was no significant difference in the weight of the pupae reared on the different host plants.

Thus, the larval host range of *A. ancylis* is restricted to species in the genus *Rhamnus* under no-choice conditions.

Table 8 Preliminary larval host range of *Ancylis apicella* in no-choice conditions (test started 28 June 2003).

Host plant	# replicate (L1)	# pupae obtained	Time to pupation (days–SD)(N)	Pupal weight (mg) (mean–SD)(N)
Rhamnus cathartica	10	10	17.5–1.4 (10)	10.8–1.1 (6)
R. alnifolium (NA)	10	9	18.6–2.6 (9)	9.2–1.9 (7)
R. caroliniana (NA)	10	6	18.5–0.5 (6)	8.8–3.1 (6)
R. alpina	10	4	27.3–5.3 (4)	9.1–2.2 (3)

6.3 *Ancylis derasana*

In the field, *A. derasana* has been recorded on *R. cathartica* and *F. alnus*. A small number of no-choice larval development tests were carried out with larvae bred from material collected in Germany.
One neonate larva was offerred one of four buckthorn species in ten replicates in individual Petri dishes (10cm diam.) kept in an outdoor shelter. Three series of tests were carried out. Feeding was interrupted on 15 November when the remaining larvae prepared silk webs for overwintering.

Larval mortality occurred usually within two weeks after set-up. The larvae that do not pupate stop feeding by late September and start preparing a silk web for overwintering. *Frangula alnus* and to a lesser extent *R. caroliniana* are less suitable hosts than *R. cathartica*, *R. alnifolia* and *R. alpina* (Table 9).

Table 9 Preliminary larval host range of *Ancylis derasana* in no-choice conditions (2003)

Host plant	# replicate (L1)	# pupae obtained	Time to pupation (N)	Pupal weight (mg) (N)
Rhamnus cathartica (test started Aug. 7)	10	2 (+2 larvae alive*)	19.0 (2)	10.0 (2)
Rhamnus cathartica (test started Aug. 19)	10	7 larvae alive*	-	-
Rhamnus cathartica (test started Aug. 20)	10	9 larvae alive*	-	-
Frangula alnus (test started Aug. 7)	10	1 (+3 larvae alive*)	19.0 (1)	7.2 (1)
Frangula alnus (test started Aug. 19)	10	-	-	-
Frangula alnus (test started Aug. 20)	10	-	-	-
R. alnifolium (NA) (test started Aug. 7)	10	3 (+3 larvae alive*)	22.0 (3)	9.3 (3)
R. alnifolium (NA) (test started Aug. 19)	10	9 larvae alive*	-	-
R. alnifolium (NA) (test started Aug. 20)	10	4 larvae alive*	-	-
R. caroliniana (NA) (test started Aug. 7)	10	5 larvae alive *		
R. caroliniana (NA) (test started Aug. 19)	10	2 larvae alive *	-	-
R. caroliniana (NA) (test started Aug. 20)	10	1 larva alive *	-	-
R. alpina (test started Aug. 19)	10	6 larvae alive*	-	-
R. alpina (test started Aug. 20)	10	7 larvae alive*	-	-

* As of March 11, 2004

7 Discussion

Work carried out in 2002-03 has identified suitable collection sites and best collection time for several of the most promising biological control agents for exotic buckthorns in the United States. Field observations and preliminary biological studies on a few species has clarified biological features for a few key species and also highlighted some potential problems for the rearing of some other species.

In general, field records and observations made in 2002-03 agree well with those made in the 1960s although the phenology of several species appear to be some 10-15 days in advance compared to 30 years ago. No unknown or undescribed species have been found on European buckthorns but progress has been made for future work with a number of less known species.

Preliminary screening tests with neonate larvae have enabled us to discard two species, *Ancylis apicella* and *A. derasana*, from the prime list of potential agents. As of now, relatively little is known on the precise potential host specificity of most other candidate agents. Preliminary screening tests carried out by Malicky *et al.* (1970) with medium-size larvae of several species always showed a relatively broad host range within European *Rhamnus* species. For example, medium-size larvae of most of those species which are rarely or never recorded on *F. alnus* in the field (i.e. *Triphosa dubitata*, *Philereme transversata*, *Sorhagenia lophyrella*) do feed on *F. alnus* in no-choice conditions. However, the realized host range is likely to be determined by a combination of oviposition preference, plant suitability to neonate larvae, and ultimately by habitat preference.

Acknowledging that biological control agents must be specific to their target plants, the selection of potentially effective organisms is a difficult task. Some criteria used for the selection of potential biological control agents are the time and duration of attack, the type of direct and indirect damage inflicted to the target plants and their populations, and of course, the population density of the herbivore. Predicting the potential to develop high population densities is difficult since not only can predation and disease play an important role in insect population dynamics, but so can density-dependent larval mortality, local abiotic conditions or the impact of plants on the agent fitness and demography. The difficulty of predicting the efficacy of biological control agents is enhanced when environmentally controlled compensatory mechanisms at the individual plant or population level moderate the impact of herbivory. This is to say that the selection of potential biological control agents for exotic buckthorns in North America is also based on some key pragmatic considerations such as 1) their likely host specificity, 2) their phenology and their food niche, and 3) their potential availability and the ability to breed them.

Potential biological control agents for *R. cathartica* and *F. alnus*:

Sap suckers

1. *Trichodermes walkeri* — Targeted host˚*R. cathartica*
This leaf galling psyllid is most probably monospecific on *R. cathartica*. It is common and the adults breed easily. Problems may be encountered with adult emergence. Its potential impact is to impair common buckthorn vital functions (photosynthesis) and to act as a nutrient sink through gall development. *Trichodermes walkeri* could also act as a vector for pathogens. The species has been selected for detailed host specificity studies.

2. *Trioza rhamni* — Targeted host: *R. cathartica*
Trioza rhamni is specific to *R. cathartica* but the direct damage inflicted to the host plant is negligible though this situation might change at high population densities. *Trioza rhamni* may also act as a vector for pathogens.

3. *Cacopsylla rhamnicola* — Targeted host:*R. cathartica*
Little is known about this psyllid species, but it seems to be specific to *R. cathartica*. As for *T. rhamni*, this species seems to have little direct impact on its host at the population densities observed.

4. *Zygina suavis* — Targeted host:*F. alnus*
This cicadellid species appears to have a strong preference for *F. alnus*. It is probably more common in Europe than indicated by the 2002-03 surveys. Its potential impact is to impair glossy buckthorn vital functions (photosynthesis) and potentially to act as a vector for pathogens. It is one of the few insects strongly associated with *F. alnus*.

5. Mites
The identification and nomenclature of the mites associated with buckthorns in Europe needs to be clarified. Until now the most interesting mites associated with buckthorns, i.e., *Tetra rhamni* and the gall-forming (?) species *Aceria rhamni* have not been found.

Shoot-borers

1. *Sorhagenia janiszewskae* —Targeted hosts: *R. cathartica* and *F. alnus*
This cosmopterygi moth attacks both *R. cathartica* and *F. alnus*. It is relatively common and easy to collect but some problems still need to be solved to successfully overwinter the adults. It is one of the two species whose larvae bore in the above ground parts of the target trees. Its potential impact is to impair growth of the current year s shoots. The species has been selected for detailed host specificity studies.

2. *Oberea pedemontana* —Targeted hosts: *R. cathartica and F. alnus*
The larvae of this cerambycid bore into the branches and trunks of *R. cathartica* and *F. alnus*, causing structural damage and occasionally death of the host tree. Work with this species is strongly handicapped by a high rate of parasitism and the three years needed by the beetle to complete its life cycle. However, once released from its parasitoids, *O. pedemontana* could have a serious impact on exotic buckthorns in the USA. The species has been selected for detailed host specificity studies.

Root-borers

1. *Synanthedon stomoxiformis* — Targeted hosts:*R. cathartica*
This sesiid moth is the sole root-boring species on buckthorn. It is therefore of great interest for biological control. In our opinion, the main disadvantage of the species is the bad track record of root-boring moths in biological control. The species has been selected for detailed host specificity studies.

Defoliators

1. *Philereme vetulata* — Targeted host: *R. cathartica*
This geometrid moth has been found on *R. cathartica* and *R. alpina*, but very rarely on *F. alnus*. The frequency of occurrence of *P. vetulata* is quite low but the population density is usually quite high where it occurs. Preliminary data indicate that it is host specific enough to justify further investigations. *Philereme vetulata* is an early defoliator of buckthorns, and as such, it could play an important role in the strategy to control the plants. Like all defoliators, *P. vetulata* impair vital functions (photosynthesis) and causes water losses. The species has been selected for detailed host specificity studies.

2. *P. transversata* — Targeted host:*R. cathartica*
Philereme transversata has a strong preference for *R. cathartica*, but it is very rare in the areas surveyed.

3. *Triphosa dubitata* — Targeted host°: *R. cathartica*
This geometrid defoliator has been found mainly on *R. cathartica* and *R. alpina* but it is very rare on *F. alnus*. The populations were usually low in most collection sites. Problems are expected in adult aestivation and overwintering. Preliminary data indicates that it is host specific enough to justify further investigations. *Triphosa dubitata* appears later in the season than *P. vetulata*. Thus, these species are complementary in their impact on the target host..

4. *Sorhagenia lophyllera* — Targeted host:*R. cathartica* ?
This defoliating moth has not been found in 2002. In the past, it had been found predominantly on *R. saxatilis*, and to a lesser extend on *R. cathartica*, suggesting that it has a preference for drier open habitats. Larval feeding tests with medium-

size field collected larvae showed that S *lophyllera* larvae developed well on *R. saxatilis* and *F. alnus* only (Malicky *et al.* 1970). Thus, in Europe *Sorhagenia. lophyllera* seems to avoid the *F. alnus* habitats, or its phenology is not well synchronized with glossy buckthorn since the larvae start feeding very early in the season. *Sorhagenia lophyrella* could be of interest to control *R. cathartica* in very dry habitats.

5. *Gonoptery rhamni* —Targeted hosts: *F. alnus* (*R. cathartica*)
This univoltine defoliating butterfly shows a clear preference for *F. alnus* over *R. cathartica.* It has also been recorded on *R. orbiculatus* and *F. rupestris* in Europe, thus showing a potential lack of specificity as a biological control agent. Larval feeding tests with medium-size field larvae showed that *G. rhamni* complete larval development on all *Rhamnus* and *Frangula* species offered (Malicky *et al.* 1970). The main advantage of *G. rhamni* is its preference for *F. alnus*, for which there are few potential agents.

6. *Ancylis apicella* — Targeted hosts:*F. alnus* (*R. cathartica*)
The tortricid *Ancylis apicella* has been recorded on *F. alnus*, *R. cathartica*, *R. alpina*, *R. saxatilis*, and *R. alaternus*. This defoliator prefers *F. alnus* to *R. cathartica*. Preliminary screening tests with neonate larvae indicate that *A. apicella* will develop on the North American *R. alnifolium* and *R. caroliniana*. The species is thus excluded from the prime list of potential biological control agents.

7. *Ancylis derasana* — Targeted hosts:*R. cathartica* (*F. alnus*)
Ancylis derasana prefers *R. cathartica* to *F. alnus*. It is a bivoltine species and thus of interest because of its prolonged feeding period. Preliminary screening tests with neonate larvae indicate that *A. derasana* will develop on the North American *R. alnifolium* and *R. caroliniana* as well as on *R. alpina*. However, *A. derasana* has only been found on *R. cathartica* and *F. alnus* indicating that its field host range is probably more specific than the experimental larval host range. *Ancylis derasana* should not be included in the prime list of potential biological control agents, at least for now.

Leaf miners
Several leaf-mining moths are associated with buckthorns in Europe. Their feeding on the foliage of buckthorns must impair vital functions like photosynthesis and cause water losses.

1. *Bucculatrix frangutella* — Targeted hosts:*R. cathartica* and *F. alnus*
The larvae leave the mines to complete feeding and development externally. This univoltine moth has been recorded on *R. cathartica*, *F. alnus* and *R. alpina*. This species seems of little interest because it is active late in the season, but *B. frangutella* is the only leaf miner recorded on *F. alnus*.

2. *Calybites quadrisignella* —Targeted host': *R. cathartica*

This univoltine moth has been recorded exclusively on *R. cathartica*. Like *B. frangutella*, the larvae leave the mines to continue feeding and development externally. The handicap of *C. quadrisignella* is its rarity in the areas surveyed.

3. *Stigmella catharticella* and *S. rhamnella* — Trageted host:*R. cathartica*
Both species are closely associated with *R. cathartica*. Neither species has been recorded on *F. alnus*. Both species are bivoltine and complete their development within the leaf mines. *Stigmella catharticella* seems to be relatively more common than *S. rhamnella.* No good collection sites have yet been found for either species.

Of the four leaf-mining species, *S. catharticella* seems to be the most suitable candidate biological control agent for *R. cathartica. Bucculatrix frangutella* could be considered since it includes *F. alnus* in its diet in its natural host range.

8 Conclusions and work planned for 2004-05.

Dr. Luke Skinner, Minnesota Department of Natural Resources, project manager of this project, visited the CABI Bioscience Switzerland Centre, 14-21 June 2003. Several field sites were visited in Germany and Switzerland, the project was reviewed in detail and priorities set for 2004-2005.

Several insect species have been selected for detailed host specificity studies based on their food niche, period of attack, potential availability and likely specificity. Most of these species are targeted for *R. cathartica*. These are: *Trichochermes walkeri*, *Philereme vetulata*, *Synanthedon stomoxiformis* and as a lower priority *Triphosa dubitata*. The other species, *Sorhagenia janiszewskae* and *Oberea pedemontana*, are targeted for both *R. cathartica* and *F. alnus*. The screening tests will much depend on successful rearing (e.g. for *Trichochermes walkeri* and *Sorhagenia janiszewskae*) or successful collection of a particular stage of the insect (e.g. collection of adults of *S. janiszewskae* or eggs of *Triphosa dubitata*).

Based on surveys completed in 2002 and 2003, new emphasis will be put on field surveys of flower and fruit/seed feeding insects (Appendix 23). According to the literature, the gall midges *Contarinia rhamni* and *Dasyneura frangulae*, are known from *F. alnus* (see Gassmann *et al.* 2001). *Lasioptera kosarzewskella* and *Wachtliella krumbholzi* are known from *Rhamnus cathartica.* The cosmopterygid moth *Sorhagenia rhamniella* is known to live in the flowers of both species and the tortricid moth *Phtheochroa sodaliana* attacks their fruits.

The study and distribution of potential natural enemies of *Rhamnus* spp. in Europe will be continued.

Acknowledgments

We would like to thank Drs. P. Baronio, N. Baldassari, A. Marini°, H. Malicky, M. Tschirnhaus, C. Lambelet, R. Mayor, J.-P. Sorge, A. Bogenrieder, F. Schuhwerk and T. Le Bourgeois for providing information on *R. cathartica* and *F. alnus* and their assistance in field work. We also would like to thank Drs. Z. Lastuvka, P. Lauterer, R. Bryner, M.J.W. Cock, S. Whitebread, B. Landry, J. Buszko, A. Haltrich and L.O. Hansen for identifying the material collected on buckthorns and providing information on various arthropod species.

References

Anonymous (2001a). Den virtuella floran. *Rhamnus cathartica.* http://linnaeus.nrm.se/flora/ ' *Naturhistoriska riksmuseet 1996.*

Anonymous (2001b). Den virtuella floran. *Frangula alnus.* http://linnaeus.nrm.se/flora/ ' *Naturhistoriska riksmuseet 1996.*

Baronio, P., M. Marini and G. Sama (1988). Studies on *Oberea pedemontana* Chevrolat 1856 (Coleoptera, Cerambycidae) (in Italian). Monti e Boschi **39**: 45-52.

Bradley, J. D., W. G. Tremewan and A. Smith (1979). *British Tortricoid Moths. Tortricidae: Olethreutinae*, Cambridge University Press, 336 pp.

Buhr, H. (1965). *Bestimmungstabellen der Gallen (Zoo- und Phytocecidien) an Pflanzen Mittel und Nordeuropas. Band II.* Jena, Veb Gustav Fischer Verlag.

Carter, D. J. (1987). *Raupen und Schmetterlinge Europas und ihre Futterpflanzen*. Hamburg und Berlin, Verlag Paul Parey.

Cherix, D. (1976). Remarques a propos d'un Lepidoptere Trogloxene. Mitteilungen der Schweizerischen Entomologischen Gesellschaft **49**: 45-50.

Contarini, E. and P. Garagnani (1980). The cerambycids of the coastal pinewoods of Ravenna (Coleoptera) (in Italian). Memorie della Societa Entomologica Italiana **59**: 49-57.

Converse, C. K. (2001). Element Stewardship Abstract for *Rhamnus cathartica*, *Rhamnus frangula* (syn. *Frangula alnus*). The Nature Conservancy. Arlington, Virginia.

Demelt, C. v. and H. Franz (1990). *Ein systematisches Verzeichnis aller auf oesterreichischem Gebiet festgestellten Tierarten. Coleoptera, Fam.: Cerambycidae*. Wien, Verlag der Oesterreichischen Akademie der Wissenschaft.

Frisch, J. (1992). Ein neuer Bockk fer f r die Fauna K rntens - *Oberea pedemontana* Chevrolat 1856 (Coleoptera, Cerambycidae). Carinthia II **182**: 637-642.

Gale, S. W. (2001). Control of the invasive exotic *Rhamnus cathartica* in temperate North America forests. http://www.hort.agri.umn.edu/h5015/00papers/gale.htm.

Gassmann, A., M. Seier, M. D'Alessandro and M. Cock (2001). An assessment of the potential for biological control of buckthorns in North America, CABI Bioscience Switzerland Centre, Report.: 101 pp.
Goater, B. (1986). *British pyralid moths. A guide to their identification.*, Harley Books, Colchester, Essex, 175 pp.
Haber, E. (1997, a). Invasive exotic plants of Canada. Fact sheet No. 6. Glossy Buckthorn - *Frangula alnus* P. Mill. http://infoweb.magi.com/~ehaber/factcbck.htlm, National Botanical Services, Ottawa, ON, Canada.
Hannemann, H.-J. (1964). Kleinschmetterlinge oder Microlepidoptera. II. Die Wickler (s. l.) (Cochylidae und Carposinidae), die Z nselartigen (Pyraloidea). In: Dahl, F., M. Dahl. and F. Peus (eds.) Die Tierwelt Deutschlands und der angrenzenden Meeresteile. 50. Teil. In: (Eds.). Jena, Gustav Fischer Verlag.
Heath, J., (Ed.) (1976). *Moths and butterflies of Great Britain and Ireland. Vol. 1. Micropterygidae-Heliozelidae.* Colchester, UK, Harley Books.
Heath, J. and A. M. Emmet (1985). *The Moths & Butterflies of Great Britain and Ireland. Vol.2: Cossidae - Heliodinidae.* Colchester, UK, Harley Books.
Hodkinson, I. D. and I. M. White (1979). Homoptera, Psylloidea. Handbook Ident. Br. Insects. **2(5a)**: 1-98.
Horion, A. D. (1974). *Faunistik der Mitteleuropaeischen Kaefer. Cerambycidae.* Bodensee, Ueberlingen.
Lastuvka, A. and Z. Lastuvka (1997). *Nepticulidae Mitteleuropas: ein illustrierter Begleiter.*, Konvoj Verlag, Brno, 230 pp.
Lekic, M. and L. Mihajlovic (1976). A contribution to the investigation of the ecology of *Oberea pedemontana* Chevrolat on *Rhamnus cathartica* as a host plant (in Serbian). Glasnik Sumarskog Fakulta Serbia **50**: 67-72.
Malicky, H. and R. Sobhian (1971). Untersuchungen ber Bionomie, Pr imaginalstadien und Verbreitung der europ ischen *Sorhagenia* -Arten. Beitr. Ent. **21**: 179-190.
Malicky, H., R. Sobhian and H. Zwoelfer (1965). Phytophagous insects attacking Rhamnaceae in Europe, Commonwealth Institute of Biological Control, European Station, Del mont, Switzerland: 24 pp.
Malicky, H., R. Sobhian and H. Zw lfer (1970). Investigations on the possibilities of biological control of *Rhamnus cathartica* L. in Canada: Host ranges, feeding sites, and phenology of insects associated with European Rhamnaceae. Zeitschrift f r angewandte Entomologie **65** : 77-97.
McLean, I.F.G. (1994) The host plant associations and life history of *Trichochermes walkeri* F rester (Psylloidea: Triozidae). Br. J. Ent. Nat. Hist. **6**: 4 pp.
Medan, D. (1994). Reproductive biology of *Frangula alnus* (Rhamnaceae) in southern Spain. Plant Systematics and Evolution **193**: 173-186.
Meyer, J. (1987). *Plant Galls and Gall Inducers.* Berlin, Stuttgart, Gebr der Bortr ger.
Moe, D. (1984). The late quaternary history of *Rhamnus frangula* in Norway. Nord. J. Bot. **4**: 655-660.

Ossiannilson, F. (1992). *The Psylloidea (Homoptera) of Fennoscandia and Denmark*. Leiden, New York, Koeln.

Ossiannilson, F. (1981). *The Auchenorrhyncha (Homoptera) of Fennoscandinavia and Denmark. Part. 2: The Families Cicadidae, Cercopidae, Membracidae, and Cicadeliidae (excl. Deltocephalinae)*. Klampenborg - Denmark, Scandinavian Science Press LTD.

Puplesis, R. (1994). *The Nepticulidae of eastern Europe and Asia*. Leiden, Backhuys Publishers.

Rameau, J. C., D. Mansion, G. Dum , J. Timbal, A. Lecointe, P. Dupont and R. Keller (1989). *Flore foresti re fran aise. Guide cologique illustr . 1. Plaines et collines.*, Institut pour le D veloppement Forestier. Minist re de l'Agriculture et de la For t.

Sama, G. (1988). *Fauna D'Italia - Coleoptera, Cerambycidae, Cataloguo topographico e sinonimico*. Bologna, Edizioni Calderini.

Scamoni, A. (1985). Ueber das kologische und soziologische Verhalten von *Rhamnus cathartica* L. und *Frangula alnus* Mill. in der planaren Stufe der DDR (in German). Feddes Repertorium **96**: 139-144.

Sobhian, R., H. Malicky and H. Zwoelfer (1964). Insects attacking *Rhamnus cathartica* L. and related species in Central Europe. Commonwealth Institute of Biological Control, European Station. Progress Report XIII, 17 pp.

Tutin, T. G. (1968). Rhamnaceae. In: Tutin, T.G., V.H. Heywood, N.A. Burges, D.M., Moore, D.H. Valentine, S.M. Walters and D.A. Wegg (eds.) Flora Europaea, Vol. 2. In, Cambridge University Press: 243-245.

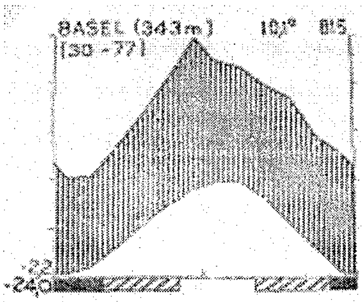
USDA and NRCS (2001). The PLANTS Database, Version 3.1. http://plants.usda.gov, National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

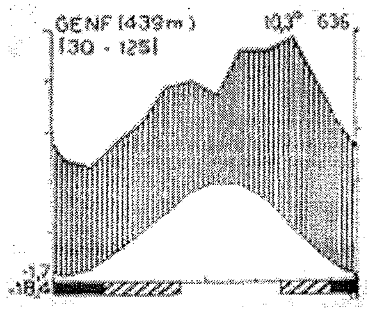
Walter, H and L. Lieth (1967) Klimadiagramm - Weltatlas. Veb Gustav Fischer Verlag, Jena

Appendix 1 Climate graphs of the main collection areas (from Walter and Lieth 1967) (Explanation at end of Appendix 2)

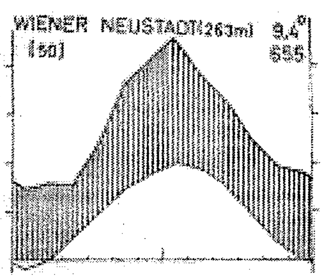
A. Humid with cold season type of climate (VI). The subdivisions are made according to the mean annual temperature and rainfall.

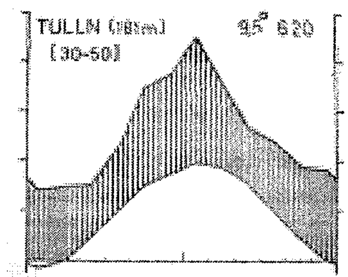
VI 2a



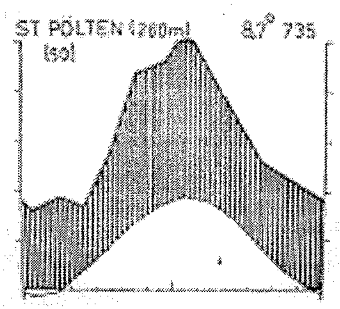


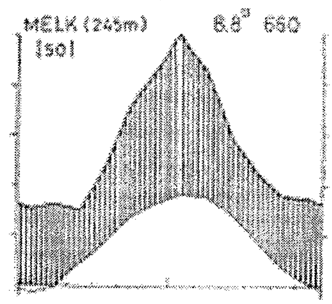
VI 2b



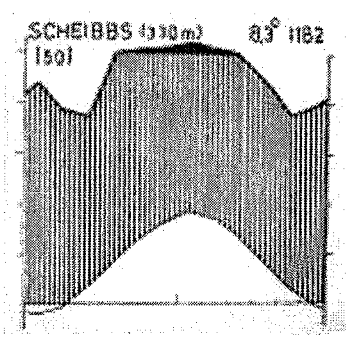


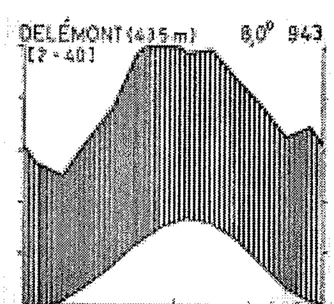
VI 3



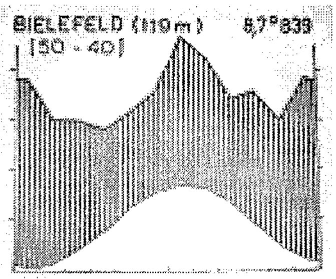


VI 4

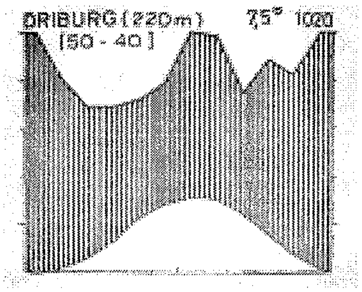




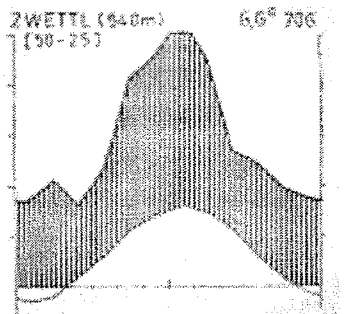
VI 5a

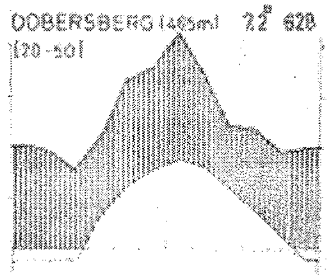


VI 9d



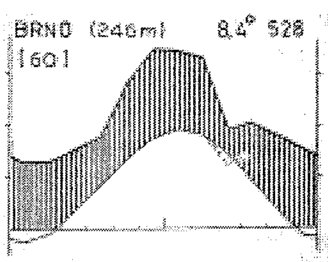
VI 9b





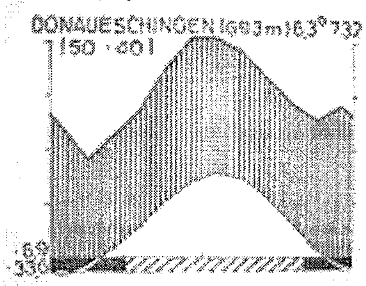
B. Humid with cold season type of climate (VI) (with some characteristics of arid with cold season type of climate (VII))

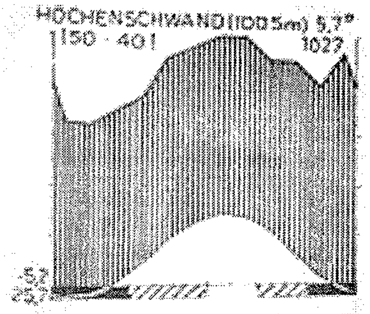
VI (VII) 1



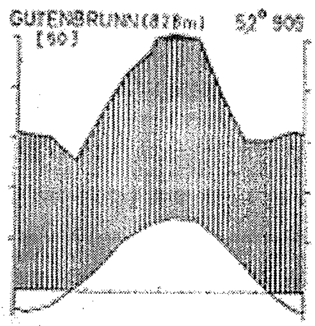
C. Humid with cold season type of climate (VI) (with some characteristics of mountain type of climate (X))

VI (X) c

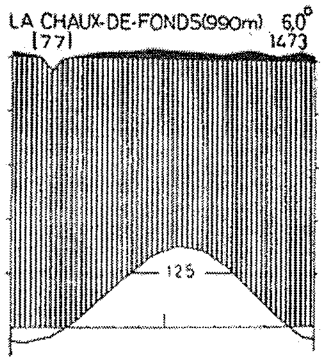




VI (X) 2

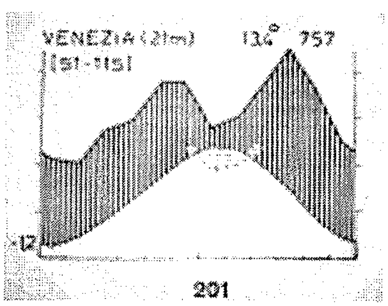


VI (X) 3



D. Mediterranean, winter rains type of climate (IV) (with some characteristics of humid with cold season type of climate (VI))

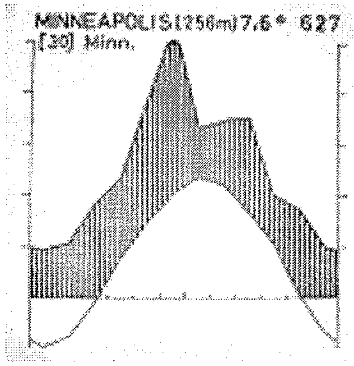
IV (VI) 4

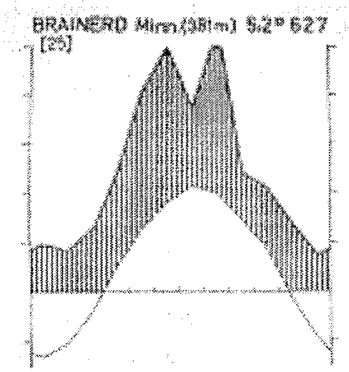


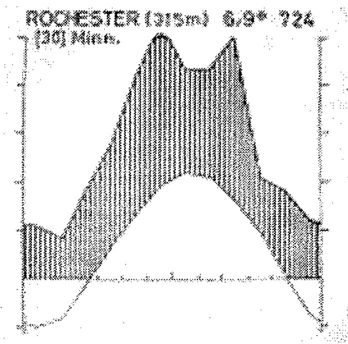
Appendix 2 Climate graphs of some areas in Minnesota

A. Humid with cold season type of climate (VI)

VI 1a

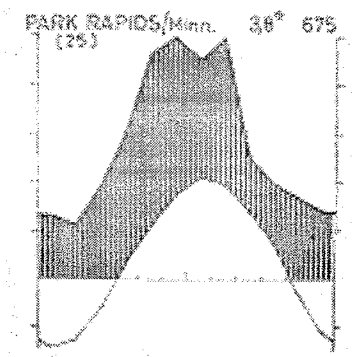


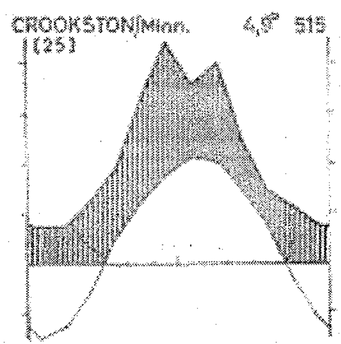


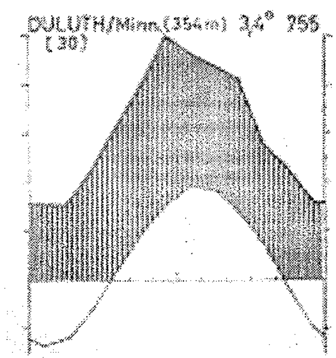


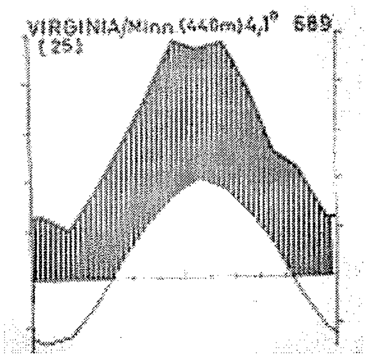
B. Humid with cold season type of climate (VI) (with some characteristics of the boreal type of climate (XIII))

VI (VIII) 1a









Legend

The climate graphs have been taken from Walter and Lieth (1967).
The x-axis shows the months. The left y-axis indicates the temperatures (¡C) and the right y-axis the precipitation in mm.
The top curve represents the mean monthly rainfall. The lower curve is the mean monthly temperature (the ratio is 10¡C =20mm rain). The vertical lines between the two curves indicate a period of humidity. On some diagrams (i.e. Brno and Venice), a partial second rainfall curve is drawn with a ratio of 10¡C= 30 mm rain. The area filled with dashes indicates a period of drought (e.g. Venice). The black horizontal bar (e.g. Basel) indicates the months with a mean lowest daily temperature < 0 ¡C. The horizontal bar with black stripes shows the months with the absolute minimum temperature < 0¡C.

For example, on the Basel graph: 30-77 indicates the period of observations in years (30 years of observation for the temperature and 77 years of observations for rainfall); —2.2is the mean lowest daily temperature of the coldest month (¡C);
-24.0 is the absolute lowest temperature (¡C);
10.1 ¡C is the mean annual temperature;
815 is the mean annual rainfall in mm;
Similarly, on the graph for La Chaux-de-Fonds, 125 is the number of days with a mean daily temperature above 10¡C.

Walter and Lieth (1967) have divided the world climate in several types:

IV is a Mediterranean type of climate with winter rains
V is a warm-temperate and humid type of climate
VI is a humid with cold season type of climate
VII is an arid with cold season type of climate
VIII is a boreal type of climate
X is a mountain type of climate

Appendix 3. Collection sites of and relative abundance of buckthorn specialist insects (2002-2003)

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
D2: Uchte	D	*F. alnus*	*Ancylis apicella*	rare	52¡28.726	08¡48.851	36	clear forest	Bielefeld
			A. derasana	rare					
D3: Teuteburger Wald	D	*F. alnus*	-		51¡58.844	08¡35.030	200	forest margin	Bielefeld
D6: Stukenbrock	D	*F. alnus*	*Ancylis derasana*	rare	51¡53.433	08¡40.689	104	clear forest	Bielefed
			Zygina suavis	x					
D7: Steinhagen	D	*F. alnus*	-		52¡00.635	08¡23.148	108	clear forest	Bielefeld
D8: Zienken	D	*F. alnus*	*Ancylis apicella*	x	47¡50.676'	07¡34.308'	160	forest margin	Basel
			A. derasana	x					
			Bucculatrix frangutella	rare					
			Gonepteryx rhamni	x					
		R. cathartica	*Ancylis apicella*	xx					
			A. derasana	rare					
			Bucculatrix frangutella	rare					
			Cacopsylla rhamnicola	xx					
			Philereme transversata	rare					
			Trichochermes walkeri	xxx					
			Trioza rhamni	xxx					
			Triphosa dubitata	rare					
D9: Muenstertal-Neuhausen	D	*F. alnus*	*Gonepteryx rhamni*	xx	47¡48.613'	07¡47.282'	670	thicket	H chenschwand
D10: Muenstertal	D	*F. alnus*	*Gonepteryx rhamni*	xx	47¡48.655'	07¡46.924'	700	forest margin	H chenschwand
D11: Hinterzarten-reserve	D	*F. alnus*	-				800	clear forest	H chenschwand
D12: Hinterzarten	D	*F. alnus*	-		47¡54.978'	08¡05.489'	864	forest margin	H chenschwand
D13: Hinterzarten- forest	D	*F. alnus*	*Ancylis apicella*	xx	47¡55.107'	08¡05.305'	878	forest margin	H chenschwand
			Bucculatrix frangutella	xx					
			Gonepteryx rhamni	x					
D14: Hinterzarten- parking	D	*F. alnus*	*Ancylis sp.*	rare	47¡58.931'	07¡43.074'	830	clear forest	H chenschwand
			Bucculatrix frangutella ?	x					

Location	Country [1]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
D15: Loeffingen- road	D	*R. cathartica*	*Cacopsylla rhamnicolla*	x	47¡53.499'	08¡21.399'	771	hedge	Donaueschingen
			Trichochermes walkeri	x					
			Trioza rhamni	x					
			Triphosa dubitata	x					
D16: Loeffingen	D	*R. cathartica*	*Trichochermes walkeri*	x	47¡53.461'	08¡21.771'	776	hedge	Donaueschingen
D17: Doeggingen	D	*F. alnus*	*Gonepteryx rhamni*	xx	47¡53.332'	08¡25.275'	655	forest	H chenschwand
D18: Koenigsfeld	D	*F. alnus*	*Bucculatrix frangutella ?*	rare	48¡08.785'	08¡25.412'	730	clear forest	H chenschwand
			Gonepteryx rhamni	rare					
			Zygina suavis	xx					
D19: Lauterbach	D	*F. alnus*	*Ancylis apicella*	rare	48¡15.126'	08¡17.969'	770	forest margin	H chenschwand
			Bucculatrix frangutella	xx					
			Gonepteryx rhamni	x					
			Zygina suavis	x					
D20: Griessheim	D	*R. cathartica*	*Ancylis apicella*	x	47¡52.608'	07¡34.551'	205	forest margin	Basel
			A. derasana	x					
			Bucculatrix frangutella	rare					
			Calybites quadrisignella	rare					
			Gonepteryx rhamni	rare					
			Philereme vetulata	rare					
			P. transversata	rare					
			Stigmella rhamnella	x					
			Trichochermes walkeri	xxx					
			Trioza rhamni	xx					
I1: Lido di Classe	I	*F. alnus*	*Oberea pedemontana*	xx	44¡21.410'	12¡19.139'	0	clear forest	Venice
		R. cathartica	*Oberea pedemontana*	xx					
I2: Pineta di Classe	I	*F. alnus*	*Ancylis apicella*	rare ?	44¡20.418'	12¡16.701'	0	clear forest	Venice
			Ancylis derasana ?	rare ?					
			Gonopyteryx rhamni	x					
			Oberea pedemontana	xx					

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
		R. cathartica	*Oberea pedemontana*	x					
A1: Purgstall	A	*R. cathartica*	*Ancylis apicella*	rare ?	48¡05.171	15¡08.372'	179	forest margin	Scheibbs
			Sorhagenia janiszewskae	xx					
			Trichochermes walkeri	xx					
			Trioza rhamni	xx					
			Triphosa dubitata	rare					
A2: Handhab	A	*F. alnus*	--		47¡53.246'	15¡00.234'	690	isolated tree	Scheibbs
		R. cathartica	*Trichochermes walkeri*	x					
			Trioza rhamni	xx					
A3: Kienberg	A	*R. cathartica*	*Bucculatrix frangutella*	rare ?	47¡56.743'	15¡07.793'	381	thicket	Scheibbs
			Sorhagenia janiszewskae	x					
			Trichochermes walkeri	x					
			Trioza rhamni	x					
			Triphosa dubitata	xx					
A5: Bad Fischau	A	*R. cathartica*	*Aceria annulata ?*	x	47¡49.498'	16¡08.703'	308	hedge	Wienerneustadt
			Sorhagenia janiszewskae	xx					
			Trichochermes walkeri	xx					
			Trioza rhamni	x					
			Triphosa dubitata	xx					
		R. saxatilis	*Stigmella sp.*	xx					
A6: Bad Fischau/Brunn	A	*R. saxatilis*	*Stigmella sp.*	xx	47¡49.664'	16¡08.002'	362	other	Wienerneustadt
A7: Bad Fischau- forest	A	*R. cathartica*	*Aceria annulata ?*	xx	47¡50.054'	16¡09.608'	340	forest	Wienerneustadt
			Trichochermes walkeri	x					
A8: Malleithenberg	A	*R. cathartica*	*Sorhagenia janiszewskae*	x	47¡51.095'	16¡08.257'	534	clear forest	Wienerneustadt
			Trichochermes walkeri	x					
			Trioza rhamni	x					
		R. saxatilis	--						
A9: Bergland/Kendl	A	*F. alnus*	--		48¡08.883'	15¡10.346'	235	forest margin	Melk
A10: Maria Taferl	A	*R.cathartica*	*Trichochermes walkeri*	xx	48¡13.328'	15¡09.461'	364	hedge	Melk

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
			Trioza rhamni	x					
A11: Hof	A	*R. cathartica*	*Trichochermes walkeri*	x	48¡17.963'	15¡21.750'	526	hedge	Melk
			Trioza rhamni	x					
			Triphosa dubitata	xx					
A12: Jauerling	A	*R. cathartica*	*Trichochermes walkeri*	x	48¡20.099'	15¡20.785'	853	forest margin	Gutenbrunn
			Trioza rhamni	x					
			Triphosa dubitata	xxx					
A13: Tausendblum	A	*F. alnus*	*Sorhagenia janiszewskae*	xx	48¡11.755'	15¡52.953'	284	forest margin	St-Polten
A14: Alland	A	*R. cathartica*	*Trichochermes walkeri*	x	48¡04.848'	16¡02.813'	363	thicket	Wolfsgraben
A15: Siegenfeld	A	*R. cathartica*	*Trichochermes walkeri*	xx	48¡02.320'	16¡11.693'	395	forest margin	Wolfsgraben
			Triphosa dubitata	xx					
A16: Siegenfeld/Rosenthal	A	*R. cathartica*	*Aceria annulata ?*	x	44¡01.925'	16¡10.625'	344	hedge	Wolfsgraben
			Cacopsylla rhamnicolla	xx					
			Sorhagenia janiszewskae	xx					
			Trichochermes walkeri	xx					
			Trioza rhamni	x					
			Triphosa dubitata	rare					
A17: Traiskirchen	A	*R. cathartica*	*Aceria annulata ?*	xx	48¡00.456'	16¡17.835'	218	forest	Wienerneustadt
			Ancylis derasana	x					
			Sorhagenia janiszewskae	xx					
			Trichochermes walkeri	xx					
			Trioza rhamni	x					
			Triphosa dubitata	rare					
A18: Trumau	A	*R. cathartica*	--					forest margin	Wienerneustadt
A19: Oberwaltersdorf	A	*F. alnus*	*Sorhagenia janiszewskae*	xx	47¡57.730'	16¡20.991'	217	thicket	Wienerneustadt
		R. cathartica	*Aceria annulata ?*	x					
			Ancylis derasana	rare					
			Calybites quadrisignella	rare					
			Sorhagenia janiszewskae	xxx					

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
			Trichochermes walkeri	x					
			Trioza rhamni	xxx					
			Triphosa dubitata	rare					
A20: Wimpassing	A	*R. cathartica*	*Aceria annulata ?*	x	47¡54.701'	16¡26.407'	252	hedge	Wienerneustadt
			Sorhagenia janiszewskae	x					
			Trioza rhamni	x					
A21: Unterwaltersdorf- river	A	*R. cathartica*	*Aceria annulata ?*	xx	47¡56.240'	16¡25.684'	223	isolated tree	Wienerneustadt
			Ancylis apicella	rare					
			A. derasana	x					
			Calybites quadrisignella	x					
			Sorhagenia janiszewskae	x					
			Trichochermes walkeri	x					
			Trioza rhamni	x					
A22: Unterwaltersdorf	A	*R. cathartica*	*Sorhagenia janiszewskae*	x	47¡57.577'	16¡29.794'	217	forest margin	Wienerneustadt
			Trioza rhamni	x					
A23: Seibersdorf- forest	A	*F. alnus*	*Ancylis apicella*	x	47¡57.146'	16¡31.992'	223	clear forest	Wienerneustadt
			Sorhagenia janiszewskae	x					
A24: Seibersdorf- field	A	*F. alnus*	*Sorhagenia janiszewskae*	xx	47¡57.415'	16¡31.965'	223	hedge	Wienerneustadt
A25: Purbach	A	*R. cathartica*	*Ancylis derasana*	rare	47¡55.182'	16¡40.608'	160	hedge	Wienerneustadt
			Philereme vetulata	xxx					
			Sorhagenia janiszewskae	xx					
			Trichochermes walkeri	x					
			Trioza rhamni	x					
			Triphosa dubitata	rare					
A26/27: St. Margarethen	A	*R. cathartica*	*Sorhagenia janiszewskae*	x	47¡48.276'	16¡37.790'	176	other	Wienerneustadt
			Trichochermes walkeri	x					
			Trioza rhamni	xx					
			Triphosa dubitata	Rare					
		R. saxatilis	-						

Location	Country [1]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
A30: Oberwaltersdorf	A	*R. cathartica*	*Sorhagenia janiszewskae*	xx	47¡57.780'	16¡21.393'	208	forest margin	Wienerneustadt
			Trichochermes walkeri	x					
A31: Maria Ponsee	A	*R. cathartica*	*Trichochermes walkeri*	x				forest margin	Tuln
			Trioza rhamni	xxx					
A32: Loiwein	A	*R. cathartica*	*Triphosa dubitata*	xx			600	hedge	Zwettl
A33: Rastenberg	A	*F. alnus*	*Gonepteryx rhamni*	xxx	48¡33.491'	15¡19.248'	531	forest	Zwettl
			Sorhagenia janiszewskae	x					
A34: Brand	A	*F. alnus*	--		48¡32.069'	15¡18.453'	650	forest margin	Zwettl
		R. cathartica	*Trichochermes walkeri*	xx					
			Trioza rhamni	x					
A35: Zwettl	A	*F. alnus*	*Gonepteryx rhamni*	x	48¡33.468'	15¡06.147'	666	clear forest	Zwettl
			Sorhagenia janiszewskae	x					
			Zygina suavis	x					
		R. cathartica	*Philereme vetulata*	xxx					
			Trichochermes walkeri	rare					
			Trioza rhamni	xx					
A36: Stierberg	A	*F. alnus*	--					forest margin	Wurmbrand
A37: Nondorf	A	*F. alnus*	*Gonepteryx rhamni*	x	48¡36.945'	14¡52.753'	741	hedge	Wurmbrand
			Sorhagenia janiszewskae	x					
		R. cathartica	*Philereme vetulata*	x					
			Trichochermes walkeri	xx					
			Trioza rhamni	xx					
A38: Wetzles	A	*F. alnus*	*Gonepteryx rhamni*	x	48¡41.014'	14¡57.667'	614	hedge	Wertra
		R. cathartica	*Philereme vetulata*	xx					
			Trichochermes walkeri	x					
			Trioza rhamni	x					
A39: Woermshart	A	*F. alnus*	*Gonepteryx rhamni*	rare	48¡40.878'	14¡58.439'	662	hedge	Wertra
		R. cathartica	*Gonepteryx rhamni*	rare					
			Philereme vetulata	xx					

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
			Trichochermes walkeri	x					
			Trioza rhamni	x					
A40: Jagenbach	A	*F. alnus*	*Ancylis apicella*	rare	48¡38.784'	15¡02.431'	660	forest margin	Wertra
			Gonepteryx rhamni	x					
A41: Klein Eberharts	A	*F. alnus*	--				550	forest margin	Dobersberg
A42: Pfingstbuehel	A	*F. alnus*	*Gonepteryx rhamni*	x			600	forest	Dobersberg
A43: Speisendorf	A	*F. alnus*	*Gonepteryx rhamni*	x			460	forest margin	Dobersberg
A44: Aigen	A	*F. alnus*	--					forest margin	Dobersberg
		R. cathartica	*Gonepteryx rhamni*	x					
			Trichochermes walkeri	x					
			Trioza rhamni	x					
A45: Sieghartsreith	A	*F. alnus*	--					hedge	Dobersberg
		R. cathartica	*Trichochermes walkeri*	x					
			Trioza rhamni	x					
CH1: Allondon	CH	*R. cathartica*	*Cacopsylla rhamnicola*	xx	46¡13.195'	05¡59.897'	429	forest margin	Geneva
			Philereme transversata	rare					
			P. vetulata	xxx					
			Trichochermes walkeri	x					
			Trioza rhamni	xx					
			Triphosa dubitata	rare					
CH2: Bossy/La Batie	CH	*F. alnus*	*Gonepteryx rhamni*	rare	46¡17.559'	06¡07.381'	455	clear forest	Geneva
			Sorhagenia janiszewskae	xxx					
CH3: Satigny	CH	*F. alnus*	*Gonepteryx rhamni*	x	46¡12.258'	06¡02.833'	437	clear forest	Geneva
			Sorhagenia janiszewskae	xxx					
		R. cathartica	*Gonepteryx rhamni*	xx					
			Philereme transversata	x					
			P. vetulata	xx					
			Sorhagenia janiszewskae?	rare					
			Trichochermes walkeri	xx					

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
			Trioza rhamni	xx					
			Triphosa dubitata	xxx					
CH4: Collet	CH	*F. alnus*	*Ancylis sp.*	x	46¡16.819'	06¡07.873'	336	clear forest	Geneva
			Sorhagenia janiszewskae	x					
CH5: Sauverny	CH	*F. alnus*	*Ancylis sp.*	x	46¡18.150'	06¡08.143'	385	forest margin	Geneva
			Gonepteryx rhamni	x					
			Sorhagenia janiszewskae	x					
CH13: Jussy	CH	*F. alnus*	*Gonepteryx rhamni*	xx				forest	Geneva
			Philereme vetulata	rare					
			Sorhagenia janiszewskae	xxx					
		R. cathartica	*Gonepteryx rhamni*	xx					
			Philereme vetulata	xxx					
			Triphosa dubitata	xx					
			Trichochermes walkeri	xx					
CH6: Chatillon	CH	*F. alpina*	*Ancylis apicella*	rare	47¡18.977'	07¡21.008'	929	clear forest	La Chaux de F.
			Bucculatrix frangutella	xxx					
			Caleptrimerus rhamni ?	xx					
			Gonepteryx rhamni	rare					
			Sorhagenia janiszewskae ?	xx					
			Stigmella rhamnella	x					
			Triphosa dubitata	x					
CH7: La Combe-lake	CH	*F. alnus*	*Zygina suavis*	xxx	47¡16.774'	07¡05.153'	880	forest margin	La Chaux de F.
		R. cathartica	*Trichochermes walkeri*	xxx					
			Trioza rhamni	x					
			Triphosa dubitata	x					
CH8: La Combe-farm	CH	*R. alpina*	*Bucculatrix frangutella*	xxx	47¡17.343'	07¡06.148'	864	clear forest	La Chaux de F.
			Gonepteryx rhamni	x					
			Triphosa dubitata ?	x					
		R. cathartica	*Bucculatrix frangutella*	xx					

Location	Country [1)]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
			Trioza rhamni	x					
			Triphosa dubitata	rare					
CH10: Delemont-Courroux	CH	*R. cathartica*	*Bucculatrix frangutella*	x				hedge	Del mont
			Sorhagenia janiszewskae ?	rare					
			Stigmella sp.	x					
			Trichochermes walkeri	xxx					
			Trioza rhamni	x					
			Triphosa dubitata	x					
CH11: Delemont- nord	CH	*R. cathartica*	*Cacopsylla rhamnicola*	xx				hedge	Del mont
			Gonepteryx rhamni	x					
			Trichochermes walkeri	xxx					
			Trioza rhamni	x					
			Triphosa dubitata	xx					
CH12: Del mont- CABI	CH	*F. alnus*	*Gonepteryx rhamni*	xx				other	Del mont
		R. cathartica	*Gonepteryx rhamni*	xx					
			Philereme vetulata	x					
			Triphosa dubitata	rare					
CZ1: Otnice	CZ	*R. cathartica*	*Ancylis apicella*	rare	49¡04.933'	16¡49.479'	179	hedge	Brno
			Stigmella catharticella	rare					
			Trichochermes walkeri	x					
			Trioza rhamni	x					
CZ2: Hardy	CZ	*R. cathartica*	*Trichochermes walkeri*	x	49¡12.756'	16¡40.124'	230	hedge	Dobersberg
			Trioza rhamni	x					
CZ3: Jedovnice	CZ	*F. alnus*	*Ancylis sp.*	x	49¡19.637'	16¡44.222'	417	forest margin	Dobersberg
			Gonepteryx rhamni	rare					
CZ4: Vielemovice	CZ	*R. cathartica*	*Trichochermes walkeri*	x	49¡22.211'	16¡44.279'	392	hedge	Dobersberg
			Trioza rhamni	x					
			Triphosa dubitata	rare					
Belgrad	Serbia	*F. alnus*	*Oberea pedemontana*	xx					

Location	Country [1]	*Plant species*	Insect species	Relative abundance	Latitude	Longitude	Elevation (meter)	Habitat	Climate graph graph
		R. cathartica	*Ancylis apicella*	x					
			Ancylis derasana	xx					
			Calibytes quadrisignella	rare					
			Oberea pedemontana	xx					
			Synanthedon stomoxif.	x					
			Trichochermes walkeri	xx					
		R. saxatilis	*Stigmella sp.*	x					
		R. alpina	*Calepitrimerus rhamni*	xx					

Explanation of relative abundance*:

Rare - the number of specimens collected is less than 25% of the number of trees checked
x relatively uncommon - the number of specimens collected is between 25-75% of the number of trees checked
xx common - the number of specimens collected is – similar to the number of trees checked (75-125%)
xxx abundant - the number of specimens is much larger than the number of trees checked

1) Country codes:
A Austria
CH Switzerland
D Germany
Italy
CZ Czech Republic

Appendix 4: Collections and rearing of *Bucculatrix frangutella* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Switzerland	CH6	x	B	27 June 02	R. alpina	Adults	8	-	-	-
	CH6	x	B	3 July 02	R. alpina	Adults	4	-	-	-
	CH6	x	B	25 July 02	R. alpina	Larvae	40	Late Aug 02	25	29 May-6 June 03
	CH8	x	A	5 July 02	R. alpina	Adults	2	-	-	-
	CH8	x	A	8 Aug 02	R. alpina	Larvae	30	Early Sept 02	26	30 May — 6 June 03
	CH8	x	A	8 Aug 02	R. cath.	Larvae	10	Early Sept 02	7	2-3 June 03
Germany	D8	xxx	C	30 July 02	R. cath.	Larvae in leaf-mines	4	Late Aug 02	2	3-6 June 03
	D20	xxx	C	16 July 03	R. cath.	Larvae	3	Mid Aug 03		
Austria	A3	x	A	27 May 02	R. cath.	Adult	1	-	-	-
Germany	D13	x	B	23 July 02	F. alnus	Larvae	15	Late Aug	1	2 June 03
	D14	xx	B	23 July 02	F. alnus	Larvae	3	-	-	-
	D19	xxx	C	23 July 02	F. alnus	Larvae	20	Mid Aug 02	14	3-6 June 03
	D8	x	A	16 July 03	F. alnus	Larvae	1	28 Aug 03		

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 5: Collections and rearing of *Sorhagenia janiszewskae* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	No. shoot-tips collected	No. of adults emerged	Date of emergence	Date of shoot dissection	Results of dissection
Switzerland	CH6	x	B	27 June 02	*R. alpina*	27*	-	-	28 June 02	all mined, 2 dead larvae
Switzerland	CH3	x	B	16 May 02	*R. cath.*	1*	-	-	7 June 02	empty mine
	CH10	x	A	11 July 02	*R. cath.*	5*	-	-	7 June 02	5 empty mines
Austria	A1	xx	B	27 May 02	*R. cath.*	24	1	10 July 02	24 June / 2 July 02	19 shoots mined, 7 dead larvae
	A3	x	A	27 May 02	R. cath.	5	-	-	6 June 02	all mined, empty
	A8	x	A	27 May 02	*R. cath.*	6	-	-	24 June 02	4 shoots mined, 2 dead larvae
	A5	x	A	28 May 02	*R. cath.*	12	-	-	24 June 02	6 shoots mined, 1 dead larva
	A26/27	x	A	2 June 02	*R. cath.*	5	1	7 July 02	6 June 02	3 living larvae
	A16	x	A	30 May 02	*R. cath.*	20	4	2-9 July 02	28 June / 2 July 02	Shoots all mined, empty
	A21	x	B	30 May 02	R. cath.	5	-	-	25 June 02	shoots all mined, empty
	A19	xxx	C	31 May 02	*R. cath.*	100	-	-		
	A17	x	B	31 May 02	R. cath.	7	-	-	24 June 02	5 shoots mined, 4 dead larvae
	A16	x	A	16 May 03	*R. cath.*	20	5	20-23 June 03	-	

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	No. shoot-tips collected	No. of adults emerged	Date of emergence	Date of shoot dissection	Results of dissection
	A17	x	B	16 May 03	*R. cath.*	50	27	17-23 June 03	-	
	A19	xxx	C	17 May 03	*R. cath.*	100	77	17-30 June 03	-	
	A25	x	B	17 May 03	*R. cath.*	30	16	17-24 June 03	-	
	A30	xxx	C	17 May 03	*R. cath.*					
Switzerland	CH3	xxx	D	16 May 02	*F. alnus*	50	21	25-27 June 02	22 May/ 10 June 02	3 living larvae, 1 dead larva, 12 empty mines
	CH3	xxx	D	19 June 02	*F. alnus*	75	-	-	28 June / 2 July 02	68shoots mined, 6 dead larvae
	CH2	xxx	D	20 June 02	*F. alnus*	16	-	-	2 July 02	14 shoots mined, 2 dead larvae
	CH4	x	A	20 June 02	*F. alnus*	9	-	-	21 June 02	8 shoots mined, 1 living larva
	CH5	x	A	20 June 02	*F. alnus*	10	-	-	1 July 02	all mined, 2 dead larvae
	CH2	xxx	C	28 April 03	*F. alnus*	10	-	-	-	
	CH3	x	B	29 April 03	*F. alnus*	40	1	17 June 03	-	
	CH2	xxx	D	12 May 03	*F. alnus*	130	82	16-30 June 03	-	
	CH3	xxx	D	12 May 03	*F. alnus*	140	56	20-27 June 03	-	
	CH13	xx	C	13 May 03	*F. alnus*	80	38	22 June-4 July 03	-	-

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	No. shoot-tips collected	No. of adults emerged	Date of emergence	Date of shoot dissection	Results of dissection
Austria	A13	x	A	30 May 02	*F. alnus*	35	9	4-7 July 02	25 June 02	31 shoots mined, 3 dead larvae
	A19	x	A	31 May 02	*F. alnus*	8	3	7 July 02	-	-
	A23	x	A	1 June 02	*F. alnus*	12	10	7-12 July 02	25 June 02	all mines empty
	A24	x	A	1 June 02	*F. alnus*	20	-	-	-	-
	A33	x	A	18 May 03	*F. alnus*	10	1	23 June 03	-	-
	A35	xxx	D	19 May 03	*F. alnus*	50	-	-	-	-

* The occurrence of *Sorhagenia janiszewskae* needs to be confirmed in these sites

Appendix 6: Collections and rearing of *Calybites quadrisignella* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Austria	A19	xxx	D	31 May 02	R. cath.	Larvae	4	20-23 June 02	3	2-22 July 02
	A21	x	B	1 June 02	R. cath.	Larvae	5	20-22 June 02	3	4-22 July 02
Germany	D20	xxx	D	26 June 02	R. cath.	Larvae	4	< 19 Sept 02	2	26 May 03

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 7: Collections and rearing of *Stigmella* spp. in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. leaf-mines collected	Date of pupation	No. of adults emerged	Date of adult emerge
Switzerland	CH6	x	A	25 June	R. alpina	Leaf-mines	3	-	1 *S. rhamnella*	16 Aug 0
Switzerland	CH6	x	A	3 July 02	R. alpina	Leaf-mines	1	-	1 *S. rhamnella*	4 Aug 02
Switzerland	CH10	x	A	11 June 02	R. cath.	Empty leaf-mines (*S. catharticella* ?)	4	-	-	-
Germany	D20	xxx	D	8 June 02	R. cath.	Mostly empty leaf-mines	13	10 July 02	1 S. *rhamnella*	10 Aug 0
Czech Rep	CZ1	xx	C	21 May 03	R. cath.	Leaf-mines (*S. catharticella*)	1	-	-	-
Austria	A6	x	A	28 May 02	R. saxatilis	Empty leaf-mines (*S. catharticella* ?)	3	-	-	-
Austria	A5	x	A	28 May 02	*R. saxatilis*	Empty leaf-mines (*S. catharticella* ?)	1	-	-	-

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 8: Collections and rearing of *Gonepteryx rhamni* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Adult emergence
Switzerland	CH6	x	B	27 June 02	R. alpina	Larvae	2	-	-	-
	CH8	x	A	27 June 02	R. alpina	Larvae	2	-	-	-
Switzerland	CH12	x	A	24 April 03	R. cath.	Eggs/larvae	12	-	1	13 June 03
	CH11	X	A	25 April 03	R. cath.	Eggs/larvae				
	CH3	x	A	29 April 03	R. cath.	Larvae	5	2-3 June 03	2	16 June 03
	CH13	x	B	30 April 03	R. cath.	Eggs	5	-	-	-
Austria	A39	x	B	19 May 03	R. cath.	Larvae	1	-	-	-
	A44	x	A	20 May 03	R. cath.	Larvae	1	-	-	-
Germany	D20	xx	C	23 April 03	R. cath.	Eggs	2	2 June 03	1	16 June 03
Switzerland	CH12	x	A	14 May 02	F. alnus	Larvae	8	-	-	-
	CH12	x	A	24 April 03	F. alnus	Larvae	1	13 June 03	1	26 June 03
	CH2	xxx	C	28 April 03	F. alnus	Larvae	2	28 May 03	2	11 June 03
	CH5	x	A	28 April 03	F. alnus	Larvae	1	-	-	-
	CH3	x	B	29 April 03	F. alnus	Larvae	2	9-12 June 03	2	16-24 June 03
	CH13	x	B	30 April 03	F. alnus	Larvae	9	10-11 June 03	3	24 June 03
	CH3	xxx	D	12 May 03	F. alnus	Larvae	2	-	-	-
Austria	A33	x	A	18 May 03	F. alnus	Larvae	8	17 June 03	1	3 July 03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Adult emergence
	A35	xxx	D	19 May 03	F. alnus	Larvae	6	-	-	-
	A40	xx	B	19 May 03	F. alnus	Larvae	3	-	-	-
	A42	xx	B	19 May 03	F. alnus	Larvae	3	13 June 03	1	26 June 03
Germany	D10	x	A	10 June 02	F. alnus	Larvae	14	20 June-3 July 03	8	2-17 July 02
	D9	x	A	12 June 02	F. alnus	Larvae	1	20 June 02	1	2 July 02
	D17	x	A	13 June 02	F. alnus	Larvae	1	24 June 02	1	15 July 02
	D18	xxx	D	13 June 02	F. alnus	Larvae	4	17-25 June 02	3	15-22 July 02
	D19	xxx	D	13 June 02	F. alnus	Larvae	6	20-25 June 02	6	5-10 July 02
	D13	x	A	23 July 02	F. alnus	Pupa	1	-	-	-
Italy	I2	xx	D	9 May 02	F. alnus	Larvae	4	6 June 02	2	22 June 02
Czech Rep	CZ3	xx	B	21 May 03	F. alnus	Larvae	2	13-17 June 03	2	26-30 June 02

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 9: Collections and rearing of *Philereme vetulata* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Switzerland	CH13	x	B	30 April 03	F. alnus	Larvae	1	8 May 03	1	2 June 03
Switzerland	CH12	x	A	14 May 02	R. cath.	Larvae	4	23 May — 3 June 02	3	14-18 June 02
	CH1	x	B	15 May 02	R. cath.	Larvae	29	Mid May-early June 02	22	10-18 June 02
	CH3	x	B	16 May 02	R. cath.	Larvae	3	Mid May-early June 02	3	22 May — 18 June 02
	CH1	x	B	29 April 03	R. cath.	Larvae	65	9-22 May 03	26	2-10 June 03
	CH3	x	A	29 April 03	R. cath.	Larvae	11	13-20 May	9	28 May — 7 June 03
	CH13	x	B	30 April 03	R. cath.	Larvae	31	8-20 May 03	23	30 May — 11 June 03
	CH3	x	A	12 May 03	R. cath.	Larvae	2	20 May 03	1	7 June 03
Austria	A25	xx	B	17 May 03	R. cath.	Empty leaf rolls	>20	-	-	-
	A35	x	A	19 May 03	R. cath.	Empty leaf rolls	>20	-	-	-
	A37	x	A	19 May 03	R. cath.	Larvae	1	Larva dead 6 June		
	A38	x	B	19 May 03	R. cath.	Larvae	11	26-28 May 03	10	10-12 June 03
	A39	x	B	19 May 03	R.cath.	Larvae	14	26-29 May 03	14	10-12 June 03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Germany	D20	xx	C	23 April 03	R. cath.	Larvae	1	14 May 03	1	10 June 03

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Annex 10: Collections and rearing of *Philereme transversata* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Switzerland	CH3	x	C	16 May 02	R. cath.	Larvae/ pupae	2	6 June 02	2	19-21 June 03
	CH1	x	B	29 April 03	R. cath.	Larvae	1	8 May 03	1	5 June 03
Germany	D20	xxx	D	6 May 03	R. cath.	Larvae	1	12 May 03	1	7 June 03
	D8	xxx	D	6 May 03	R. cath.	Larvae	1	13 May 03	1	7 June 03

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 11: Collections and rearing of *Triphosa dubitata* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Switzerland	CH6	x	B	27 June 02	R. alpina	Larvae	5	12-22 July 02	2	12 Aug 02
	CH8	x	A	27 June 02	R. alpina	Larvae	8	-	-	-
	CH6	x	B	3 July 02	R. alpina	Larvae	2	Mid July 02	1	9 Aug 02
Switzerland	CH1	x	B	15 May 02	R. cath.	Larvae	2	Early June 02	2	26 June / 15 July 02
	CH3	x	B	16 May 02	R. cath.	Larvae	4	Late May 02	4	21-24 June 02
	CH10	x	A	14 June 02	R. cath.	Larvae	3	24 June-2 July 02	2	17-24 July 02
	CH1	x	B	19 June 02	R. cath.	Larvae	1	Mid July 02	1	12 August 02
	CH7	x	A	27 June 02	R. cath.	Larvae	3	Mid July 02	1	9 Aug 02
	CH8	x	A	27 June 02	R. cath.	Larvae	1	Mid July 02	1	12 Aug 02
	CH11	x	A	25 April 03	R. cath.	Eggs	3	22 May-10 June 03	3	11 June-3 July 03
	CH12	x	A	24 April 03	R. cath.	Larvae	1	Early June 03	1	27 June 03
	CH3	x	A	29 April 03	R. cath.	Eggs/larvae	22	22 May-9 June 03	17	10-18 June 03
	CH13	x	B	30 April 03	R. cath.	Larvae	4	26 May-9 June 03	4	13-27 June 03
	CH3	x	A	12 May 03	R. cath.	Larvae	19	20 May-2 June 03	10	12-18 June 03
Austria	A1	xx	B	27 May 02	R. cath.	Larvae	3	6 June 02	1	1 July 02

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
	A3	x	A	27 May 02	R. cath.	Larvae	5	11-17 June 02	2	26 June-3 July 02
	A5	x	A	28 May 02	R. cath.	Larvae	5	6-10 June 02	5	20 June-1 July 03
	A11	x	A	29 May 02	R. cath.	Larvae	3	10 June 02	2	1-4 July 02
	A12	x	A	29 May 02	R. cath.	Larvae	6	17 June 02	1	5 July 02
	A16	x	A	30 May 02	R. cath.	Larvae	1	4 June 02	1	24 June 02
	A19	xxx	C	31 May 02	R. cath.	Larvae	1	17 June 02	1	7 July 03
	A25	x	B	1 June 02	R. cath.	Larvae	1	24 June 02	1	15 July 02
	A15	x	A	16 May 03	R. cath.	Larvae	2	26 May 03	2	13 June 03
	A16	x	A	16 May 03	R. cath.	Larvae	1	26 May 03	1	16 June 03
	A17	x	B	16 May 03	R. cath.	Larvae	1	30 May 03	1	16 June 03
	A19	xxx	D	17 May 03	R.cath.	Larvae	2	28-31 May 03	2	12-20 June 03
	A25	x	B	17 May 03	R. cath.	Larvae	1	28 May 03	1	13 June 03
	A26/27	x	A	17 May 03	R. cath.	Larvae	1	28 May 03	1	10 June 03
	A32	x	A	18 May 03	R. cath.	Larvae	4	3 June 03	1	20 June 03
	A5	x	A	18 May 03	R. cath.	Larvae	3	26-30 May 03	3	12-16 June 03
Germany	D8	xx	C	12 June 02	R. cath.	Larvae	3	Late June 02	1	22 July 02
	D15	x	A	13 June 02	R. cath.	Larvae	2	Late June 02	2	15 July-9 Aug 02
	D8	xxx	C	23 April 03	R. cath.	Eggs	2	26 May 03	1	13 June 03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
	D8	xxx	D	5 June 03	R. cath.	Larvae	2	11-16 May 03	2	27 June —3 July 03
Czech rep.	CZ4	x	B	21 May 03	R. cath	Larvae	2	9-12 June 03	2	25-30 June 03

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 12: Collections and rearing of *Ancylis apicella* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Switzerland	CH6	x	B	3 July 02	R. alpina	Larvae	2		1	26 May 03
Austria	A1	xx	B	27 May 02	R. cath.	Larvae	4	21 June 02	1	24 July 02
	A21	x	B	1 June 02	R. cath.	Larvae	1	18 June 02	1	24 June 02
Germany	D20	xxx	D	26 June 02	R. cath.	Larvae	7	15-20 July 02	6	26-29 July 02 / 16 May 03
	D20	xxx	B	8 July 02	R. cath.	Larvae	1	Mid July 02	1	1 Aug 02
	D20	xxx	D	6 May 03	R. cath.	Larvae	1	6 June 03	1	15 June 03
	D20	xxx	D	5 June 03	R. cath.	Larvae	12	13-26 June 03	7	24 June — 6 July 03
	D20	xxx	D	18 June 03	R. cath.	Larvae	2	30 June — 3 July 03	2	13-15 June 03
	D8	xxx	D	5 June 03	R. cath.	Larvae	17	18-24 June 03	10	30 June — 4 July 03
	D8	xxx	D	18 June 03	R. cath.	Larvae	10	30 June - 11 July	3	17 July — 9 Aug 03
	D8	xxx	B	16 July 03	R. cath.	Larvae	2	11-18 Aug 03	2	20-28 Aug 03
	D8	xxx	B	22 July 03	R. cath.	Larvae	1	7 Aug 03	1	18 Aug 03
	D8	xxx	B	8 Aug 03	R. cath	Larvae	1	20 Aug 03	1	3 Sept 03
Czech Rep	CZ1	xx	C	21 May 03	R. cath.	Larvae	3	3-6 June 03	3	11-16 June 03
Austria	A23	x	A	1 June 02	F. alnus	Larvae	3	11-15 June 02	2	23 June 02
	A40	xx	C	19 May 03	F. alnus	Larvae	1	12 June 03	1	23 June 03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Germany	D13	x	B	23 July 02	F. alnus	Larvae	10		1	28 May 03
	D19	xxx	D	13 June 02	F. alnus	Larvae	3	20-24 June 02	3	28 June — 11 July 02
	D2	xxx	D	9 July 03	F. alnus	Larvae	1	17 July 03	1	28 July 03
	D8	x	B	12 June 02	F. alnus	Larvae	2	2 July 02	1	18 July 02
	D8	x	B	5 June 03	F. alnus	Larvae	5	18-24 June 03	5	30 June — 4 July 03
	D8	x	B	18 June 03	F. alnus	Larvae	1	28 July	1	9 Aug 03

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 13: Collections and rearing of *Ancylis derasana* in 2002-03

Country	Site No.	No. of trees sampled	Time spent (h) (one person)	Collection Date	Host plant	Stage at collection	No. specimens collected	Date of pupation	No. of adults emerged	Date of adult emergence
Austria	A17	xx	C	31 May 02	R. cath.	Larvae	3	Mid June 02	2	25 June — 1July 02
	A19	xxx	D	31 May 02	R. cath.	Larvae	2	10 June 02	1	19 June 02
	A21	x	B	1 June 02	R. cath.	Larvae	7	18-20 June 02	1	26 June 02
	A25	xx	B	17 May 03	R. cath.	Larvae	1	3 June 03	1	12 June 03
Germany	D20	xxx	D	26 June 02	R. cath.	Larvae	6	20-25 July	3	1-9 Aug 02 / 26 May 03
	D20	xxx	B	8 July 02	R. cath.	Larvae	4	27 July / 12 Aug 02	2	4 Aug / 18 Aug 02
	D20	xxx	D	5 June 03	R. cath.	Larvae	5	26 June — 9 July 03	2	9-21 July 03
	D20	xxx	D	18 June 03	R. cath.	Larvae	7	12 July 03	2	21-22 July 03
	D20	xxx	B	16 July 03	R. cath.	Larvae	1	11 Aug 03	1	25 Aug 03
	D8	xxx	B	8 July 02	R. cath.	Larvae	3	Late July	2	7-12 Aug 02
	D8	x	B	18 June 03	F. alnus	Larvae	2	2-7 July 03	1	21 July 03
	D6	xxx	D	8 July 03	F. alnus	Pupa	1		1	22 July 03
	D2	xxx	D	9 July 03	F. alnus	Larvae	1	17 July 03	1	28 July 03

x	† 10 trees	A	< 1 h
xx	< 10 † 20 trees	B	1-2 h
x	> 20 trees	C	2-3 h
		D	> 3 h

Appendix 14: Collections and rearing of *Trichochermes walkeri* in 2002-03

Country	Site No.	Collection Date	Host plant	No. of galls collected	% L1	% L2	% L3	% L4	% of empty galls	No. of adults emerged	Date of adult emergence
Switzerland	CH3	19 June 02	R. cath.	30	21	58	21	-	-	-	-
	CH7	27 June 02	R. cath.	20	-	37	61	2	-	-	-
	CH10	11 July 02	R. cath.	30					-	-	-
	CH10	1 Aug 02	R. cath.	450					47	32	5-19 Aug 02
	CH11	1 Aug 02	R. cath.	500	-	-	55	45	38	37	5-19 Aug 02
	CH7	8 Aug 02	R. cath.	600					13	76	12-26 Aug 02
	CH7	19 Aug 02	R. cath.	450					53	80	20 Aug-2 Sept 02
	CH11	5 Sept. 02	R. cath.	No galls but 1 adult					100	-	-
	CH11	10 May 03	R. cath.	30	84	16	-	-	-		
	CH11	20 May 03	R. cath.	30	94	6	-	-	-		
	CH7	19 June 03	*R. cath.*	50					-	-	-
	CH11	13 Aug 03	*R. cath.*	25	-	-	-	100	76	-	-
Austria	A1	27 May 02	*R. cath.*	Small sample	89	11	-	-	-	-	-
	A5	27 May 02	R. cath.	Small sample	55	45	-	-	-	-	-
	A7	28 May 02	R. cath.	Small sample	70	30	-	-	-	-	-
Germany	D15	13 June 02	*R. cath.*	30					-	-	-
	D8	18 June 02	R. cath.	15	30	70	-	-	-	-	-
	D8	24 June 02	R. cath.	45	-	82	18	-	-	-	-
	D20	8 July 02	R. cath.	45					-	-	-

Country	Site No.	Collection Date	Host plant	No. of galls collected	% L1	% L2	% L3	% L4	% of empty galls	No. of adults emerged	Date of adult emergence
	D8	8 July 02	R. cath.	10	22	44	34	-	-	-	-
	D8	18 July 02	R. cath.	20	-	-	80	20	-	-	-
	D20	23 July 02	R. cath.	40	-	31	46	23	-	-	-
	D8	30 July 02	R. cath.	30	-	38	35	27	Few	-	-
	D8	7 Aug 02	R. cath.	1030					25	53	8-23 Aug 02
	D20	7 Aug 02	R. cath.	820					24	70	8-20 Aug 02
	D8	23 April 03	R. cath.	No galls present but eggs							
	D20	23 April 03	R. cath.	No galls present but eggs							
	D8	6 May 03	*R. cath.*		80	20	-	-	-		
	D20	6 May 03	*R. cath.*		84	16	-	-	-		
	D8	18 June 03	*R. cath.*		64	36	-	-	-		
	D20	18 June 03	*R. cath.*		21	71	8	-	-		
	D8	16 July 03	*R. cath.*		-	16	55	29	Not recorded	-	-
	D20	16 July 03	*R. cath.*		-	11	81	8	Not recorded	-	-
	D8	22 July 03	*R. cath.*	70	-	4	70	26	20		
	D8	22 July 03	R. cath.	400						-	-
	D20	22 July 03	*R. cath.*	70	-	-	54	46	29		
	D20	22 July 03	R. cath.	700						-	-
	D8	30 July 03	*R. cath.*	60	-	-	81	19	42		
	D8	30 July 03	R. cath.	500						2	5 Aug 03
	D20	30 July 03	*R. cath.*	90	-	-	78	22	33		
	D20	30 July 03	R. cath.	800						6	6-11 Aug 03

Country	Site No.	Collection Date	Host plant	No. of galls collected	% L1	% L2	% L3	% L4	% of empty galls	No. of adults emerged	Date of adult emergence
	D8	8 Aug 03	R. cath.	400						1	21 Aug 03
	D20	8 Aug 03	R. cath.	500						-	-
	D8	13 Aug 03	*R. cath.*	30	-	-	67	33	53		
	D8	13 Aug 03	R. cath.	400						-	-
	D20	13 Aug 03	*R. cath.*	30	-	-	25	75	57		
	D20	13 Aug 03	R. cath.	800						4	19-20 Aug 03

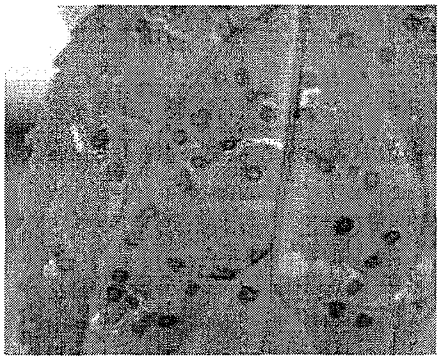
Appendix 15. Collections and rearing of *Trioza rhamni* in 2002

Country	Site No.	Collection Date	Host plant	No. specimens collected	Nymphal instar at collection time*	No. of adults emerged	Date of adult emergence
Switzerland	CH1	15 May	R. cath.	Small sample	Eggs and L1 nymphs	None	
	CH1	19 June	R. cath.	Small sample	100% L5	Not recorded	
	CH7	27 June	R. cath.	Small sample	16% L2 / 21% L3 / 5% L4 / 58% L5	Not recorded	
Austria	A1	27 May	R. cath.	Small sample	23 % L4 / 77% L5	None	
	A2	27 May	R. cath.	Small sample	8% L2 / 15% L3 / 23% L4 / 54% L5	None	
	A3	27 May	*R. cath.*	Small sample		Few	9-14 June
	A19	31 May	*R. cath.*	Small sample	Mostly mature nymphs	Few	9-14 June
Germany	D8	12 June	*R. cath.*	Mass collection (> 500)	Mostly mature nymphs	ca. 250	13-17 June
	D8	18 June	*R. cath.*	Mass collection (> 500)	Mostly mature nymphs	ca. 250	19-23 June
	D8	24 June	R. cath.	Small sample	Mostly mature nymphs	Not recorded	
	D20	26 June	*R. cath.*	Small sample	Mostly mature nymphs	Not recorded	

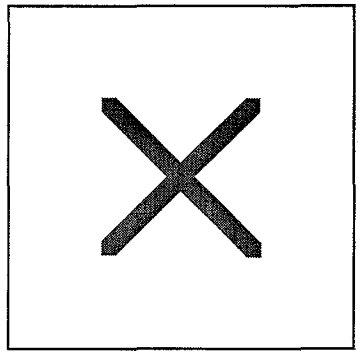
* Based on a small number of observations and measurements

Appendix 16

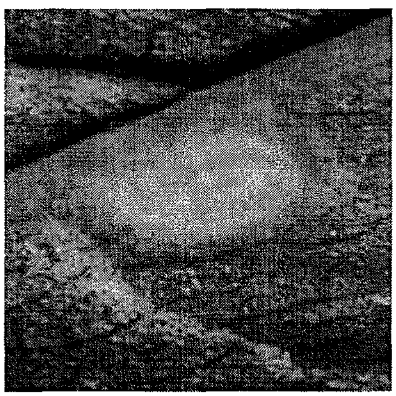
Bucculatrix frangutella



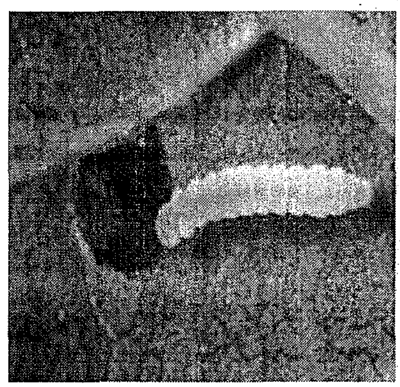
Leaf mines with L1



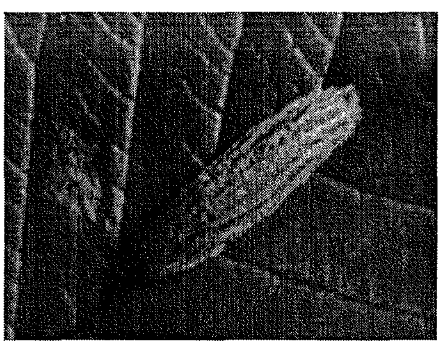
L2



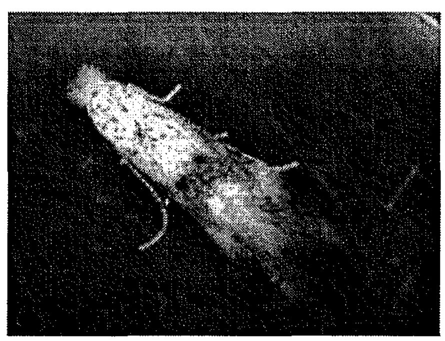
L2 (magnified)



Mature larva



Overwintering cocoon

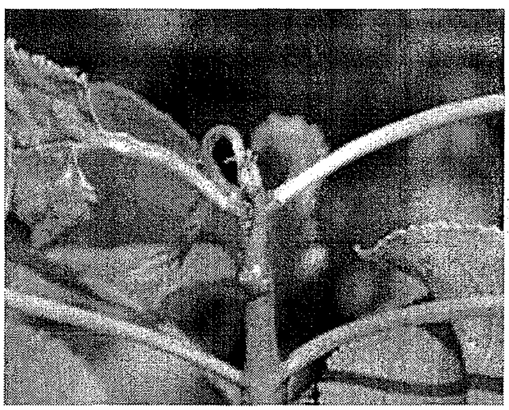


Adult

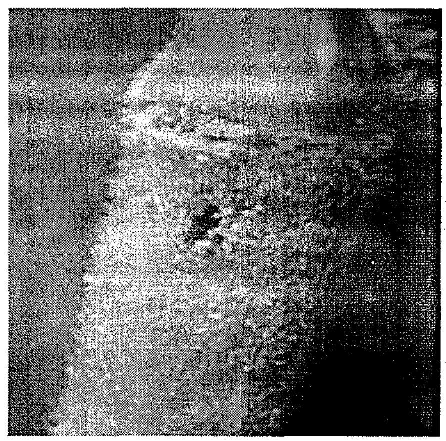
Sorhagenia janiszewskae

Mature larva in mine

Damaged bud



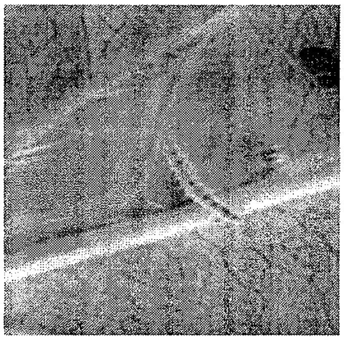
Damaged shoot-tip and larval exit hole



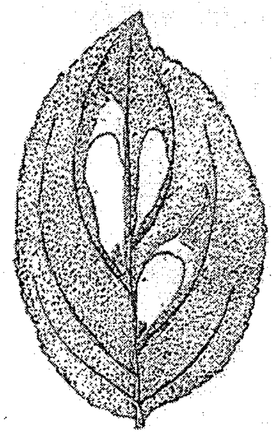
Larval exit hole

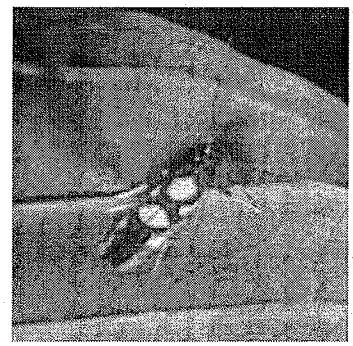
Adult

Calybites quadrisignella



Mature larva

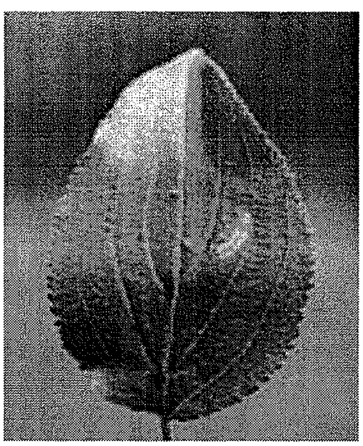


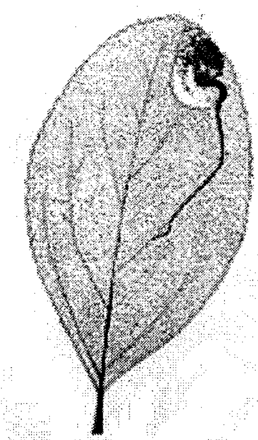


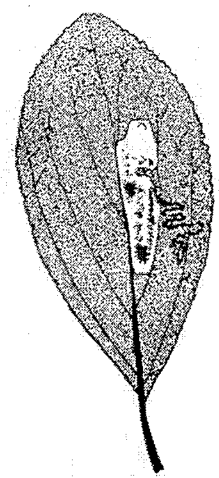
Adult

Leaf mines

Stigmella spp.







Leaf mines

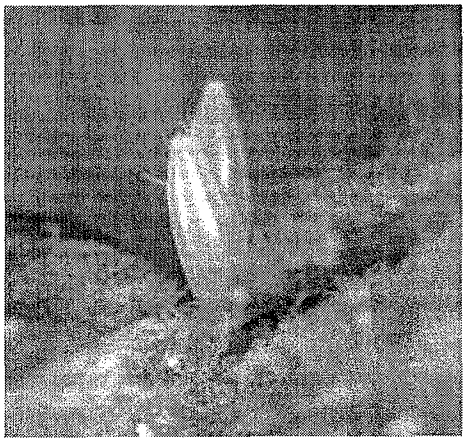
S. catharticella?

S. catharticella
Lastuvka & Lastuvka (1997)

S. rhamniella

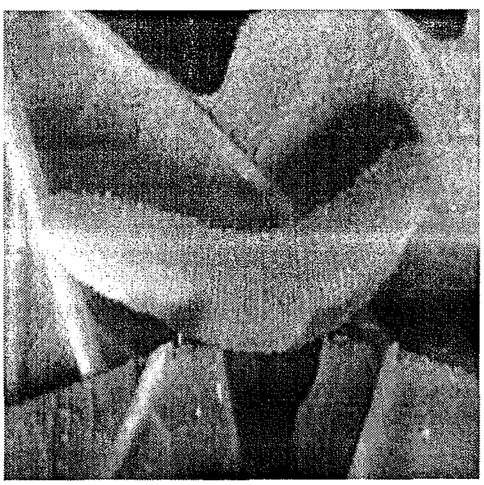
Appendix 19

Gonepteryx rhamni

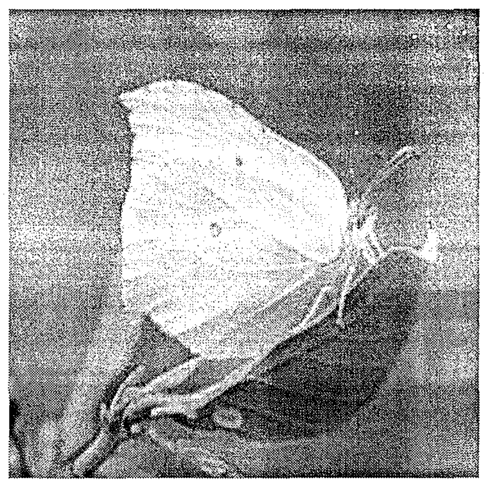


Eggs

Young larva



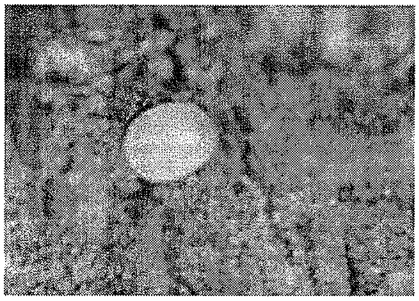
Mature larva



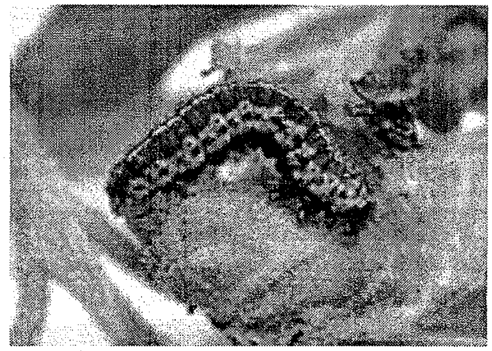
Adult

Appendix 20

Philereme vetulata

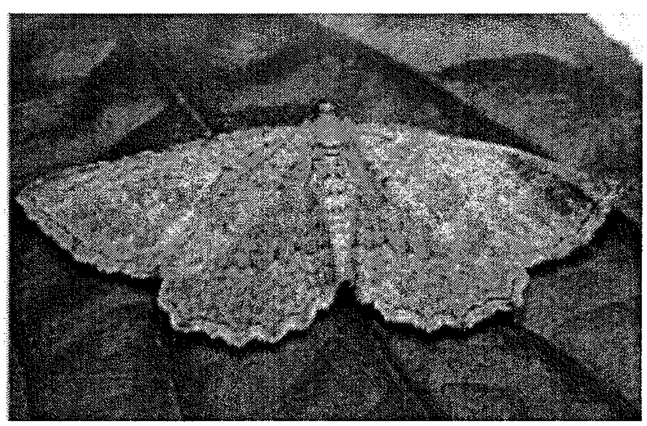


Egg



Mature larva

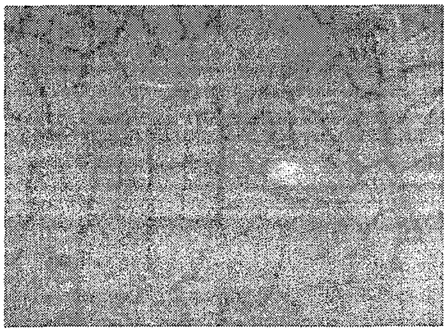
Leaf damage



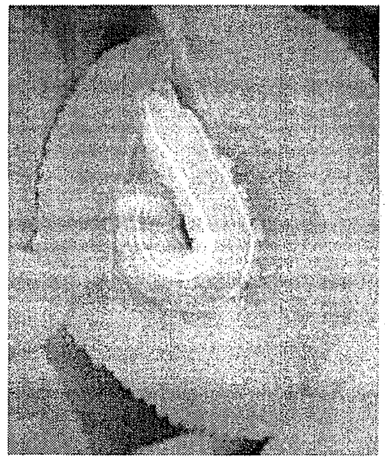
Adult

Appendix 21

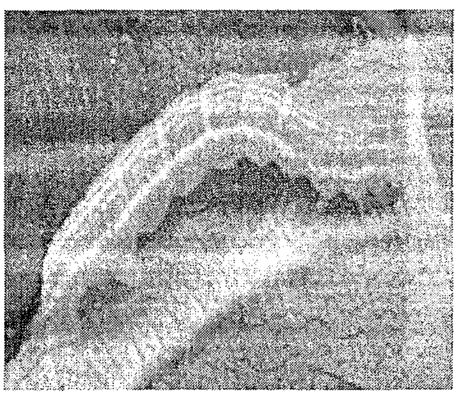
Triphosa dubitata



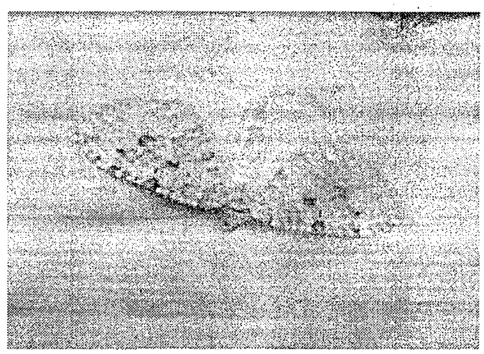
Egg



Medium-size larva



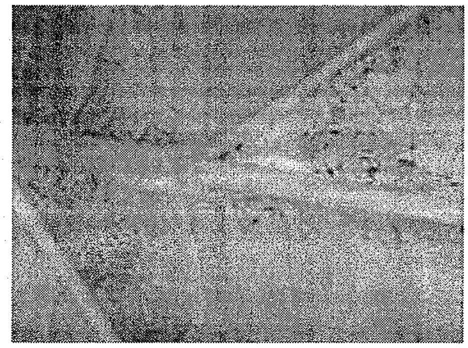
Mature larva



Adult

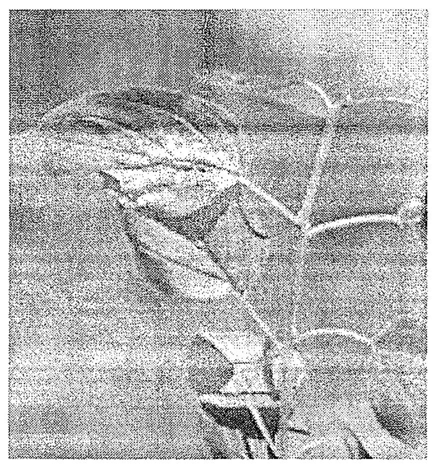
ppendix 22

Ancylis spp.



Young larvae

Mature larva



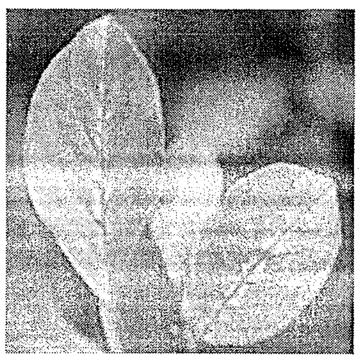
Leaf damage

Ancylis derasana

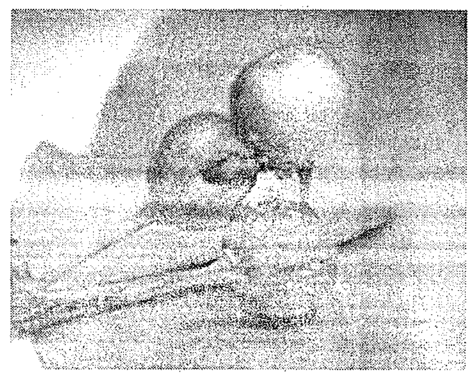
Appendix 23

Synanthedon stomoxoformis attracted by a pheromone lure

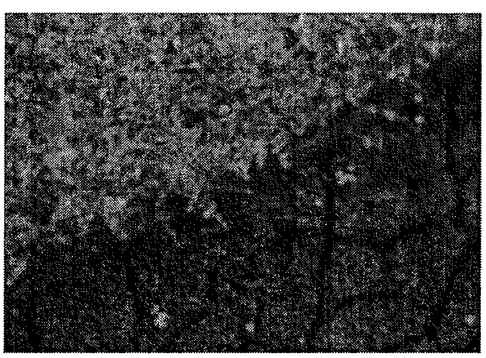
Zygina suavis



Damage by *Z. suavis* (°?) on *F. alnus*



Fruit damage of unknown origin (*F. alnus*)

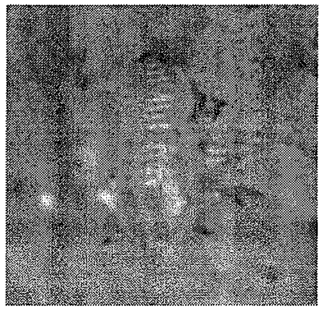


Aceria annulata (°?) galls on *R. cathartica*

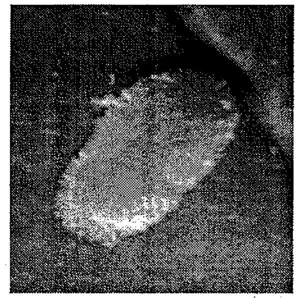
Calepitrimerus rhamni galls on *R. alpina*

Trichochermes walkeri **Appendix 24**

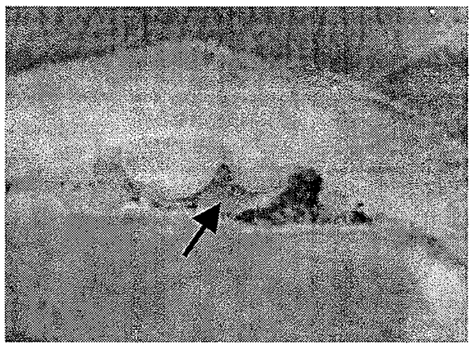
Eggs



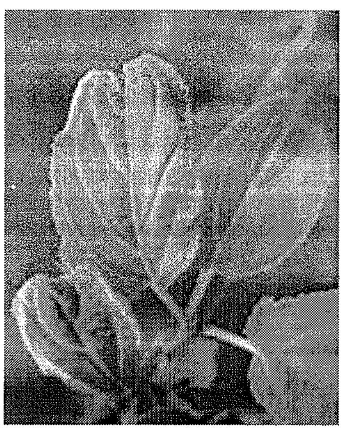
L2



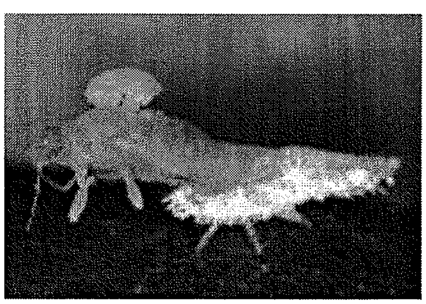
L5



Early instar nymph in gall (arrow).
Note the large honeydew spheres



Leaf galls

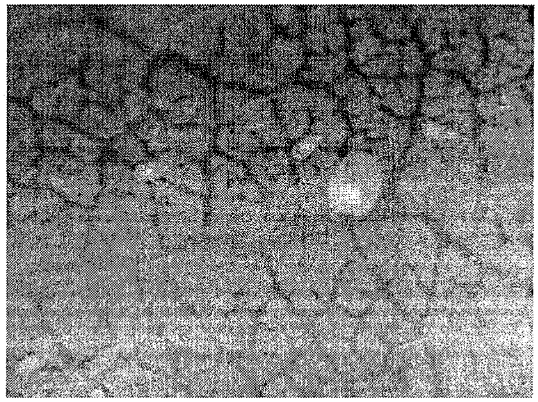


Emerging

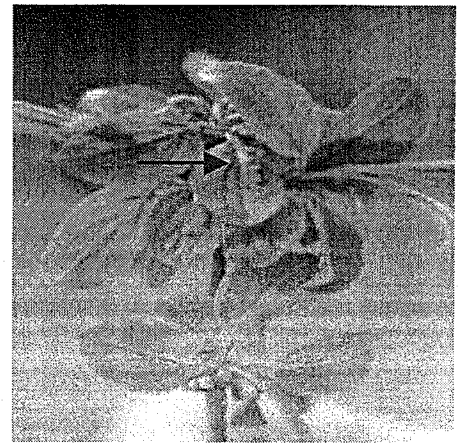
Mating

Appendix 25

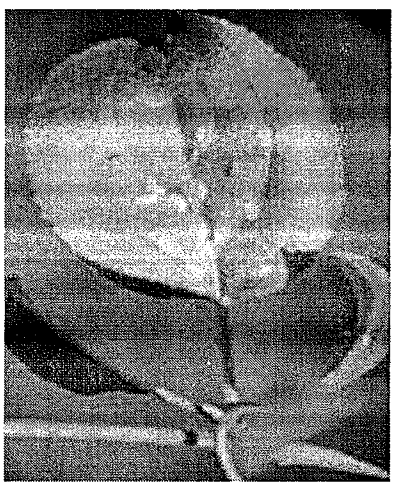
Trioza rhamni



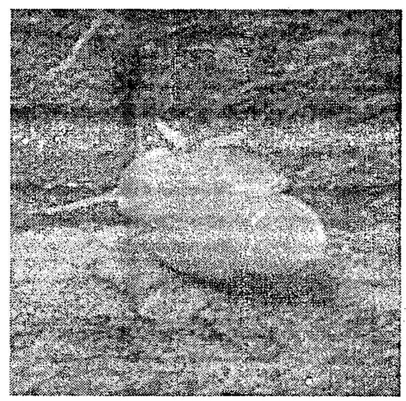
Eggs of *T. rhamni* with one egg of *T. dubitata*



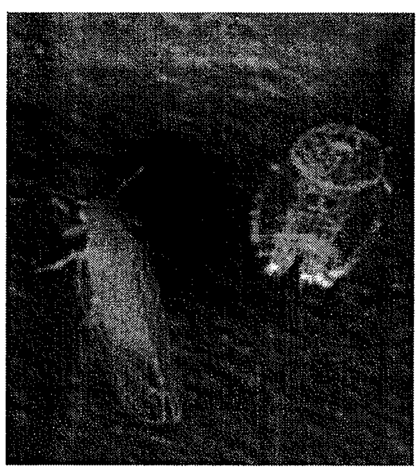
Pit galls on *R. cathartica*



Large instar nymphs



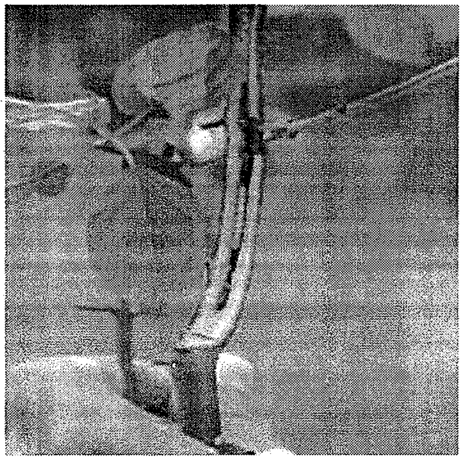
L5



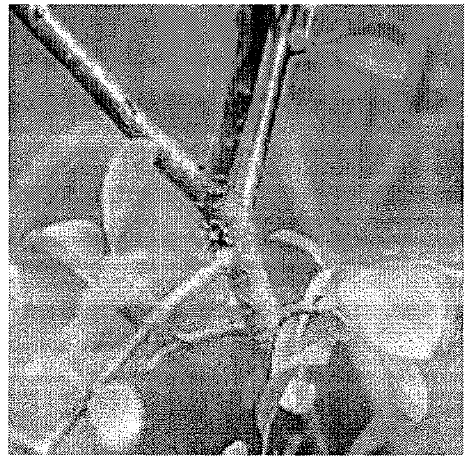
Newly emerged adult

Appendix 26

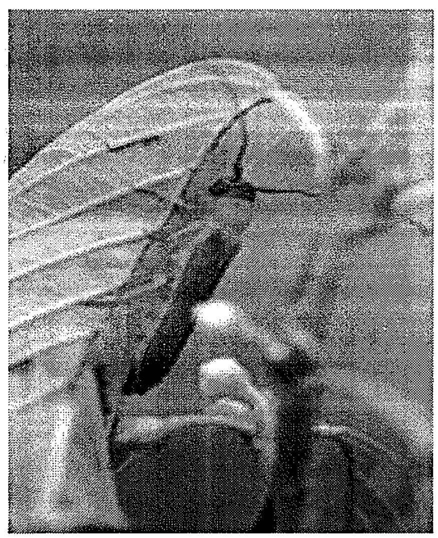
Oberea pedemontana



Larva in mine



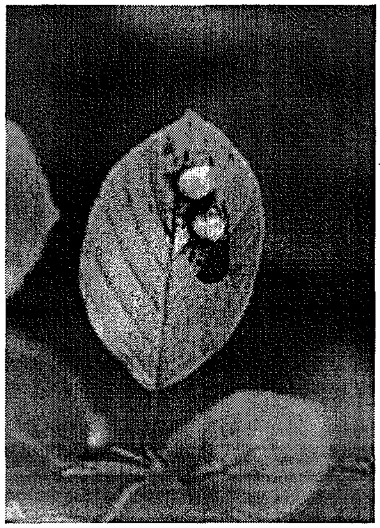
Frass and exit hole



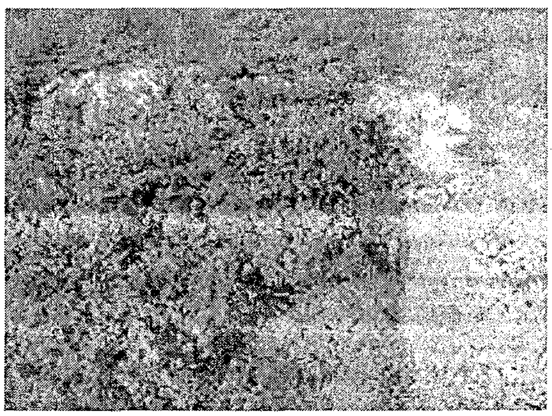
Adult

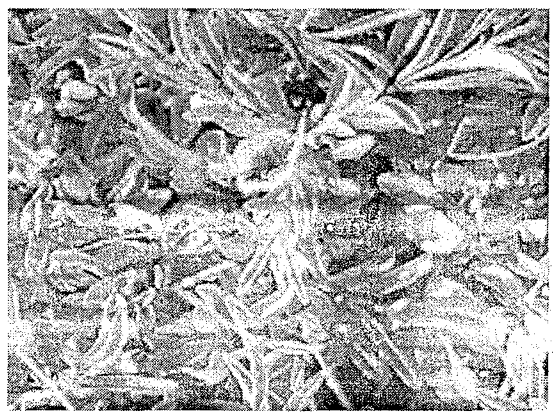
Damaged tree

Appendix 27



Birds that eat the fruits help to spread the seeds of *F. alnus*





Rhamnus saxatilis

Rhamnus alpina