Länsstyrelsen
GOTLANDS LÄN

Åtgärdsprogram
för hotade arter

Ecology and conservation aspects of the moth *Eucosma scorzonerana* on Gotland

Rapporter om natur och miljö – nr 2007: 19

Ecology and conservation aspects of the moth *Eucosma scorzonerana* on Gotland

Degree project in conservation biology

SONJA KLEMICH

Cover image: *Eucosma scorzonerana,* photo: Jan-Olov Björklund.

ISSN 1653-7041

LÄNSSTYRELSEN I GOTLANDS LÄN – VISBY 2007

SVENSK SAMMANFATTNING

Svinrotvecklaren *Eucosma scorzonerana* är en starkt hotad (EN) art i Sverige. Den är för närvarande endast känd från fyra lokaler på Gotland, men har tidigare även hittats i Garphyttans nationalpark på fastlandet. Studien genomfördes under sommaren 2007 för att samla information om svinrotvecklarens ekologi, livscykel och habitatpreferenser. Mycket lite är känt om artens ekologi, men man förmodar att larven utvecklas i blommor av svinrot *Scorzonera humilis*. Fynd av troliga svinrotvecklarlarver 2006 är gjorda i gallbildningar i svinrotsblommor. De kända lokalerna är dels ängen, dels gläntor eller hyggen i tallskog. I områden utan svinrot i Norge och Baltikum där arten är funnen, har även slåtterfibbla *Hypochoeris maculata* föreslagits som värdväxt.

I slutet av maj samlades vuxna fjärilar in och sattes i burar över svinrotsplantor. Tanken var att fjärilarna skulle lägga ägg och att man sedan skulle kunna följa larvutvecklingen och även jämföra utvecklingen mellan burar som stod soligt och skuggigt. En bur sattes också över slåtterfibbla. Trots idogt letande kunde vare sig ägg, eller senare larver, hittas på blommorna, i omgivande vegetation eller i marken. I slutet av juni när blommorna fröade av sig, skivades alla blommor, och i fyra blommor fanns då spår av exkrementer som kan härröra från fjärilslarver. Svinrotvecklaren är svårodlad (vilket även tidigare försök har visat) antagligen på grund av att den är känslig för de ändringar i mikroklimat som burarnas nät medför. Att den är kräsen vad gäller mikroklimatet kan vara en orsak till att den finns på så få lokaler trots att svinrot är en vanlig växt på Gotland.

Vissna svinrotsblommor samlades i början av juni, dels från ängen, dels från tallskogslokaler. Dessa genomsöktes på fjärilslarver och andra insekter. Två olika arter av fjärilslarver hittades, varav en sedan kläcktes i början av juni och blev bestämd till småprickig gråvecklare *Cnephasia genitalana*, en polyfag fjäril, men svinrot verkar inte nämnas bland dess värdväxter i litteraturen. Den andra fjärilsarten verkade göra sig redo för övervintring i slutet av juli och kunde inte artbestämmas. Mycket tyder på att detta kan vara svinrotvecklarlarver (habitat, likhet med nära släktingar). Senare hittades två andra arter av fjärilslarver, varav den ena också är en kandidat till att vara svinrotvecklarens larv.

I svinrotblommorna hittades också en stor mängd andra insektslarver (steklar och flugor) som åt på de mognande fröerna. Endast ca 5 % av blommorna var utan några larver alls. Drygt två tredjedelar av blommorna hade gallbildningar där frukterna är uppsvällda, vilket ofta syns tydligt utifrån. I dessa lever knubbiga vita larver, vars arttillhörighet är okänd (övervintrar antagligen som larver). Den rika förekomsten av andra insektslarver medför att det finns en stor konkurrens om svinrotsfrukterna. Även andra typer av interaktioner är tänkbara, i synnerhet med de gallbildande insekterna där fruktämnena sväller upp och sitter kvar hela sommaren. De förmodade svinrotvecklarlarverna hittades dock både i blommor med och utan gallbildningar.

Motsvarande undersökning gjordes även på slåtterfibblans blommor, men där hittades inga insekter alls! Man kan antagligen utgå från att slåtterfibbla inte utgör någon viktig värdväxt för svinrotvecklaren på Gotland.

Jämförelser mellan ängen och tallskogshabitat visade ingen signifikant skillnad mellan andelen blommor som hyste gallbildande respektive icke gallbildande insektslarver. Dock hittades samtliga förmodade svinrotvecklarlarver i tallhabitat, men fynden är för få för att dra några säkra slutsatser. Även vuxna fjärilar hittades huvudsakligen i tallskog.

ABSTRACT

This study was conducted to gather facts about the ecology, life cycle and habitat preferences of the moth *Eucosma scorzonerana*, a rare *Tortricids* species that is classified as "endangered" (EN / "Starkt hotad") in the national Swedish Red List 2005.

The moth's known distribution in Sweden is restricted to four constant locations on Gotland and Garphyttans National Park on the mainland. The basic idea for the realization of the task was the employment of flight cages to increase the chances to find eggs and / or larvae of the species. It was assumed that the larvae of *E. scorzonerana* rely on *Scorzonera humilis* as their host plant. The adults were caught with a net during their flight period from the end of May until the beginning of June and several moths were put in each of the 13 cages set on dense patches of *S. humilis* at the edge of Botes källmyr at Lojstahajd. This approach turned out to be unsuccessful at the end of June when neither eggs nor larvae had been found inside the cages.

Additionally, withered flower-heads of *S. humilis* were collected and sliced during the first two weeks of June. By this proceeding two different kinds of *Lepidoptera* caterpillars as well as gall-inducing and other insect larvae were found inside the flower-heads feeding on the ripening seeds. One breed of caterpillars pupated and emerged by the beginning of July, the moth was determined as *Cnephasia genitalana* PIERCE and METCALFE, 1922 by means of genitalia preparation. The other sort of caterpillars got ready to hibernate by the end of June, it could not be determined yet but some circumstances (habitat, locations, identification of other caterpillar species, hibernation) indicate that this could be the larva of *E. scorzonerana*. Later, two more breeds of *Lepidoptera* caterpillars were found. The gall-inducing larvae stayed inside the galls throughout the vegetation period. During July it became apparent that the not gall-inducing larvae belong to different insect orders.

INTRODUCTION

The purpose of this degree project is to ascertain more facts about the ecology, life cycle and habitat preferences of *Eucosma scorzonerana* (*Lepidoptera – Tortricidae*) on the island of Gotland (Sweden).

Microlepidoptera are a very species rich category of insects (about 2000 species in Scandinavia), the family of *Tortricids* alone contains about 500 species in northern Europe (SVENSSON 2006, p. 11). At the same time they remain a category that is only poorly studied and until today "undetected species are supposed to exist" (SVENSSON 2006, p. 11) even in Scandinavia. The life cycle and the developmental biology of most species are still unknown. The only information that is easily available about *Microlepidoptera* is the best way for the elimination of species that occur as pests in agricultural or forest plantations under certain conditions. The value of particular species from a nature conservation perspective is being thoroughly disregarded. Species that show only a scattered and fragmented distribution throughout Europe, that build only small populations with an extended risk of extinction, that have suffered a considerable decline in recent years, that are affected by the intensification of land use, that seem to have a complicated developmental biology and that demand special habitat qualities and that are at the same time supposed to be endangered in smaller or wider geographical units (cp. Red Lists wherever those contain *Microlepidoptera*, for example Sweden) certainly possess values from a conservational point of view. The positive side-effects on other species or biotope types as a whole that are obtainable through the protection of certain *Microlepidoptera* species can only be evaluated after comprehensive knowledge about the species themselves has been acquired. *E. scorzonerana* satisfies all the

mentioned criteria and is therefore definitely worth the effort of further investigations and the conduction of conservation measures.

E. scorzonerana is classified as "endangered" (EN / "Starkt hotad") according to the national Swedish Red List 2005 and features a geographical restriction regarding its occurrence as well as its occupancy. The species is supposed to be rare; it shows only a scattered distribution over the European continent. Additionally, *E. scorzonerana* possesses only fragmented and isolated populations within its area of distribution. Furthermore the species has undergone a considerable decline throughout recent years. NATURVÅRDSVERKET (The Swedish Environmental Protection Agency, SEPA) and ARTDATABANKEN (Swedish Species Information Centre) decided to focus on the protection of several moth species (småfjärilar). *E. scorzonerana* meets the criteria for providing a special action program ("Åtgärdsprogram") to secure the survival of the species. As the distribution of *E. scorzonerana* is virtually exclusively restricted to Gotland, LÄNSSTYRELSEN GOTLANDS LÄN is in charge of establishing and conducting the action program.

In 2006 JAN-OLOV BJÖRKLUND and GÖRAN PALMQVIST did a basic research on *E. scorzonerana* on Gotland. In their "Åtgärdsprogram för bevarande av småfjärilar på slåtteräng" (2007) there are given guidelines for management measures to sustain and to strengthen the populations of this and two other rare moths. This study is based on the recommendation to investigate the developmental biology and the population structure as well as habitat preferences of *Eucosma scorzonerana* in detail.

The moth has a wing span of 17-22 mm; male individuals are on average larger. The forewings are light grey in the front and in the back part but dark brownish-grey in the centre and at the front rim. The species can be identified by the characteristic two-coloured scales on the forewings. These are white and silvery-white with black markings in the centre. Head, palpi, thorax and abdomen are grey. The hind-wings feature a white-grey colour with darker rims. The cilia are also greyish-white. (BJÖRKLUND and PALMQVIST 2007, SVENSSON 2006).

Figure 1. *Eucosma scorzonerana*, setting and photo: Jan-Olov Björklund.

It is supposed that the larvae of *Eucosma scorzonerana* live monophagously on *Scorzonera humilis* but there is also an assumption that they might feed on *Hypochoeris maculata* as well, since the species occurs in regions where *S. humilis* is absent, for example in Norway and Latvia (BJÖRKLUND and PALMQVIST 2007, p.12). Suitable habitats for *E. scorzonerana* are probably fresh and dry meadows and wooded meadows, waysides and clearings in pine forests with strong populations of the host plant *S. humilis* (BJÖRKLUND and PALMQVIST 2007). Along the Habitats Directive of the Natura 2000-network biotopes of *E. scorzonerana* include "Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis* / 6510)" and "Fennoscandian wooded meadows (priority habitat type / 6530*)".

The flight period of *E. scorzonerana* is short – it stretches between the end of May and the middle of June – and is influenced considerably by the prevalent weather conditions (BJÖRKLUND and PALMQVIST 2007). It is assumed that the early flight period of the imagines is an adoption to the early flowering period of *S. humilis.*

The life cycle of *E. scorzonerana* is unknown. In 2006 larvae that probably belong to the species were found in firm, gall-like structures at the base of the flower-heads, probably induced by other insect larvae. A mutualistic interaction between the gall-inducing larvae and the caterpillars of *E. scorzonerana* is possible but still needs to be proved. (BJÖRKLUND and PALMQVIST 2007). *E. scorzonerana* is described as an indicator species for fresh meadows with a high proportion of the host plant *S. humilis* on total vegetation. Ideal management combines haymaking in the summer and grazing by cattle in autumn (BJÖRKLUND and PALMQVIST 2007).

There is a special need for investigations on the moth's developmental biology and its preferred habitat structure as well as interactions with other insect species because of the great difference between the distribution of the larvae's host plant *S. humilis* and the occurrence of the moth on Gotland. *S. humilis* is very common and can be found everywhere throughout the island whereas the distribution of *E. scorzonerana* is restricted to only a few confined areas. According to BJÖRKLUND and PALMQVIST (2007), *E. scorzonerana* has been found constantly on four sites on Gotland throughout the years:

1. Between Sjonhem's church and the road leading to Ardre
2. Lojsta area: Lojsta prästänge, Russparken, Botes källmyr
3. Next to road 141 between Klinte and Levide
4. Beside the road near Austris in Hall-Hangvars Nature Reserve.

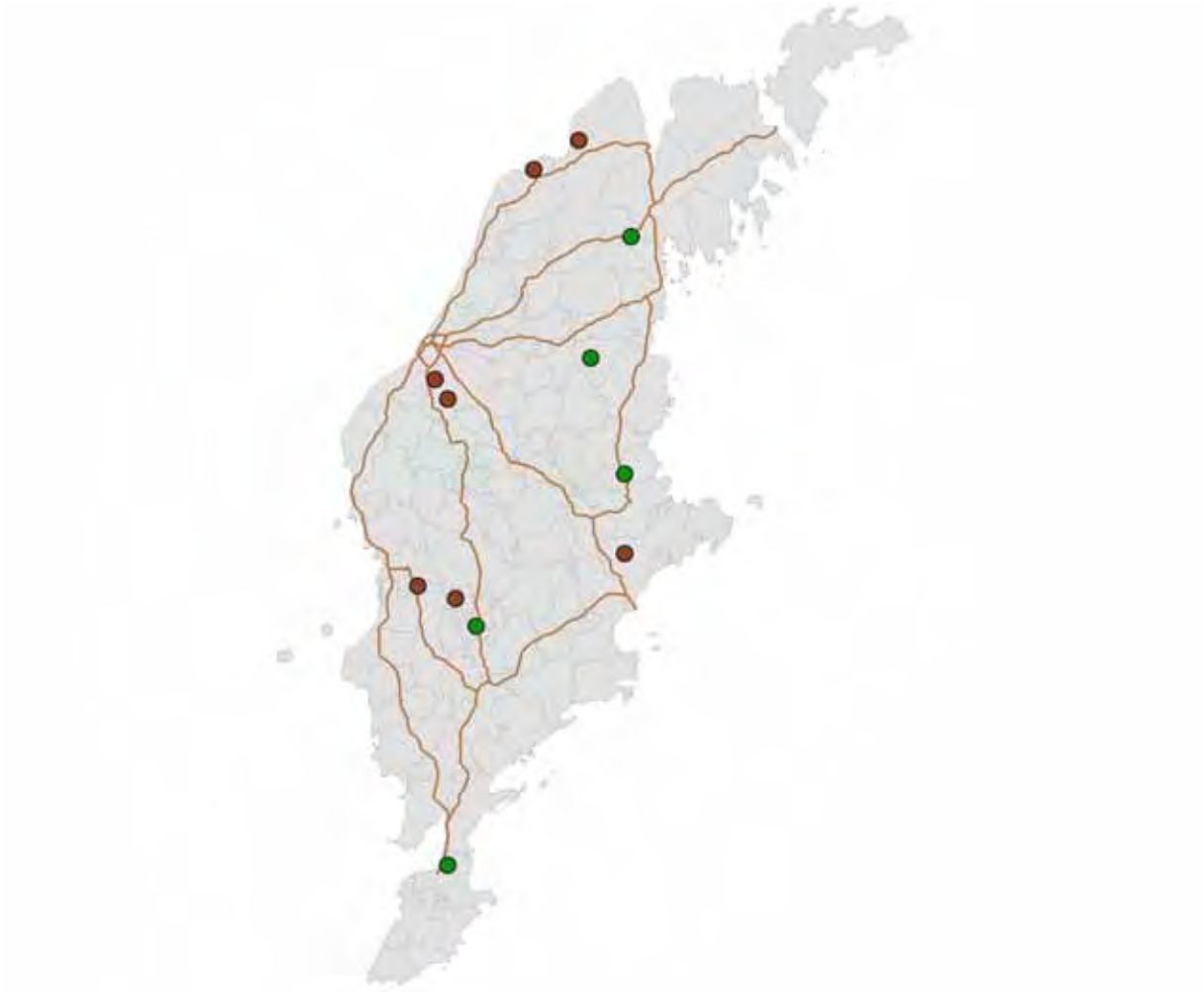
In contrast to those localities with continuous occurrences there are two sites where *Eucosma scorzonerana* could not be confirmed recently:

1. Öja (last finding 1931)
2. Träkumla (last finding 1984).

The distribution of the local populations on Gotland suggests that *E. scorzonerana* could be endangered by genetic drift and bottle-neck events because of failing genetic exchange between the populations. Fragmentation caused by a continuing decline of suitable habitat thus increases the risk for random extinctions of local populations. Persistent reduction and cessation of haymaking and grazing are in different ways the cause for deteriorating habitat quality. Large distances between suitable habitat patches prevent natural colonisation processes of patches and undersized local populations are exposed to extended risks of extinction (cp. HANSKI 1999).

This study was conducted to gather information about the ecology and habitat preferences of *E. scorzonerana*. The problems that were supposed to be addressed included:

1. Does *H. maculata* serve as an alternative host plant for the larvae of *E. scorzonerana*?
2. Where do the females oviposit? How long does the time span of the eggs stretch?
3. How long does the time span stretch so that the larvae stay as larvae? Where do the larvae develop? When and where do the larvae pupate?
4. How and where does the species hibernate?
5. Does *E. scorzonerana* prefer certain vegetation structures and compositions? Does the species prefer light and sunny or shady locations for oviposition?
6. What kind of management has to be arranged on the habitat sites of *E. scorzonerana* to secure the survival of the species on Gotland?
7. Do other insect larvae develop inside the flower-heads of *S. humilis*? Is a correlation between the moth's caterpillars and other insect larvae observable?



Legend

	habitat-type	no.	location
●	pine forest	1	Lojsta Russpark/ Botes källmyr
●	meadow	2	Lojsta prästänge
●	pine forest	3	Träkumla
●	pine forest	4	Visby Gudmyrskog
●	meadow	5	Othems korsänge
●	meadow	6	Alvena lindaräng
●	meadow	7	Anga prästänge
●	meadow	8	Öja prästänge
●	pine forest	9	Austris; Hall-Hangvar
●	pine forest	10	Klinte/ Levide
●	pine forest	11	Sjonhem/ Ardre
●	pine forest	12	Grausne källmyr

Analysis of ecological needs of *Eucosma scorzonerana* on Gotland

Map no. 1

Examensarbete (Diploma thesis)
Sonja Klemich

Field studies between May and July 2007

Figure 2. Confirmed habitat sites of *E. scorzonerana* on Gotland and localities where the study 2007 was conducted. Copyright © Lantmäteriet 2001 Dnr:L2002/83.

1. MATERIALS AND METHODS

1.1. Catching of adult moths

The flight period of the adult moths stretches from the end of May until the middle of June (BJÖRKLUND and PALMQVIST 2007). The moths were caught with a butterfly net between 5pm and sunset around 9/10pm (see also annex:D-M "capture records"). To ensure the exact identification, GÖRAN PALMQVIST directed the catch on the 25th of May, pointing out the characteristic features and wing patterns of *E. scorzonerana*. Furthermore, the behaviour of the flying moths outside the cages was studied as often as possible – the flight characteristics of one moth were observed over a longer time.

1.2. Cage experiment

The caught individuals were put into cages measuring 0.3m x 0.3m x 0.5m to make the detection of eggs and larvae easier. The idea of working with cages and the general construction scheme had been accounted by GÖRAN PALMQVIST (see Fig.3). The aim of the employment of the cages was to find eggs and larvae of *E. scorzonerana* and to get suitable data for statistical analysis. Possible examinations include the measurement of the larvae's´ length and comparison between preferred locations for oviposition or larval development in sunny versus shady cages.

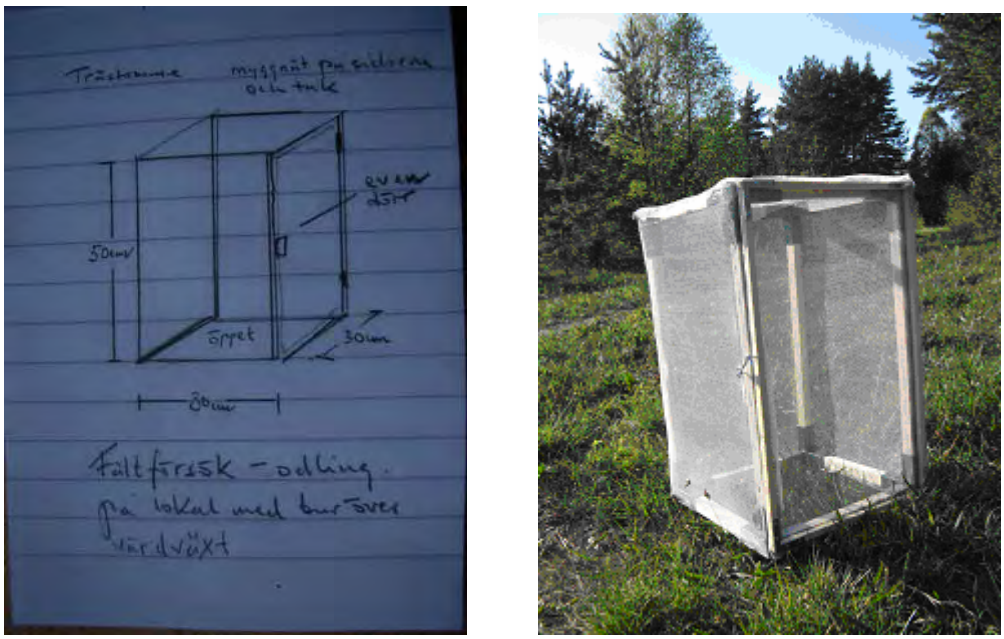


Figure 3. Drawing of the construction scheme by Göran Palmqvist (spring 2007) and photo of a cage at the flight area near Lojsta Russpark (May 2007).

There were placed between two and five moths in each cage. Altogether 13 cages were placed at the eastern edge of Botes källmyr – a nature reserve at Lojstahajd – at a light former clearing site surrounded by pine forest. The area is located in direct proximity to a calcareous flush fen and features a dense cluster of *S. humilis* along with diverse and species-rich ground vegetation. The cages were set right upon dense and vital plants of *S. humilis* ensuring that several flower-heads respectively flower buds or withered flowers were situated inside each cage.

Of the total 13 cages, five were placed in completely sunny locations whereas seven were set in more shady positions and one was put over *Hypochoeris maculata*, another potential host plant for the moth's larvae (table 1).

Figure 4. Lojsta Russpark/ Botes källmyr – the area where the moths were caught and where the cages were placed (27.05.2007).

Table 1. Locations of the cages.

Cage-no.	Fresh flowers of *S. humilis*	Withered flowers of *S. humilis*	Flower buds of *S. humilis*	Proximity: plants	Light conditions
1	3	2	3	*Pinus sylvestris, Calluna vulgaris*	sun
2	6	4	3	*stones, Juniperus communis, Filipendula vulgaris*	sun
3	4	0	1	*Pinus sylvestris, Juniperus communis, Sesleria caerulea*	sun
4	5	4	0	*Calluna vulgaris, Betula pendula, Pinus sylvestris, Sesleria caerulea*	sun
5	5	0	2	*Calluna, Pteridium aquilinum, Sorbus aucuparia, Pinus, Frangula alnus*	shade
6	0	2	5	*Frangula alnus, Pinus sylvestris, Rubus spec., Sesleria caerulea*	sun
7	1	0	3	*Pinus sylvestris, Filipendula vulgaris, Rubus spec., Sesleria caerulea*	shade
8	1	0	4	*Pinus, Filipendula vulgaris, Convallaria majalis, Calluna, Asperula tinctoria*	shade
9	0	0	3	*Juniperus, Geranium sanguineum, Sesleria caerulea, Filipendula vulgaris*	shade
10	1	0	2	*Juniperus, Geranium sanguineum, Sesleria caerulea, Calluna vulgaris*	shade
11	1	2	8	*Pinus, Calluna, Geranium sanguineum, Potentilla erecta, Pteridium*	shade
12	2	0	5	*Calluna, Frangula alnus, Rubus, Pinus sylvestris, Pteridium aquilinum*	shade
13	0	0	0	*Hypochoeris maculata*	

During the last days of May and the first week of June the vegetation inside the cages was examined accurately but unsuccessfully several times in the attempt to find eggs of *E. scorzonerana*. On 20th of June the cages were opened and the rests of the flower-heads that had developed seeds by that time were examined closely again but no larvae were found. Between end of June and middle of July the ground vegetation was inspected and the soil underneath the cages was dug out and closely investigated, again without success.

1.3. Collecting and slicing of flower-heads

Flower-heads of *S. humilis* were collected from different pine forest localities and meadow habitats during the first two weeks of June. By that time the withered flowers featured a considerable range of variation in breadth and size and their slicing was supposed to show the cause for the mutation. Moreover, it was an alternative to find caterpillars of *E. scorzonerana*. The flower-heads were taken from known flight areas of *E. scorzonerana* as well as from other randomly chosen sites. They were sliced with the aim of finding *Lepidoptera* caterpillars as well as other insect larvae that were feeding inside on the ripening seeds.

In each site I also roughly counted all flowers and noted how many of them that had broad and hard flower heads, to get a picture of how many percentages of the flowers that had galls.

1.4. Lepidoptera larvae

The detected caterpillars were kept alive to find out more about their developmental biology and finally to allow the identification. They were provided with fresh withered flower-heads of *S. humilis* as long as those were available (until the second half of June). After the ripening of not infested seeds - when it was no longer possible to provide flower-heads - leaves, ripe seeds and parts of the plant's stipe were offered to the caterpillars. As a substitute for the soil, newspaper was modelled to form the "ground". After the brown caterpillars had settled and it had become apparent that they were prepared to hibernate, they were put into the refrigerator. This attempt was supposed to simulate winter conditions and to shield the caterpillars from variations in temperature, therewith facilitating the caterpillars´ development. During the winter they should be kept outside in a dry place where they are exposed to natural temperatures but not to direct sunlight.

1.5. Other insect larvae

Pupae were reared from the other larvae to subsequently enable the identification of these insects that had also been found feeding inside the flower-heads of *S. humilis*. Whenever flower-heads were opened and insect larvae were found inside, their feeding patterns were analyzed. Galled flower-heads of *S. humilis* as well as the insect larvae that were sitting inside the pappus area were put into jars capped with gauze to ensure air convection. When one breed of larvae began to fall out of the pappus area of the withered flower-heads, they were provided with a jar filled with sand simulating the ground.

1.6. Hypochoeris maculata

During June and July high numbers of blossoms, withered flower-heads and clocks of the second potential host plant for the larvae of *E. scorzonerana, H. maculata* were collected from confirmed flight areas of the moth as well as from other randomly chosen localities. They were sliced to enable a comparison between this species and *S. humilis* regarding the infestation of seeds and the percentage of flower-heads containing insect larvae. The detection of *Lepidoptera* caterpillars would have been of special interest.

1.7. Short description and habitat requirements of the two potential host plants

Scorzonera humilis is a long-lived herbaceous perennial of the family *Asteraceae*. In central Europe it is a characteristic species of wet, nutrient-poor grasslands and wet heathlands (OBERDORFER 1994, in COLLING et al. 2002). In the Swedish definitive book "Den nya nordiska Floran" (2003) as habitat types of *S. humilis* are given forest edges, waysides, semi-natural pastures and hay-meadows. On Gotland, *S. humilis* is a very common plant that grows in abundance in all the mentioned habitats types over the whole island. Its occurrence is neither restricted to acid soil (rather the opposite) as suggested by ROTHMALER (2002) nor does it occur on wet grounds only.

Hypochoeris maculata is also a perennial belonging to the family of *Asteraceae*. Along "Den nya nordiska Floran" (2003) habitat types of this species include semi-natural pastures, heathlands, waysides, light forest edges, oak stands, dunes and bare rock areas. It grows in particular on dry or temporarily wet grounds. These habitat types possess relatively great expanses on Gotland and *H. maculata* grows everywhere on the island where the soil is deficient in nutrients. Thus *H. maculata* is also a very common species on Gotland and it is flourishing in vital populations often alongside *S. humilis.*

1.8. Comparisons

Basic statistical methods were used to compare the counted numbers of the various breeds of larvae and to calculate the significance of the data sets. To confer pine forest sites and meadow habitats the "t-test" was employed to check the significance of the dissimilar percentages of "gall-inducing larvae", "not gall-inducing larvae" and "no infestation".

A comparison between the occurrences of caterpillars together with versus without gall-inducing larvae was calculated by utilisation of "χ^2-test statistic" in combination with "Yates' correction". Help to conduct the statistical methods was gathered from FOWLER and COHEN (1990), with emphasis on pages 112-116 and 175.

2. RESULTS

2.1. Catching of adult moths

The first flying adults of *E. scorzonerana* were caught on the 24th of May 2007 despite earlier attempts around the Russpark area at Lojstahajd. At 25th of May there seemed to be a peak in the activity of the species with high numbers of flying individuals easily caught and observed. Even though it was only the second day of successful captures the moths looked worn as if they had already been flying for about a week (GÖRAN PALMQVIST 23.07.).The flight period stretched until 4th of June 2007. The flight period 2007 could have started slightly earlier or lasted presumably shorter than normal in other years because of the unusually dry and warm weather conditions during spring and early summer.

Table 2. Captures of *E. scorzonerana* during the flight period 2007.

area	date	time	weather conditions	captures	females	males
Lojsta Russpark/ Botes källmyr	25.05.	18.15-21.00	cloudy, very warm, windy, thunderstorm ahead	25	?	?
Lojsta Russpark/ Botes källmyr	26.05.	18.30-21.30	pure sunshine, after 20h clouds	8	1	7
Lojsta Russpark/ Botes källmyr	27.05.	18.00-21.00	sun, light clouds, after 20h dark clouds	6	3	3
Lojsta Russpark/ Botes källmyr	28.05.	17.45-21.30	pure sunshine	9	7	2
Öja Prästänge	30.05.	17.00-18.15	very foggy, cool, windy	0	0	0
Lojsta Russpark/ Botes källmyr	30.05.	18.45-20.00	very foggy, cool	5	3	2
Visby Gudmyrskog	03.06.	17.00-19.30	pure sunshine, very windy, warm	1	1	0
Lojsta Russpark/ Botes källmyr	04.06.	17.30-19.30	pure sunshine	1	1	0
Lojsta Prästänge	04.06.	19.45-21.00	pure sunshine	0	0	0

From 30th of May to 1st of June there was a period of foggy, cool and wet weather that might have had some negative influence on the reproduction of *E. scorzonerana* because the mobility of the moths was constricted.

The behaviour of the flying moths - outside the cages - was studied by following certain individuals over a longer time. The moths flew low over the vegetation and settled after relatively short distances, often after one to three meters or up to six meters but from time to time they flew also longer distances up to 30 meters. Their preferred resting places were young pine trees and *Calluna*-shrubs during the first days, later they also sat down at *S. humilis*. Few individuals could be observed flying from one plant of *S. humilis* to the next where they examined the flower-heads – often slightly withered ones – by crawling around them. Sometimes they could also be seen going down the stipe and back up to the flower-head again. It was not possible to observe neither mating individuals nor an ovipositing female.

The active time of *E. scorzonerana* is not restricted to evenings only, the moths could also be seen flying in Lojsta Russpark/ Botes källmyr in the late mornings, they seem to be active "most of the day" (GÖRAN PALMQVIST 23.07.07) but not at noon and in the early afternoon.

Figure 5. *E. scorzonerana* examining the flower-head of *S. humilis* at Lojsta Russpark/ Botes källmyr on 27th of May 2007.

2.2. Cage experiments

The employment of cages - as done in this study - did not bring any results. I could find neither eggs nor caterpillars inside the cages, neither in flower-heads nor in the ground vegetation and neither in the soil beneath the cages. The application of cages – similar to those used in this study – has not been expedient; it is therefore not recommendable for further studies of *E. scorzonerana*.

If there had been *Lepidoptera* larvae of any species inside the flower-heads of *S. humilis* inside the cages – as feeding patterns and excrements inside withered flower-heads on 20th of June inside cages 3,5,11 and 12 suggest - they would already have left before the 20th of June (table 3). After leaving the flowers the larvae may have dug into the ground but they have neither been found inside the ground vegetation nor inside the soil beneath the cages (table 4).

Table 3. Opening of the cages on 20th of June.

cage no.	date of opening	stipes of *S. humilis* (*H. mac.* in nr 13)	seeds forming clocks	completely without seeds	with some standing seeds left	with NOT gall-inducing insect larvae	with gall-inducing insect larvae	Lepidoptera larvae	with larvae excrements	area
1 (sun)	20.06.	10	0	4	6	1	1	0	0	Lojsta Botes
2 (sun)	20.06.	11	4	0	7	6	0	0	0	Lojsta Botes
3 (sun)	20.06.	5	0	2	3	0	1	0	3	Lojsta Botes
4 (sun)	20.06.	9	0	1	8	5	1	0	0	Lojsta Botes
5 (shade)	20.06.	7	0	1	6	3	0	0	3	Lojsta Botes
6 (sun)	20.06.	4	0	0	4	0	2	0	0	Lojsta Botes
7 (shade)	20.06.	4	0	0	4	0	1	0	0	Lojsta Botes
8 (shade)	20.06.	4	0	0	4	0	2	0	0	Lojsta Botes
9 (shade)	20.06.	2	0	2	0	0	0	0	0	Lojsta Botes
10 (shade)	20.06.	4	0	0	4	0	3	0	0	Lojsta Botes
11 (shade)	20.06.	12	0	0	12	0	3	0	1	Lojsta Botes
12 (shade)	20.06.	7	0	0	7	0	1	0	1	Lojsta Botes
13 (*H. maculata*)	20.06.	16	0	0	recently withered: 5 completely withered: 8	0	0	0	0	Lojsta Botes
14 Visby!	20.06.	13	0	0	13	0	10	0	0	Visby

Table 4. Digging and examination of the soil beneath the cages.

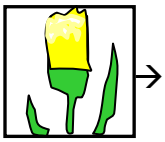
cage-no.	date	depth (cm)	observations
1	26.06.	10	grey Lepidoptera larva (c)
2	26.06.	15	
3	29.06.	15	
4	29.06.	15	
5	29.06.	10	
6	02.07.	10	
7	02.07.	10	
8	02.07.	15	two Tenthredinidae larvae
9	02.07.	15	
10	04.07.	10	
11	04.07.	10	
12	04.07.	10	
13	04.07.	15	Cage placed over *Hypochoeris maculata*

2.3. Collecting and slicing of flower-heads

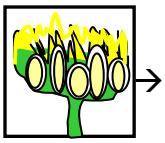
By collecting flower-heads of *S. humilis* from known flight areas of *E. scorzonerana* as well as from other randomly chosen sites two different kinds of *Lepidoptera* caterpillars and three different sorts of other insect larvae were detected. Furthermore, there were *Thysanopthera* larvae and imagines in every inspected flower-head. Boreholes caused by *Lepidoptera*, *Diptera* or *Hymenoptera* at flower-heads of *S. humilis* for egg-laying can not be identified from the outside.

Figure 6. Comparison between “broad” and “slim” flower-heads of S. humilis.

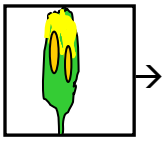
Inside the flower-heads of *S. humilis* taken from each of the visited areas, gall-inducing and not gall-inducing insect larvae occurred together in several of the collected flower-heads. Therefore the sum of all kinds of infestation always exceeds the numbers of colleted flower-heads. The moths that developed from the grey caterpillars [b] were identified later as *Cnephasia genitalana* PIERCE and METCALFE, 1922 by GÖRAN PALMQVIST.



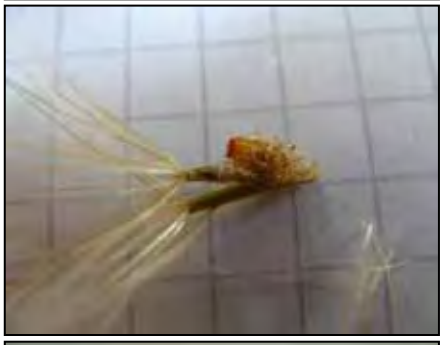
withered flower-heads of *S. humilis* , not influenced by any kind of infestation

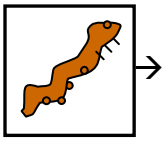


galled flower-heads from the inside, gall-inducing larvae feeding inside the modified seed tissue

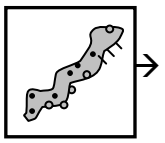


flower-heads with not gall-inducing larvae feeding on the seeds





brown caterpillars (a) found inside flower-heads at Lojsta Russpark, Visby Gudmyrskog and Träkumla in the beginning of June; hibernation as caterpillar



grey caterpillar (b) found inside flower-heads in the beginning of June; pupated in June; *Cnephasia genitalana*

Photo: Göran Palmqvist

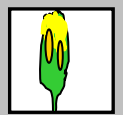
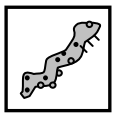
Figure 7. Explanations of the symbols applied to illustrate the results of the collecting and slicing of flower-heads of *S. humilis* during the first two weeks of June 2007.

It turned out to be hard to discover the flower heads with galls without slicing them. Flower-heads of *S. humilis* that were infested with many gall indicing larvae were easily recognized, but those with only very few larvae were not recognizable from the outside as gall-infested, but the larvae were easily found when slicing the flowerheads. This means that there will be a much lower amount of galls found with this method, than when I sliced the collected flower heads. There were much easier to see the galls later in the season, when they had grown bigger, which means that the percentages of galls in different localities are hardly comparable.

Figure 8. Visby Gudmyrskog. In this area 150 flower-heads of *S. humilis* were collected on 7th of June 2007. Inside those nine brown caterpillars and one grey caterpillar of *C. genitalana* have been found.

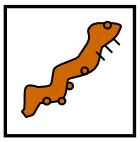
Figure 9. Träkumla. At this locality 150 flower-heads of *S. humilis* were collected on 3rd of June 2007. Inside those seven brown caterpillars have been found.

Table 5. Results of the collecting and slicing of flower-heads of S. humilis in the beginning of June. Since gall inducing and not gall inducing larvae sometimes were in the same flower the sum of all flowers with larvae may be larger than the number of collected ones. The amount of broad flower heads of all flowers in each area is also presented, even though it turned out to not include all flower heads with galls.

	Visby Gudmyrskog 07.06.07	**Anga prästänge 08.06.07**	**Othem korsänge 10.06.07**	**Träkumla 11.06.07**	**Öja prästänge 12.06.07**	**Grausne källmyr 13.06.07**	**Alvena lindaräng 15.06.07**
Total number	150	100	110	150	130	110	100
	91	25	100	77	112	105	92
	38	66	26	102	26	20	13
	14	15	-	8	3	-	-
 + 	6	-	-	2	-	-	-
 + 	-	-	-	1	-	-	-
 + 	3	-	-	4	-	-	-
 + 	1	-	1	-	-	-	1 (probably a different species than the two others)
Amount of broad flower heads	22 %	4 %	35 %	16 %	33 %	40 %	42 %

2.4. Lepidoptera larvae, descriptions of collected species

2.4.1. Lepidoptera larva a:



Length: about 13mm

Head: Dark brown. Prothoracic plate large, brown (darker coloured than the caterpillar's abdomen).

Meso- and metathorax, abdomen: Light, ocher-yellowish brown. Bowl translucent (darker brown). Abdomen without visible pinacula, but with separate, delicate, white hairs. Anal plate light brown. Three pairs of thoracic legs and four distinct pairs of abdominal prolegs with crochets; anal prolegs developed.

The caterpillars are feeding on the developing seeds inside the flower-heads of *S. humilis* from the beginning of June. When fully fed the larvae seem to leave the flower-heads. They seem to get ready for hibernation at the end of June inside a silken cocoon (observations from the fostered caterpillars that had been taken inside, see below for details).

Table 6. Detection of brown Lepidoptera caterpillars A.

area	date	individuals	fostering
Visby	07.06.	10	7
Träkumla	11.06.	7	3

Fostered caterpillars
The brown *Lepidoptera* larvae a that had been found during the first weeks of June and taken inside for further rearing produced light cocoons in the pappus area or the hollow stipes of *S. humilis* and stayed motionless there from the end of June.

On the 30th of June the brown caterpillars a were inspected inside their jars. Four of them were (presumably) sitting in cocoons inside hollow stipes of *S. humilis* (three individuals from Träkumla, one individual from Visby Gudmyrskog). Four others were located in the pappus area of the seeds of withered flower-heads of *S. humilis* (four individuals from Visby Gudmyrskog). Two of those were apparently using the texture modified by not gall-inducing larvae (not gall-inducing larvae are sitting in the pappus area over the eaten seeds, the pappus texture mutated in a way that it is building a "cloak" around the larva/ pupa).One other insect pupa and a *Lepidoptera* larva were also found sitting close together in the pappus area in one flower-head. One brown caterpillar was detected inside a cocoon in seed texture modified by not gall-inducing larvae (one individual from Visby Gudmyrskog). When sitting like this the brownish *Lepidoptera* larva is looking very similar to not gall-inducing insect pupae.

The remaining caterpillar was (presumably) located inside a cocoon in its own excrements inside the bottom of the flower-head (one individual from Visby Gudmyrskog). Even after extensive search outside at Lojsta Russpark/ Botes källmyr and Visby Gudmyrskog until the end of July it was not possible to detect any *Lepidoptera* larvae in the seed rests or inside the stipes. The pappus area respectively the hollow stipes are obviously an alternative for the location the caterpillars use outside under natural circumstances. Since the brown larvae had not been moving until September they seem to hibernate in that state.

During the winter 2007 the caterpillars were kept inside the refrigerator as well as outside on Gotland, they were observed and cared for by OSKAR KULLINGSJÖ/ LÄNSSTYRELSEN GOTLAND. If the caterpillars manage to survive and to develop into moths it will be possible to identify the species in the early summer of 2008.

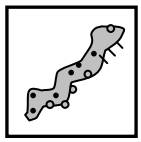
The brown caterpillars [a] could not be determined yet but some circumstances (habitat, locations, identification of other caterpillar species, hibernation) indicate that this could be the larva of *E. scorzonerana*.

Figure 10. Brown caterpillar [a] sitting inside a partly galled withered flower-head of *S. humilis* , collected on 4th of June at Lojsta Russpark/ Botes källmyr.

Figure 11. Brown caterpillar [a] , photo: Göran Palmqvist.

2.4.2. Lepidoptera larva b:

Cnephasia genitalana PIERCE and METCALFE, 1922



Length: about 11mm

Head: Light brown. Prothoracic plate of the same colour as the caterpillar's abdomen.

Meso- and metathorax, abdomen: Greenish-grey. Bowl translucent (greenish). Abdomen with black pinacula that bear the primary setae (1-2), 14 pinacula on every segment (figure 12). Anal plate dark grey. Three pairs of thoracic legs and four distinct pairs of abdominal prolegs with crochets; anal prolegs well developed.

The caterpillars feed (among other plant species, BRADLEY et al. 1973) on the developing seeds inside the flower-heads of *S. humilis* in June. They spin a silken cocoon during the second half of June inside which they pupate. The pupa is dark brown and lasts for about 12 days. The adult moths emerge in the last days of June or at the beginning of July.

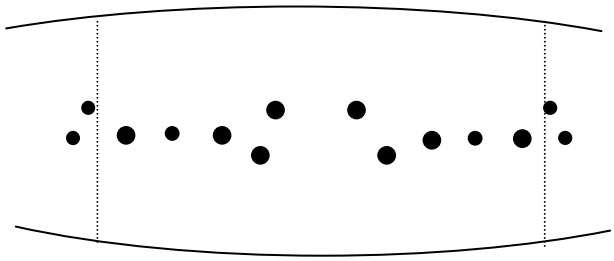


Figure 12. Pinacula-pattern of the grey caterpillar b - *Cnephasia genitalana* .

Table 7. Detection and development of grey Lepidoptera caterpillars b.

area	date	individuals	pupa: date	date of emerging	length: pupa-period
Visby	07.06.	1	14.06.	26.06.	12 days
Othem	10.06.	1	22.06.	03.07.	11days
Alvena	15.06	1	Did not pupate!		

Fostered caterpillars

During the second half of June the caterpillars built cocoons at the covers of their jars and became pupae. They stayed as a pupa for 11 respectively 12 days. The first emerging moth had heavily damaged wings; the second moth emerged unscathed a week later. To enable the identification they were frozen shortly after emerging. At the end of August, the moth was determined by GÖRAN PALMQVIST as *Cnephasia genitalana* PIERCE and METCALFE, 1922 (*Tortricidae*) by means of genitalia preparation. *E. scorzonerana* is not the only *Lepidoptera* species that larvae either feed on *S. humilis* or that uses its flower-heads for the larval development!

Figure 13. Moth that emerged out of the pupa of caterpillar b from Othem korsänge on 3rd of July - *Cnephasia genitalana*.

Cnephasia genitalana is an uncommon species and occurs only in local populations in southern Britain (Bradley et al. 1973) and in the southern part of Norway where it is listed as VU ("Vulnerable") in the national Norwegian Red List 2006 (www2.artsdatabanken.no/rodlistesok/Artsinformasjon.aspx?ArtsId=8053).
In the southern part of Sweden it is more common (http://www2.nrm.se/en/svenska_fjarilar/c/cnephasia_genitalana.html).

Its caterpillars feed on *Senecio, Hieracium, Teucrium, Chrysanthemum* and *Ranunculus* (Bradley et al. 1973) – the caterpillars´ host plants differ in the various bibliographies but *Scorzonera* has not been quoted yet. Bradley et al. (1973) specify the time of the pupa at June and early July, corresponding with the observations of this study. The adult moths fly in July and August (Bradley et al. 1973). It is unknown when and how the caterpillars reach the flower-heads of *S. humilis*, because at the approximate time of oviposition in July and August the seeds of *S. humilis* are already ripe and blown away and the stipes are about to topple down. New flower-heads begin to grow the following year in late April and May (Gotland).

In July it became apparent that the caterpillar found at Alvena lindaräng was not of the same breed as the other grey caterpillars b of *Cnephasia genitalana*. As though it's outward physical appearance seemed to be the same, this caterpillar took no efforts to pupate throughout July (table 7).

2.4.3. Lepidoptera larva c:

Length: about 13mm

Head: Black. Prothoracic plate large, black (stretching over the whole breadth of the segment).

Meso- and metathorax, abdomen: Grey, in places light grey. Bowl not translucent. Abdomen with dark brown pinacula that bear the primary, rather short setae (1-2), 8 pinacula on every segment (figure 14). Additional dark, short hairs at the last segment. Three pairs of thoracic legs and four distinct pairs of abdominal prolegs with crochets; anal prolegs well developed and with dark bottom.

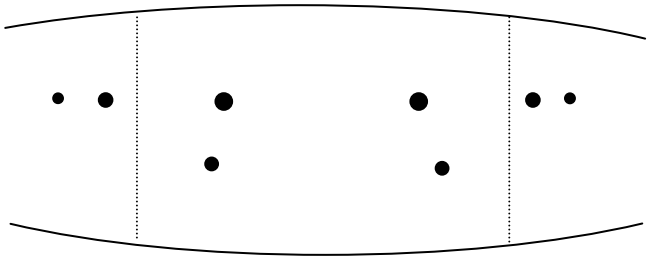


Figure 14. Pinacula-pattern of the grey caterpillar [c] found in the ground beneath cage 1.

On 26th of June this caterpillar was found at Lojsta Russpark/ Botes källmyr beneath cage 1 inside the soil in the root stratum of the grasses, inside a cocoon. As one segment was thickened and the next "withered" an infestation with parasites was likely. The caterpillar was found dead by the middle of July and put into alcohol. The grey *Lepidoptera* larva [c] that was found inside the soil of cage 1 on 26th of June was the only one of its kind in the ground beneath the cages, there is no immediate connection between this larva and *S. humilis* or *E. scorzonerana* recognizable.

2.4.4. Lepidoptera larva [d]:

Length: about 8mm, thinner than the previous ones

Head: Light greenish-brown. Prothoracic plate thin, yellowish and with black dots at each side

Meso- and metathorax, abdomen: Light yellowish-green with darker stripes; the caterpillars became brownish and then dark brown within two weeks. Bowl translucent (brown), as long as the caterpillars are light coloured. Abdomen without visible pinacula, but on the prothoracic plate at each side (at the right and at the left side) lateral one black dot. Abdomen with tiny, separate, delicate white hairs (but nevertheless the caterpillars seem rather "smooth"). Three pairs of thoracic legs and four distinct pairs of abdominal prolegs with crochets; anal prolegs well developed

On 10th of July three individuals were found at Lojsta Russpark/ Botes källmyr inside the brown and dry, hard galls together with the gall-inducing larvae! Another search for these *Tortricids* larvae two weeks later was unsuccessful, despite the slicing of several hundred galls, no caterpillars were found. But there were the characteristic feeding pattern and excrements of *Lepidoptera* caterpillars observed inside some of the galls - it was hard to judge, however, how much time had passed since the caterpillar had left the flower-head.

The caterpillars [d] could not be determined yet and as they had been found inside the galled flower-heads of *S. humilis* it is possible that these caterpillars are the larvae of *E. scorzonerana*.

2.5. Other insect larvae

S. humilis flower-heads host not only *Lepidoptera* larvae but also other – presumably specialized – insect larvae, often in high numbers of individuals. The infestation with other insect larvae does not preclude that *Lepidoptera* larvae also feed inside the same flower-heads (see "Comparison between the occurrences of caterpillars with versus without gall-inducing larvae"). During the slicing in June it was easy to distinguish two main groups: gall-inducing larvae often inside very broad flower-heads and other not gall-inducing larvae inside slender flower-heads of *S. humilis*. In July, however, it turned out that at least the larvae that induced no galls belonged to different insect orders and certainly to several different species.

2.5.1. Gall-inducing larvae

Like other species of the *Asteraceae* family, the seeds of *S. humilis* possess a pappus and they compose a clock – as soon as the seeds are ripe they normally fly away with the wind. Flower-heads whose seeds are completely infested with gall-inducing larvae seem to stay as galls over the winter – those seeds are not able to fly away. Throughout the summer these larvae stayed inside their galls, which were inside the mutated tissue of the broad flower-heads. During that time no development could be observed – they remained white larvae with the size to fit into the gall-structure that had been built by the plant around the infested seed. Presumably they hibernate in this stage of development inside their galls (cp. COULIANOS and HOLMÅSEN 1991, p. 262: *Senecio jacobaea / Sphenella marginata*).

During the second half of July, wasps emerged out of the brown and dry galls. They belong to the Superfamily of *Chalcidoidea* of which several species are known to live as parasites inside gall-inducing larvae (STRESEMANN 1978 Volume 2/1 Invertebrates, p. 427/428). Altogether three different species emerged out of the galls but it was not yet possible to identify them.

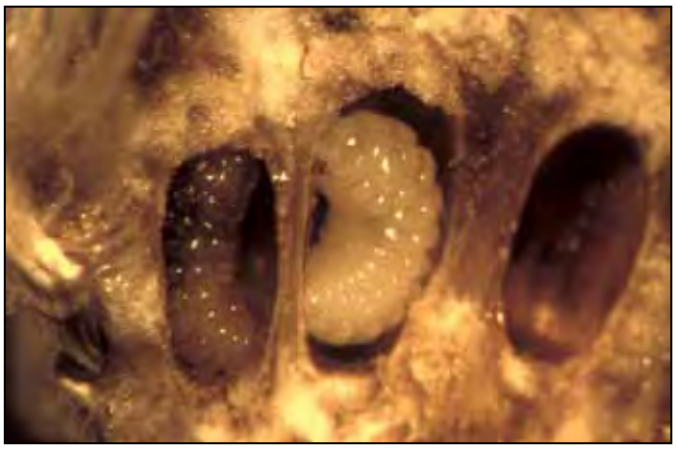


Figure 15. Gall-inducing larvae inside their galls, sliced flower-head collected at 15th of June at Alvena lindaräng.

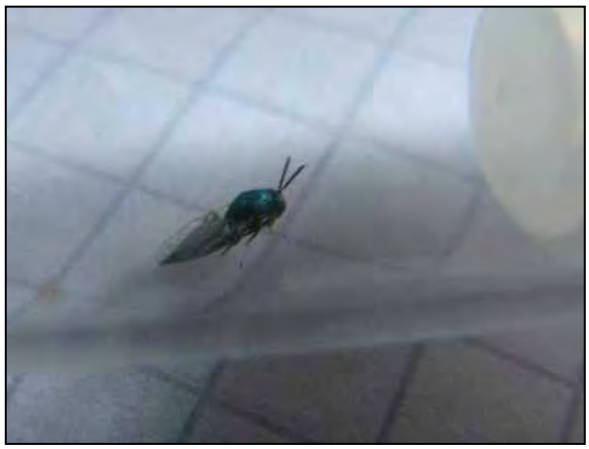
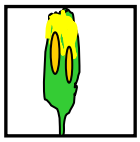


Figure 16. Chalcidoidea that emerged out of the dry galls by the end of June.

Inside the galls *Lepidoptera* larvae have been found (a and d) as well. It is possible that the *Lepidoptera* larvae use the hard gall-structure to hibernate. This may especially be adopted for the larvae d that were found inside the already dry and brown galls at 10th of July - at that time there was no seed tissue left to feed on. Observations made in June 2007 have shown that the *Lepidoptera* larvae are probably not able to enter the gall-chambers themselves formed by the modified seeds in which the gall-inducing larvae develop. They use the mutated tissue of the flower-heads around the seeds as well as not infested seeds to feed on (brown caterpillars a in June) and to stay and presumably to hibernate there (light green caterpillars that turned brown found in July d).

2.5.2. Not gall-inducing larvae



At the beginning of June a high percentage of flower-heads of *S. humilis* was infested with not gall-inducing larvae that were feeding on the seeds and in the pappus area (for more details see: “Collecting and slicing of flower-heads” and table 5). During July it became apparent that these larvae were associated with different insect orders. At the beginning of July wasps – belonging to the superfamily of Chalcidoidea - emerged out of the pappus area were they had spent their time as pupae. Other larvae that induced no galls fell out of the withered flower-heads around the end of June and buried themselves in the ground where they became brown pupae after some hours. Judged by the habitus of the pupae they are supposed to be flies. They perfectly fit the description of *Heterostylodes macrurus* (Anthomyidae – Diptera) in Colling and Matthies 2004 of the specific seed herbivore of *S. humilis.*

The buried pupae seem to hibernate in that state as the pupae of *Heterostylodes macrurus* (COLLING and MATTHIES 2004) do. During the slicing of flower-heads of *S. humilis* it was observed that not gall-inducing larvae have a special feeding pattern. Each individual feeds on one seed - they eat through it from its basis at the flower-head up to the outset of the pappus tissue. Then they fall to the ground (high percentage of the fly larvae) or they become pupae in the pappus area (few fly larvae and all wasp larvae). Particularly the wasp larvae (*Chalcidoidea*) modify the pappus tissue to form a “cloak” around them as pupae. The pappus tissue of the surrounding seeds is also affected: it gets concentrated, contracted and tightened – these seeds do not fly away either, they can be observed on the rests of the flower-heads until August (Gotland 2007). Outside it was not possible to detect any *Lepidoptera* larvae inside the modified pappus tissue but of the brown larvae a taken inside for rearing several used the pappus area, sometimes modified by wasps larvae, to build a light cocoon there to hibernate in. Whereas the gall-inducing larvae have been found with only a few up to very high numbers of individuals inside one flower-head of *S. humilis* on Gotland (in 2007), the not gall-inducing larvae perch with only one or up to a few (about four) individuals in one flower-head of their host plant.

Figure 17. Chalcidoidea-pupa sitting inside the modified tissue of the seed of *S. humilis*. The “coat”-structure that surrounds the pupa is caused by the feeding activity of the larva. Pupae were also found parching further upwards in the pappus area.

Figure 18. Fly larvae and pupae that fell out of withered flower-heads of *S. humilis* and buried themselves in the soil around middle of June.

2.6. Hypochoeris maculata

Throughout June and July high numbers of blossoms, withered flower-heads and clocks of *H. maculata* – the other possible host plant for the larvae of *E. scorzonerana* - were examined. They were taken from Lojsta Russpark / Botes källmyr and Visby Gudmyrskog but also from other randomly chosen localities. No kind of any infestation could be detected, there were no insect larvae feeding inside the ripening seeds of *H. maculate*. The seeds always looked untouched and later the completely empty seed-floors were observed everywhere – in blatant contrast to *S. humilis* the clocks of *H. maculata* had been formed by ripe and reproductive seeds that had completely flown away. Therefore it can be conditionally assumed that *Hypochoeris maculata* does not serve as a host plant for the caterpillars of *E. scorzonerana* on Gotland.

2.7. Comparisons

Two comparisons to decide about the significance of differences in counted numbers of the various breeds of larvae were conducted by employing basic statistical methods:

2.7.1. Comparison between pine forest sites and meadow habitats

The collecting and slicing of flower-heads of *S. humilis* was conducted at three pine forest sites: Visby Gudmyrskog, Träkumla and Grausne källmyr as well as at four meadow habitats: Anga prästänge, Othem korsänge, Öja prästänge and Alvena lindaräng. No significant difference can be observed between pine forest localities and meadow habitats regarding the amounts of gall-inducing larvae respectively not gall-inducing larvae (see also below: t-test). The most conspicuous result is that the brown caterpillars [a] were exclusively found in flower-heads that had been collected at pine forest sites (Visby Gudmyrskog, Träkumla). However, the number of samples is too small to test the significance of this observation statistically.

Table 8. Distribution of different kinds of infestation inside the collected flower-heads of *Scorzonera humilis* from pine forest sites and meadow habitats.

	collected flower-heads	gall-inducing larvae	%	not gall-inducing larvae	%	no infestation	%	brown larvae	%	grey larvae	%
pine forest	410	273	66,6	160	39,0	22	5,4	16	3,9	1	0,2
meadows	440	329	74,8	131	29,8	18	4,1	0	0	1	0,2

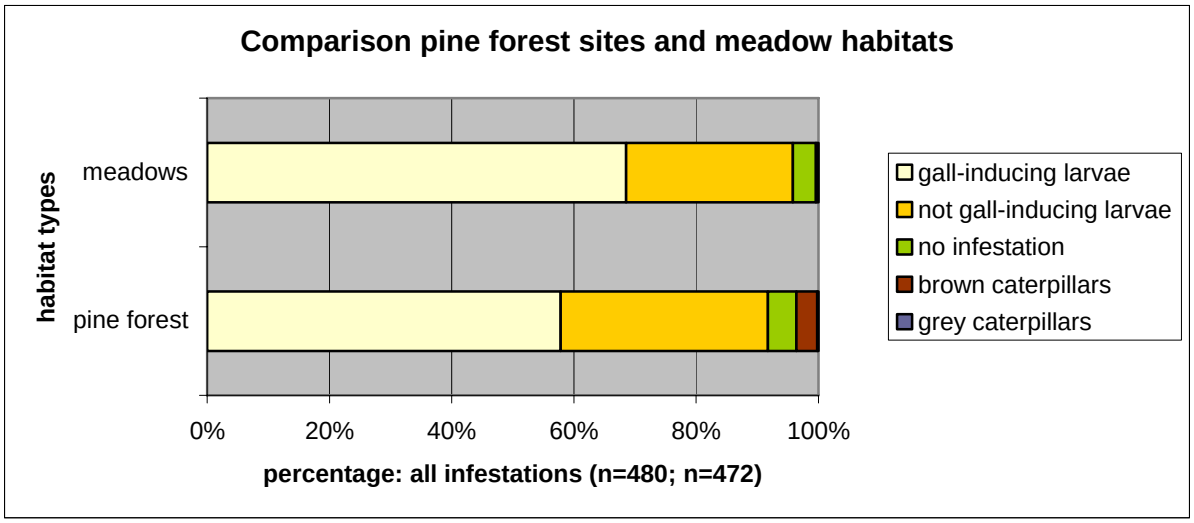


Figure 19. Visual comparison between the proportions of different sorts of infestation at pine forest localities and meadow habitats.

2.7.2. Comparison between the occurrences of caterpillars with versus without gall-inducing larvae

By applying the "χ^2-test statistic" in combination with "Yates' correction" (Fowler and Cohen 1990, p. 112-116) no significant difference between the distribution of caterpillars inside flower-heads with gall-inducing larvae versus without gall-inducing larvae were found.

3. DISCUSSION

3.1. Cage experiments

It is conjecturable that the females of *E. scorzonerana* do neither mate nor oviposit inside the cages used for this study. As the cages were placed inside the flight area over dense and vital plants of *S. humilis* that offered several flower heads inside each of the cages, conditions were supposed to be optimal for the moth. Potential unavailable resources could have been food plants for the adult moths, special features of required mating places or the lack of flight area respectively vegetation structure. There is also the alternative that the net of the cages was too compact and shaded the inside area, therewith alternating temperatures, moisture level and other essential premises for oviposition. The possibility that the moths escaped before the egg laying seems most unlikely because the cages did not provide facilities for escape.

As there were few flower-heads inside some of the cages that bore the characteristics of the caterpillars' feeding pattern and rests of their excrements it is also possible that the cage conception worked to some extent - but then the disappearance of the caterpillars from the vegetation as well as the entire cage area, including the soil, is even harder to explain.

The conduction of this study may have been an intervention in the reproduction rate of *E. scorzonerana* because of the unsuccessful employment of the cages. Therefore the use of cages is not recommendable for further studies of this species. The occurrence of other insect larvae, especially when appearing in high numbers of individuals, certainly means competition for food for the *Lepidoptera* caterpillars. But the induction of gall-structures that makes the flower-heads persistent over a longer time may also have positive effects. In the case of the caterpillars [d] found inside dry galls in July there is a closer interaction between the caterpillars and the gall-inducing larvae imaginable. It is likely that these *Lepidoptera* larvae use the modified tissue of the galled flower-heads for hibernation.

3.2. Habitat conditions

As Lojsta Russpark/ Botes källmyr is currently considered the best locality for *E. scorzonerana* on Gotland (GÖRAN PALMQVIST 24.07.07.), this area is supposed to provide presently almost optimal habitat conditions for the species (summers 2006/07). The young pine trees as well as other shrubs are growing fast and thus the site shifts towards a shaded locality with a cooler and therefore more humid microclimate. Such an alteration poses a considerable threat to the population of *E. scorzonerana* because under shaded conditions *S. humilis* will drastically reduce the number of flowers that are vital for the development of the caterpillars. To secure the survival of the population of *E. scorzonerana* in this area it will be necessary to enforce suitable management measures.

Figure 20. Dense upper-stratum of young pine trees at Lojsta Russpark/ Botes källmyr (25.09.2007).

The successful captures of moths at Lojsta Russpark/ Botes källmyr: pine forest edge/ clearing and at Visby Gudmyrskog: pine forest clearing and the unsuccessful efforts at two meadow sites: Öja prästänge and Lojsta prästänge indicate that *E. scorzonerana* is connected to pine forest habitats rather than meadows. This is confirmed – with reservation – by the fact that the brown caterpillars [a] that may belong to *E. scorzonerana* have only been found at pine forest sites: Visby Gudmyrskog, Träkumla and Lojsta Russpark/ Botes källmyr. With equally dense and rich-flowering populations of *S. humilis* the meadow sites provide conditions as good as the pine forest habitats for the development of the larvae under consideration of food-availability.

It is known from *macrolepidoptera*, however, that the density of the vegetation around the larvae's host plants is a crucial criterion for the choice of the exact oviposition location (plant). VOGEL (1998) found out that *Melitaea didyma* prefers plants of *Stachys recta*, on which its larvae feed, growing in sites with sparse vegetation (in AMLER et al. [ed.] 1999, p.112). It is possible that *E. scorzonerana* shows a similar preference for plants of *S. humilis* surrounded by the rather sparse vegetation of pine forest sites compared to the dense grasslands. Otherwise the pine forest areas may provide better resources for the adults.

The meso- and microclimate at the pine forest localities are in general remarkably drier and warmer than the average moisture level and temperatures of the meadow habitats. As *Microlepidoptera* like *Macrolepidoptera* mostly benefit from a warm and dry climate (BJÖRKLUND and PALMQVIST 2007), this may be the most decisive factor that determines favourable habitat conditions for *E. scorzonerana.* It is also possible that the small flying moths prefer the structure of vegetation less dense than the impenetrable grass and herb stratum of the meadows. The structure of the ground vegetation of edges or clearings in pine forests, in comparison, is mainly low and covered only by *Calluna vulgaris*, *Pinus sylvestris*, *Juniperus communis* as well as other bigger and smaller shrubs forming a loose upper stratum that is spatially absent. A vegetation composition as that of the pine forest sites certainly favours the flight characteristics of *Microlepidoptera* – nevertheless there are many small *Lepidoptera* species that live in meadow habitats regardless of the dense grass and herb strata.

Another resource that might be accessible only in pine forest habitats or rather more easily amenable there is the source of food for the adults. As the nutrition of most adult *Tortricids* is unidentified, it is impossible to verify this assumption. By comparing the lists of plant species of the different pine forest sites and meadows (see annex A-C) it becomes apparent that *Pinus sylvestris* (young and small trees), *Juniperus communis, Pteridium aquilinum* and *Melica nutans* are the species that have been found in all pine forest areas (Lojsta Russpark/ Botes källmyr, Visby Gudmyrskog and Träkumla) and that are at the same time absent from Othems korsänge and Lojsta prästänge. If the imagines of *E. scorzonerana* rely on a source of food (for example sap) that is provided by one of these plant species, this circumstance could be an explanation for its assumed connection to pine forest habitats.

3.3. *E. scorzonerana* and its relation to traditional meadow management

BJÖRKLUND and PALMQVIST (2007) assume that *E. scorzonerana* is an indicator species for traditional haymaking. Suitable management of meadows comprises extensive mowing to secure the bloom of the host plant and other plant species. Vital populations of *S. humilis* indicate such a qualified system of meadow maintenance. Thus *S. humilis* is used as a flagship species for traditional haymaking and extensively grazed pastures (cp. ERIKSSON et al. 1995). Whereas the species is more or less restricted to traditionally managed remnants of an old agrarian landscape on the Swedish mainland (ERIKSSON et al. 1995) it is growing in abundance in other habitat types like pine forest clearings and waysides on Gotland.

The results of this study suggest – with reservation - that *E. scorzonerana* is connected to pine forest habitats rather than meadows. Thus the analysis of the current findings seems to question the assumption that *E. scorzonerana* is a suitable indicator species for fresh meadows.
Instead, it may depend on a landscape mosaic of nature-oriented forestry that allows natural succession to overgrow clearing sites for several years. *E. scorzonerana* – like all other species that rely on light sites inside forest areas - certainly loses considerable amounts of suitable habitat through the practice of immediate reforestation.

As the main cause of the reduction in viable populations of *E. scorzonerana* the Action plan (BJÖRKLUND and PALMQVIST 2007) names the change from traditional small-scale agricultural practices towards modern rational, industrial farming methods. The new agricultural system ended the meadow

management tradition thus presenting a considerable threat to many meadow-dwelling species, including *S. humilis*. The results of this study show that the changes in forest management towards modern industrial forestry and timber production play at least an equally important role for the reduction in populations of *S. humilis* and *E. scorzonerana*, especially through the practice of reforestation.

3.4. Population size and risk of extinction

It is generally assumed that "small populations face a high risk of extinction and that with increasing population size the risk of extinction practically always decreases" (HANSKI 1999, p.144). All local populations of *E. scorzonerana* on Gotland can be defined as rather small (BJÖRKLUND and PALMQVIST 2007) and therefore face the risk of extinction due to environmental stochasticity (HANSKI 1999, p.32-36). NIEMINEN (1996) conducted a statistic study of the risk of population extinction in moths and found that "the pattern of population extinction in moths is affected by host plant characteristics rather than by the characteristics of the moths themselves" (NIEMINEN 1996). He defined "the important plant characteristics….. [as] the size and stability of host plant patches and especially the life history traits of the host plants". This can not be confirmed, though, for *E. scorzonerana* and *S. humilis* on Gotland. Whereas *S. humilis* grows in abundance all over the island in stable, dense and vital populations, *E. scorzonerana* is restricted to only few localities. Moreover, *S. humilis* is a long-lived perennial. Along NIEMINEN (1996), moths that rely on perennials as their larvae's host plants show decreasing extinction risks, because "perennials provide more stable and predictable resources for moths than annuals" (NIEMINEN 1996). It is concluded that the distribution and availability of *S. humilis* are not the only essential requirements for *E. scorzonerana*. To sustain this species there has to be an almost equally critical requisite – whether in the characteristics of the moth itself or in the interaction with other insects – to ensure its survival. The pattern of population extinction of *E. scorzonerana* is not, as generally suggested by NIEMINEN´s study, affected mainly by the host plant characteristics but also basically determined by other – still unknown - criterions.

3.5. Interactions between Lepidoptera caterpillars and other insect larvae

Interspecific interactions in ecosystems usually include the competition for the more or less limited resource of food. As the larvae of *E. scorzonerana* are (supposed to be) feeding monophagously on the ripening seeds of *S. humilis*, the moth relies on dense and rich blossoming populations of this species of *Asteraceae*. *S. humilis* does not spread clonally but by wind-dispersed seeds only (COLLING and MATTHIES 2006). As the seeds are large (ca. 2.6 mg) the dispersal is very limited (COLLING and MATTHIES 2006). COLLING and MATTHIES (2004) studied "The effects of plant population size on the interactions between the endangered plant *S. humilis*, a specialized herbivore, and a phytopathogenic fungus" (OIKOS 105: 71-78). They conclude that the systemic pathogen *Ustilago scorzonerae* and the seed-feeding fly *Heterostylodes macrurus* together have a considerable impact on the reproduction of *S. humilis*, especially in bigger populations (COLLING and MATTHIES 2004).

During summer 2007 on Gotland there have been found different kinds of larvae inside the flower-heads of *S. humilis*, among those insect larvae that perfectly fit the description of *Heterostylodes macrurus* in COLLING and MATTHIES (2004). But inside the flower-heads on Gotland there were also the larvae of a *Chalcidoidea* wasp feeding on the seeds as well as gall-inducing larvae inside the capitula – apart from the sporadic *Lepidoptera* caterpillars that had no noteworthy effect on the plant's reproduction because of their small numbers compared to the high quantity of blossoming flower-heads. Especially the gall-inducing larvae have an enormous impact on the reproduction of *S. humilis* with up to 100% of all collected flower-heads in some areas (especially meadow habitats) infested with gall-inducing larvae. As capitula that are infested with high numbers of these larvae (that is to say, a high percentage of the seeds of one flower-head hosts a larva) are easily identified from the outside (they are much broader and their tissue is extremely hard) it is very unlikely that, while conducting their study, COLLING and MATTHIES (2004) overlooked them. In their paper they calculate the impact of the fly and the fungus

on the successful seed production of *S. humilis* accurately – they did not stand a chance to ignore galled flower-heads if those had occurred also at their study sites in Luxembourg and Belgium. It is concluded that the gall-inducing larvae, maybe along with the *Chalcidoidea* species, are not distributed everywhere throughout Europe, presumably because populations of *S. humilis* in central Europe are too small and isolated (cp. COLLING and MATTHIES 2004). With high numbers of flower-heads infested with gall-inducing larvae on Gotland these larvae certainly have a strong influence on the reproduction of *S. humilis* and therefore also on the population structure and the numbers of blossoming flower-heads of the host plant. Additionally, all kinds of other insect larvae are competing with the caterpillars of *E. scorzonerana* for the seeds of *S. humilis* as their nutrition but there is also a mutualism between the gall-inducing larvae and the caterpillars imaginable.

3.6.Life cycle of a closely related species: *Eucosma obumbratana* (Lienig and Zeller, 1846) and possible analogies to *E. scorzonerana*

The larvae of *E. obumbratana* feed - like the caterpillars of *E. scorzonerana* - on the ripening seeds of plant species that belong to the family of *Asteraceae*. The larvae of *E. obumbratana* live inside the flower-heads of *Sonchus arvensis* and *Picris* in August and September. When fully fed, the larvae leave the flower-heads and construct cocoons in which they hibernate (BRADLEY et al. 1979, SVENSSON 2006). It is likely that the caterpillars of *E. scorzonerana* also leave the flower-heads of *S. humilis* after they have stopped feeding there. This seems to happen quite early in summer because after the middle of June investigated flower-heads of *S. humilis* contained no caterpillars anymore (with the exception of dry and brown galled flower-heads that held the caterpillars [d] at 10th of July at Lojsta Russpark / Botes källmyr). As the seeds of *S. humilis* are wind-dispersed the reproductive and ripe seeds fly away at the end of June and at the beginning of July (on Gotland, personal observation). All larvae that have lived inside the flower-heads of *S. humilis* before have to leave for gall-structures, other parts of the plant or the ground.

As the larvae of *E. obumbratana* feed inside their flower-heads until September, their time for hibernation starts much later. They leave their flower-heads and move to the soil. Inside the soil they spin a cocoon in which they stay over the winter and in which they also pupate in May and June (BRADLEY et al. 1979, SVENSSON 2006).

It has not yet been possible to find out where the caterpillars of *E. scorzonerana* hide after they have left their flower-heads – as early as June. It can be assumed that they also move into the soil but it was not feasible to detect them during summer 2007 while conducting the cage experiment. Therefore their hibernation localities as well as the time and the appearance of their pupae remain unidentified. The brown caterpillars [a] that may be the larvae of *E. scorzonerana* also spin a cocoon in which they stay motionless from the end of June and probably over the winter.

The flight period of the adult moths of *E. obumbratana* is set between July and August; they are active around sunset (BRADLEY et al. 1979, SVENSSON 2006). The adults of *E. scorzonerana* are not only active around sunset but also in the late afternoons and the early mornings (GÖRAN PALMQVIST 27.07.07). Their flight period is short and stretches between the end of May and the beginning of June (BJÖRKLUND and PALMQVIST 2007).

4. CONCLUSIONS

Within this study it was not possible to follow the life cycle of *E. scorzonerana.* Even though there was the typical feeding-pattern of *Lepidoptera* larvae along with excrements in some of the flower-heads inside the cages it was not possible to find out were the larvae went after they had left there respectively after the seeds had got ripe and been blown away.

4.1. Host plant

It is verified that the larvae of *E. scorzonerana* are probably not feeding on *H. maculata* on Gotland, because no insect larvae have been found sitting inside its flower-heads. By the time the seeds were ripe this observation was confirmed as the completely empty seed-floors served as prove that all seeds had been reproductive and uninfluenced by insect larvae. At Visby Gudmyrskog and Träkumla where the number of caterpillars inside the capitula of *S. humilis* was relatively high, there were no signs of caterpillars inside the inflorescences of *H. maculata*, thus certifying the contention.

Therefore *S. humilis* presumably serves as the only food plant for the larvae of *E. scorzonerana* on Gotland. It is distributed over the whole island and it is a common plant species in different habitat types. In contrast, the species has strongly declined and is now regarded as endangered in many parts of Europe (COLLING and MATTHIES 2002, 2004, 2006). As the main reasons for its decline in central Europe COLLING and MATTHIES identified "the use of fertilizers, drainage, land reclamation and the lack of suitable management in nature reserves" (COLLING and MATTHIES 2006).

On Gotland, where *S. humilis* still is a common plant, its distribution is neither restricted to wet, nutrient poor grassland and wet heathlands (COLLING and MATTHIES 2006) nor is it confined to "remnants of an "old" traditional landscape" (ERIKSSON, ERIKSSON and BERGLUND 1995) of semi-natural pastures and hay-meadows as on the Swedish mainland (ERIKSSON et al. 1995). On Gotland, where there are still great expanses of nutrient-poor ecosystems, *S. humilis* is flourishing also on drier soils at the edges or in glades of the basiphilous pine forest, along waysides and at meadow habitats.

The conditions for the specialised *Tortricids* species *E. scorzonerana* seem to be optimal at first sight but after studying the moth's distribution on the island – it is constantly known from only four locations - it becomes apparent that the larvae's food plant is not the only critical resource for the survival of *E. scorzonerana*.

4.2.General suggestions for management of habitat sites

During spring and summer 2007 it was not possible to examine the species´ life cycle extensively enough to give detailed recommendations for management schemes to optimise the habitat structures for *E. scorzonerana*. However, there are some more general suggestions that can be derived from the results of this study with the aid of the findings of the Action plan (BJÖRKLUND and PALMQVIST 2007):

1. The suggestion given in the Action plan (BJÖRKLUND and PALMQVIST 2007) to leave the larvae's host plant, *S. humilis*, uncut until at least the second half of July has to be reinforced. As though it was not possible to detect any caterpillars inside the rests of the flower-heads after 20th of June there was the significant exception of caterpillars d at 10th of July at Lojsta Russpark / Botes källmyr. As long as it is not confirmed what breed of caterpillars belongs to *E. scorzonerana* there remains an unforeseeable risk of damaging the populations of the species through any disturbance of suitable habitat sites – for example meadows or waysides that are dominated by rich-blossoming populations of *S. humilis*. Furthermore, it can be supposed that the flight period of *E. scorzonerana* started distinctly earlier in 2007 than it normally does in other years and that the larval development proceeded faster because of the exceptionally warm and dry weather conditions throughout spring and early summer. It can be concluded that under

cooler and moist weather conditions in spring and early summer the flight period begins about two weeks later (GÖRAN PALMQVIST, email 20.09.2007) and that the larval development takes longer. Therewith the caterpillars of *E. scorzonerana* could stay considerably longer inside the flower-heads of *S. humilis* and they could leave there significantly later. Therefore, at confirmed habitat sites of *E. scorzonerana* as well as at other potential suitable locations any kind of management like mowing, cutting, haymaking or grazing has to be delayed until the middle of August (GÖRAN PALMQVIST, email 20.09.2007, BJÖRKLUND and PALMQVIST 2007).

2. Lojsta Russpark/ Botes källmyr is presently the best site to host a stable population of *E. scorzonerana* on Gotland (GÖRAN PALMQVIST 24.07.07). But the optimal conditions for the moth will decline during the next years when the young pine trees grow higher and denser and begin to shade the area. The plants of *S. humilis* will continue to grow leaves but the numbers of blossoms will be reduced drastically in a shaded environment (personal observation). As the caterpillars of *E. scorzonerana* rely on the flower-heads to obtain food, it is advisable to take about 80% of all young pine trees out of the area and, if it seems necessary, a few of the other fast growing bushes.

3. At former clearing sites *S. humilis* is often flourishing in or beside holes that are otherwise more or less free of further vegetation (personal observation). COLLING, MATTHIES and RECKINGER (2002) recommend creating gaps in the vegetation cover of wet meadows to increase seedling establishment of *S. humilis*. After the implementation of forestry measures the wounded ground should not be levelled, because some disturbance of the soil may be beneficial to *S. humilis* and stimulate the regeneration of the plant's populations.

4. Ensuring the open habitat character of localities inside pine forest areas similar to the site at Lojsta Russpark/ Botes källmyr by clearing new-growing young pine trees is also a suitable measure to strengthen the populations of *Succisia pratensis*, host plant to the caterpillars of *Euphydryas aurinia.* Localities like Lojsta Russpark/ Botes källmyr with wet grounds can be considered suitable habitats for *E. aurinia* (GÖRAN PALMQVIST 24.07.07) – a species that is listed in Annex II FFH-Directive as a part of the Natura 2000-Directive. Habitats for this species have to be identified and protected by including them into the national network of Natura 2000-habitats. As *E. aurinia* is categorised as a species of Annex II FFH-Directive the effort to take out the young pine trees and the intervention in natural development – even inside nature reserves - can be justified more easily. *E. aurinia* is unlikely to live in the area at Lojsta Russpark/ Botes källmyr yet (GÖRAN PALMQVIST 24.07.07) but as the species forms true metapopulations (SETTELE et al. 2005, p.132), it is always necessary for the protection of the species to provide suitable but unoccupied habitat sites (HANSKI 1999, p.158).

5. Positive side-effects on other species that are achievable through the protection of *E. scorzonerana* include stimulating the populations of the gall-inducing insects inside the flower-heads of *S. humilis* as well as those of the presumably parasitizing wasps (*Chalcidoidea*) that emerged out of the galls in July. Furthermore, the not gall-inducing insects that feed in the pappus area benefit from any measures that are taken to strengthen the populations of *S. humilis* aimed at the protection of *E. scorzonerana*. Even though the gall-inducing insects as well as the not gall-inducing insects are very common in the great populations of *S. humilis* on Gotland, they may be considered as endangered in other parts of Europe where their host plant occurs only in small and isolated populations (COLLING and MATTHIES 2004). A list of species that also may benefit from management measures conducted to strengthen and to develop the populations of *E. scorzonerana* is given in (BJÖRKLUND and PALMQVIST 2007, it can be found in the annex: N)

6. In general, it is beneficial to the development of new populations of *E. scorzonerana* to reduce reforestation after the clearing of (pine) forests. Pine trees are wind-dispersed; their seeds are taken to clearing sites and germinate fast. During the time span required for natural development, *S. humilis* will find optimal habitat conditions for several years. A mosaic pattern of successive habitat sites with an abundance of *S. humilis* will benefit *E. scorzonerana* and secure the survival of the endangered moth species even if former locations with optimal conditions are lost due to natural succession.

4.3. Caterpillars

It can be conditionally assumed that the brown caterpillars [a] are the larvae of *E. scorzonerana*. They were found in confirmed flight areas of the species (Visby Gudmyrskog: caught individuals 2007; Träkumla: last evidence 1984) and they got ready for hibernation as early as the end of June. This presumption is not significantly objected by the fact that the first small brown larvae were found during the first week of June, directly after the flight period had been over and only about 12 days after the peak of activity of *E. scorzonerana*. The best argument to prove or to contradict this assumption would be the successful development of the fostered brown larvae. It is also possible that the caterpillars [d] that have been found on 10th of July at Lojsta Russpark / Botes källmyr inside the brown and dry, hard galls together with the gall-inducing larvae are the caterpillars of *E. scorzonerana.* As it was neither possible to find them at any other area nor on any other date it was impossible to gather further knowledge about their developmental biology.

4.4. Prospects

AS BJÖRKLUND and PALMQVIST (2007) recommend in their Action plan, it is necessary to conduct more research to gather further knowledge about the developmental biology of *E. scorzonerana*. Comprehensive cognition of the species´ life cycle is the precondition for the compilation and enforcement of detailed management schemes for suitable habitat areas. The long-term goal should be – as BJÖRKLUND and PALMQVIST suggest – an increase in habitat quality and area to create more stable and strong populations dispersed over the whole island.

ACKNOWLEDGEMENTS

I would like to thank in particular my tutor on Gotland, Oskar Kullingsjö and my German professor Erik Arndt for their assistance and encouragement. Many thanks to Göran Palmqvist for his great help; to Stellan Hedgren for scanning lots of slides; to Karolina and Tobias Johansson who provided not only accommodation but also much support and comfort and to all others working at Länsstyrelsen for their constant interest in my work. I also thank Guy Colling for his articles and his response to my queries; Manfred Kutscher for much aid and motivation as well as my family for their financial and spiritual help.

REFERENCES

Almqvist, L. [ed.] 2006. Dagfjärilar på Gotland. Länsstyrelsen Gotlands Län, Naturvårdsverket. Edita Västra Aros AB, Västerås.

Amler, K., Bahl, A., Henle, K., Kaule, G., Poschlod, P. and Settele, J. [ed.] 1999. Populationsbiologie in der Naturschutzpraxis. Verlag Eugen Ulmer, Stuttgart.

Björklund, J.-O. and Palmqvist, G. 2007?. Åtgärdsprogram för bevarande av småfjärilar på slåtteräng. Naturvårdsverket.

Bradley, J. D., Tremewan, W. G., Smith, A., Hargreaves, B. 1973. British Tortricoid Moths. Cochylidae and Tortricidae: Tortricinae. Ray Society, London.

Bradley, J. D., Tremewan, W. G., Smith, A., Hargreaves, B. 1979. British Tortricoid Moths. Tortricidae: Olethreutinae. Ray Society, London.

Colling, G., Matthies, D. and Reckinger, C. 2002. Population structure and establishment of the threatened long-lived perennial *Scorzonera humilis* in relation to environment. Journal of Applied Ecology 39: 310-320.

Colling, G. and Matthies, D. 2004. The effects of plant population size on the interactions between the endangered plant *Scorzonera humilis*, a specialized herbivore and a phytopathogenic fungus. Oikos 05: 71-78.

Colling, G. and Matthies, D. 2006. Effects of habitat deterioration on population dynamics and extinction risk of an endangered, long-lived perennial herb (*Scorzonera humilis*). Journal of Ecology 94: 959-972.

Coulianos, C.-C. and Holmåsen, I. 1991. Galler. En fälthandbok om gallbildningar på vilda och odlade växter. Interpublishing AB, Stockholm.

Eriksson, Å., Eriksson, O. and Berglund, H. 1995. Species abundance patterns of plants in semi-natural pastures. Ecography 18: 310-317. Copenhagen.

Fowler, J. and Cohen, L. 1990. Practical statistics for field biology. Open University Press.

Hanski, I. 1999. Metapopulation Ecology. Oxford University Press, Oxford.

Lüder, R. 2004. Grundkurs Pflanzenbestimmung. Quelle und Meyer Verlag, Wiebelsheim.

Kaltenbach, T. and Küppers, P. V. 1987. Naturführer Kleinschmetterlinge: beobachten-bestimmen. Neumann-Neudamm, Melsungen.

Kloth, J.-H. and Lovén, U. 2002. Field Guide to Outdoor Gotland. Gotlands Fornsals Förlag, Visby.

Mossberg, B. and Stenberg, L. 2003. Den nya nordiska Floran. Wahlström & Widstrand.

Müller, H. J. 1986. Bestimmung wirbelloser Tiere im Gelände. Bildtafeln für zoologische Bestimmungsübungen und Exkursionen. Gustav Fischer Verlag, Jena.

Nieminen, M. 1996. Risk of population extinction in moths: effect of host plant characteristics. Oikos 76: 475-484.

Oberdorfer, E. 1994. Pflanzensoziologische Exkursionsflora. 7. Auflage. E. Ulmer, Stuttgart.

Ohlsson, E. W. 2006. Det gotländska änget. Ödins förlag AB, Visby.

Ohrbach, K.-H. 2000. Dictionary of Ecology – Wörterbuch Ökologie. Wiley-Vch Verlag GmbH, Weinheim.

Scharnweber, W. 2005. Gotland: Impressionen einer Insel. Edition Temmen, Bremen. Settele, J., Steiner, R., Reinhardt, R. and Feldmann, R. 2005. Schmetterlinge – Die Tagfalter Deutschlands. Ulmer Naturführer, Verlag Eugen Ulmer, Stuttgart.

Spuler, A. 1983. Die Schmetterlinge Europas, Kleinschmetterlinge. 3. Bd. Schweizerbart, Stuttgart 1910. Bauer, Keltern 1983.

Stresemann, E., Senglaub, K. and Hannemann, H.-J. 1978. Exkursionsfauna für die Gebiete der DDR und der BRD. Band 2/1 Wirbellose: Insekten – Erster Teil. Verlag Volk und Wissen, Berlin.

Svensson, I. 2006. Nordens Vecklare – The Nordic Tortricidae. Entomologiska Sällskapet i Lund.

From Internet

Berner, U.; Streif, H. (Hrsg.) (2001): Klimafakten – Der Rückblick, ein Schlüssel für die Zukunft, 3. Aufl., Schweizerbart Verlag, Stuttgart.
http://www.bgr.bund.de/nn_333828/DE/Themen/Klimaentwicklung/Nat__Klimavariationen/Holozaen__Warmzeit/holozaen__warmzeit__node.html?__nnn=true [accessed 27 June 2007]

Bundesamt für Naturschutz (BfN) - German Federal Agency for Nature Conservation:
http://www.floraweb.de/pflanzenarten/artenhome.xsql?suchnr=5390& [accessed 30 July 2007]

Bundesamt für Naturschutz (BfN) - German Federal Agency for Nature Conservation, Prof. Dr. Michael Kleyer Landscape Ecology Group (Faculty 5) Carl von Ossietzky University of Oldenburg:http://www.leda-traitbase.org/LEDAfactsheet/search.jsp [accessed 30 July 2007]

Environmental Objectives Secretariat – Swedish Environmental Protection Agencyhttp://www.miljomal.nu/english/obj16.php [accessed 17.09.2007]

Gotlands Kommun, http://www.gotland.se/imcms/4312 [accessed 27 June 2007]

IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.IUCN 2001. IUCN Red List Categories and Criteria : Version 3.1
http://www.iucnredlist.org/info/categories_criteria [accessed 14.09.2007]
http://www.iucnredlist.org/info/categories_criteria2001 [accessed 14.09.2007]

LEO GmbH, http://dict.leo.org/ende?lp=ende&p=/gQPU.&search [accessed daily between 01.06.2007 and ….2008]

Länsstyrelsen Gotlands län, http://www.i.lst.se/i/om_lanet/gotland_fakta_.htm [accessed 14.09.2007]

Naturhistoriska riksmuseet, Arne and Anna-Lena Anderberg http://linnaeus.nrm.se/flora/ (updated 24 January 2007), [accessed between April and December 2007]

Naturhistoriska Riksmuseet, Bert Gustafsson (updated 09.01.2006)
http://www2.nrm.se/en/svenska_fjarilar/c/cnephasia_genitalana.html [accessed 09.10.2007]

Miller, Jeffrey C. 1995. Caterpillars of Pacific Northwest Forests and Woodlands. U.S. Department of Agriculture, Forest Service, National Center of Forest Health Management, Morgantown, West Virginia. FHM-NC-06-95. 80 pp. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/insects/catnw/index.htm, www.npwrc.usgs.gov/.../insects/catnw/fig1.gif (updated 21.04. 2000), [accessed 20.09.07]

Ruppert EE, Fox RS, Barnes RB. 2004**.** Invertebrate Zoology, A functional evolutionary approach, 7th ed. Brooks Cole/Thomson, Belmont, CA. 963 pp + index. Lander University Greenwood, South Carolina. http://webs.lander.edu/rsfox/invertebrates/papilio.html[accessed 20.09.07]

Swedish Environmental Protection Agency,
http://www.internat.naturvardsverket.se/ [accessed 17.09.2007]
http://www.naturvardsverket.se/Documents/bokhandeln/hotadearter.htm[accessed 08.10.2007]

The Norwegian Biodiversity Information Centre - Artsdatabanken
2006http://www2.artsdatabanken.no/rodlistesok/Artsinformasjon.aspx?ArtsId=8053[accessed 09.10.2007]

The South African National Biodiversity Institute, Author P.P.J. Herman, National Herbarium, Pretoria, April 2004.
http://www.plantzafrica.com/plantab/asteraceae3.htm (updated 25.01.2006), [accessed 27 June 2007]

The Swedish Species Information Centre – ArtDatabanken
http://www.artdata.slu.se/english/about.asp [accessed 14.09.2007]

The Swedish Species Information Centre - ArtDatabanken
http://www.artdata.slu.se/rodlista/RodSvar.cfm [accessed 14.09.2007]

ANNEX

Lists of plant species

List of plant species – Lojsta Russpark/ Botes källmyr 27.05.07

Anemone nemorosa
Anthericum ramosum
Asperula tinctria
Campanula rotundifolia
Carex flacca
Carex montana
Carex panicea
Conallaria majalis
Filipendula vulgaris
Galium boreale
Geranium sanguineum
Geranium sylvaticum
Gymnadenia conopsea var. densiflora
Gymnadenia odoratissima
Hepatica nobilis
Hypochoeris maculata
Listera ovata
Luzula campestris
Melica nutans
Molinia caerulea
Orchis mascula
Platanthera bifolia
Polygala amarella
Polygonatum odoratum
Potentilla erecta
Pteridium aquilinum
Ranunculus acris
Scorzonera humilis
Sesleria caerulea
Succisia pratensis

Betula pendula
Calluna vulgaris
Frangula alnus
Juniperus communis
Pinus sylvestris
Rubus spec.
Sorbus aucuparia
Sorbus intermedia
Vaccinium vitis-idaea
Viburnum opulus

List of plant species - Visby Gudmyrskog 03.06.07

Asperula tinctoria
Avenella flexuosa
Avenula pratensis
Brachypodium pinnatum agg.
Calamagrostis epigejos
Campanula rotundifolia
Festuca ovina agg.
Filipendula vulgaris
Galium boreale
Galium verum
Geranium sanguineum
Melica nutans
Poa pratensis
Pteridium aquilinum
Scorzonera humilis
Solidago virgaurea
Taraxacum officinale agg.
Tragopogon pratensis

Arctostaphylos uva-ursi
Calluna vulgaris
Frangula alnus
Juniperus communis
Pinus sylvestris
Quercus robur
Rubus spec.
Sorbus aucuparia
Sorbus intermedia

List of plant species Othem korsänge 10.06.07

Anemone nemorosa
Anthoxanthum odoratum
Anthyllis vulneraria
Asperula tinctoria
Avenula pratensis
Briza media
Campanula rotundifolia
Carex flacca
Carex panicea
Carex sylvatica
Cynosurus cristatus
Dactylis glomerata
Epipactis helleborine agg.
Filipendula ulmaria
Filipendula vulgaris
Galium boreale
Geranium sylvaticum
Geum rivale
Gymnadenia conopsea var. conopsea

Helianthemum nummularium
Hepatica nobilis
Hypochoeris maculata
Inula salicina
Listera ovata
Lotus corniculatus
Luzula campestris
Orchis mascula
Orchis militaris
Orchis ustulata
Paris quadrifolia
Plantago lanceolata
Platanthera bifolia
Polygala amarella
Potentilla erecta
Primula veris
Ranunculus acris
Rhinanthus angustifolius
Sagina nodosa
Scorzonera humilis
Sesleria caerulea
Taraxacum officinale agg.
Tragopogon pratensis
Trifolium montanum
Trifolium pratense

Betula pendula
Corylus avellana
Frangula alnus
Fraxinus excelsior
Juniperus communis
Pinus sylvestris
Populus tremula
Quercus robur
Rubus spec.

Capture records

date: 25.05.07	**area (nr.):** Lojsta Russpark/ Botes källmyr
time: 18.15-21.00	**light conditions:**
exact locality:	eastern edge of Botes källmyr next to the road/ cages-site
description of locality: **(plant species, Scorz. hum.)**	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	cloudy, very warm, windy, obviously rain coming
captures of moth: **(number/ all species)**	**comments:**
captures of *Eucosma scorzonerana* **(E.s.):** 25 **(number)**	**comments:** together with GÖRAN PALMQVIST and OSKAR KULLINGSJÖ / many more sightings!
E.s. females: ?	**E.s. males:** ?
exact time: captures of E.s. **(f-female/ m-male)**	
cages: situated on 26.05. **(number)**	**comments/ description of position:** 8 (of 10) at the eastern edge of Botes källmyr = west of the path; 2 east of the path
cage 1 – females: ? at all 5 (sun)	*Scorzonera humilis*: 3 flower buds+3 flowers+2 withered flowers; proximity: *Pinus, Calluna*
cage 2 – females: ? at all 5 (sun)	*Scorzonera humilis*: 3 flower buds+6 flowers+4 withered flowers; proximity: big stones, *Juniperus, Filipendula vulgaris*
cage 3 – females: ? at all 5 (sun)	*Scorzonera humilis*: 1 flower buds+4 flowers; proximity: *Pinus, Juniperus, Sesleria caerulea*
cage 4 – females: ? at all 3 (sun)	*Scorzonera humilis*: 5 flowers+4 withered flowers; proximity: *Calluna, Betula pendula, Pinus, Sesleria caerulea*
cage 5 – females: (shade)	*Scorzonera humilis*: 2 flower buds+5 flowers; proximity: *Calluna, Pteridium, Sorbus aucuparia, Pinus, Frangula alnus*
cage 6 – females: (sun)	*Scorzonera humilis*: 5 flower buds+2 withered flowers; proximity: Frangula alnus, *Pinus, Rubus, Sesleria caerulea*
cage 7 – females: (shade)	*Scorzonera humilis*: 3 flower buds+1 flower; proximity: *Pinus, Filipendula vulgaris, Rubus, Sesleria caerulea*
cage 8 – females: (shade)	*Scorzonera humilis*: 4 flower buds+1 flower; proximity: *Pinus, Filipendula vulgaris, Asperula tinctoria, Convallaria, Calluna*
cage 9 – females: (shade)	*Scorzonera humilis*: 3 flower buds; proximity: *Juniperus, Geranium sanguineum, Sesleria caerulea, Filipendula vulgaris*
cage 10 – females: (shade)	*Scorzonera humilis*: 2 flower buds+1 flower; proximity: *Juniperus, Galium sanguineum, Sesleria caerulea, Arcostaphylos uva-ursi, Calluna*

date: 26.05.07	**area (nr.):** Lojsta Russpark/ Botes källmyr
time: 18.30-21.30	**light conditions:** bright
exact locality:	eastern edge of Botes källmyr next to the road/ cages-site
description of locality: **(plant species, Scorz. hum.)**	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	pure sunshine, from 20.00 clouds
captures of moth: **(number/ all species)**	**comments:**
captures of *Eucosma scorzonerana* (E.s.): 8 **(number)**	**comments:** not nearly as many around as on 25.05.!
E.s. females: 1	**E.s. males:** 7
exact time: captures of E.s. **(f-female/ m-male)**	19.35 / 19.40 / 19.50 / 20.00 / 20.05 / 20.15 / 20.20 / 20.45
cages: **(number)**	**comments/ description of position:**
cage 1 – females:	
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	no females, three males
cage 6 – females:	one female, four males
cage 7 – females:	
cage 8 – females:	
cage 9 – females:	
cage 10 – females:	

date: 27.05.07	**area (nr.):** Lojsta Russpark/ Botes källmyr
time: 18.00-21.00	**light conditions:** bright/ from 20.00 gloomy
exact locality:	eastern edge of Botes källmyr next to the road/ cages-site
description of locality: **(plant species, Scorz. hum.)**	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	sun, light clouds/ from 20.00 dark clouds
captures of moth: **(number/ all species)**	**comments:**
captures of *Eucosma scorzonerana* (E.s.): 6 **(number)**	**comments:**
E.s. females: 3	**E.s. males:** 3
exact time: captures of E.s. **(f-female/ m-male)**	18.25 (m) / 19.00 (m) / 19.15 (m) / 19.30 (f) / 19.45 (f) / 20.00 (f) / cage-work / sighting on flower bud of *Scorzonera humilis*
cages: **(number)**	**comments/ description of position:**
cage 1 – females:	
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	two females, one male
cage 8 – females:	one female, one male
cage 9 – females:	
cage 10 – females:	

date: 28.05.07	**area (nr.):** Lojsta Russpark/ Botes källmyr
time: 17.45-21.00	**light conditions:** bright
exact locality:	eastern edge of Botes källmyr next to the road/ cages-site
description of locality: **(plant species, Scorz. hum.)**	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	pure sunshine
captures of moth: 38 **(number/ all species)**	**comments:**
captures of *Eucosma scorzonerana* (E.s.): 9 **(number)**	**comments:**
E.s. females: 7	**E.s. males:** 2
exact time: captures of E.s. **(f-female/ m-male)**	17.50 (f) / 19.15 (f) / 20.10 (m) / 20.45 (m) / 20.50 (f) / 20.55 (f) / 21.10 (f) / 21.15 (f)
cages: **(number)**	**comments/ description of position:**
cage 11 – females: 1&1male (shade)	*Scorzonera humilis*: 8 flower buds+1 flower+2 withered flowers; proximity: *Pinus, Calluna, Potentilla erecta, Pteridium*
cage 12 – females: 2&1male (shade)	*Scorzonera humilis*: 5 flower buds+2 flowers; proximity: *Calluna, Frangula, Rubus, Pinus, Pteridium*
cage 13 – females: 1	*Hypochoeris maculata*: 20 flower buds, proximity: very sparse vegetation! *Filipendula vulgaris*
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	
cage 8 – females:	
cage 9 – females: 1 (shade)	**cage 2 – females:** 1 (sun)
cage 10 – females: 1 (shade)	

date: 30.05.07	**area (nr.):** Öja prästänge and other meadows around
time: 17.00-18.15	**light conditions:** gloomy
exact locality:	Öja prästänge
description of locality: **(plant species, Scorz. hum.)**	species-rich änge; traditionally managed; Orchids; *Scorzonera humilis* in dense clusters in the back part, in the front part only very sparsely distributed
weather conditions:	very foggy, cool, windy
captures of moth: 10 **(number / all species)**	**comments:** altogether only very few moths around!
captures of *Eucosma scorzonerana* (E.s.): 0 **(number)**	**comments:**
E.s. females:	**E.s. males:**
exact time: captures of E.s. **(f-female / m-male)**	
cages: **(number)**	**comments / description of position:**
cage 1 – females:	
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	
cage 8 – females:	
cage 9 – females:	
cage 10 – females:	

date: 30.05.07	**area (nr.):** Lojsta Russpark/ Botes källmyr/ / analogy to Öja prästänge
time: 18.45-20.00	**light conditions:** gloomy
exact locality:	eastern edge of Botes källmyr next to the road/ cages-site
description of locality: (plant species, Scorz. hum.)	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	very foggy, cool
captures of moth: (number/ all species)	**comments:** high percentage of *Pyralidae*
captures of *Eucosma scorzonerana* (E.s.): 5 **(number)**	**comments:**
E.s. females: 3	**E.s. males:** 2
exact time: captures of E.s. **(f-female/ m-male)**	19.00 (f) / 19.10 (m) / 19.20 (f) / 19.40 (f) / 19.45 (m)
cages: (number)	**comments/ description of position:**
cage 1 – females:	
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	
cage 8 – females:	
cage 9 – females:	one female
cage 10 – females:	one male, one female

date: 01.06.07 / cage-control	**area (nr.):** Lojsta Russpark/ Botes källmyr
time: 15.00-17.00	**light conditions:** gloomy
exact locality:	cage-site
description of locality: **(plant species, Scorz. hum.)**	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	light rain, very windy
captures of moth: 0 **(number/ all species)**	**comments:** weather-conditions
captures of *Eucosma scorzonerana* (E.s.): 0 **(number)**	**comments:** weather-conditions
E.s. females:	**E.s. males:**
exact time: captures of E.s. **(f-female/ m-male)**	
cages: control! **(number)**	**comments/ description of position:**
cage 1 – females:	-
cage 2 – females:	-
cage 3 – females:	broad and hard withered blossoms (also out of the cage)
cage 4 – females:	-
cage 5 – females:	-
cage 6 – females:	broad and hard withered blossoms (also out of the cage)
cage 7 – females:	-
cage 8 – females:	broad and hard withered blossoms (also out of the cage)
cage 9 – females:	broad and hard withered blossoms (also out of the cage)
cage 10 – females:	broad and hard withered blossoms (also out of the cage)

date: 03.06.07	**area (nr.):** Visby Gudmyrskog
time: 17.00 – 19.30	**light conditions:** bright
exact locality:	near electricity-line
description of locality: **(plant species, Scorz. hum.)**	Pine-forest clearing, *Pinus, Junipeus, Quercus, Sorbus intermedia* emerging trees, *Calluna*, much more grasses than at 1a; *Scorzonera humilis* in scattered patches (not as dense as at 1a)
weather conditions:	pure sunshine, warm, very windy
captures of moth: 23 **(number / all species)**	**comments:** high percentage of *Pyralidae*
captures of *Eucosma scorzonerana* (E.s.): 1 **(number)**	**comments:** flying-period over? Blossoming-period of *Scorzonera humilis* (nearly) over!
E.s. females: 1	**E.s. males:**
exact time: captures of E.s. **(f-female / m-male)**	18.50
cages: **(number)**	**comments / description of position:**
cage 14 – females:	one female (03.06.)
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	
cage 8 – females:	
cage 9 – females:	
cage 10 – females:	

date: 04.06.07	**area (nr.):** Lojsta Russpark/ Botes källmyr
time: 17.30 – 19.30	**light conditions:** bright
exact locality:	eastern edge of Botes källmyr next to the road/ cages-site
description of locality: **(plant species, Scorz. hum.)**	border of nature reserve, pine-forest clearing next to a calcareous flush fen area; *Scorzonera humilis* everywhere in very dense and expanded clusters
weather conditions:	pure sunshine
captures of moth: 38 **(number/ all species)**	**comments:** high percentage of *Pyralidae*
captures of *Eucosma scorzonerana* (E.s.): 1 **(number)**	**comments:** flying-period over?
E.s. females: 1	**E.s. males:**
exact time: captures of E.s. **(f-female/ m-male)**	18.45
cages: **(number)**	**comments/ description of position:**
cage 1 – females:	
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	
cage 8 – females:	
cage 9 – females:	
cage 10 – females:	

date: 04.06.07	**area (nr.):** Lojsta prästänge
time: 19.45 - 21.00	**light conditions:** bright
exact locality:	
description of locality: **(plant species, Scorz. hum.)**	species-rich änge with sunny glades and shady places; traditionally managed; Orchids; *Scorzonera humilis* quite dense in parts of the änge where the soil is more humid
weather conditions:	pure sunshine
captures of moth: 9 **(number / all species)**	**comments:** altogether significantly less moth around compared to 1a (at the same evening)
captures of *Eucosma scorzonerana* (E.s.): none **(number)**	**comments:** flying-period over!
E.s. females:	**E.s. males:**
exact time: captures of E.s. **(f-female / m-male)**	
cages: **(number)**	**comments / description of position:**
cage 1 – females:	
cage 2 – females:	
cage 3 – females:	
cage 4 – females:	
cage 5 – females:	
cage 6 – females:	
cage 7 – females:	
cage 8 – females:	
cage 9 – females:	
cage 10 – females:	

List of species that also may benefit from management measures aiming at *Eucosma scorzonerana* (björklund and palmqvist 2007):

Euphydryas aurina (VU) [Väddnätfjäril]
Scopula virgulata (EN) [Snedstreckad lövmätare]
Atralata albofascialis (NT) [Krisslesorgmott]
Odaematophorus vafradactylus (VU) [Gråbenkrisslefjädermott]
Odaematophorus lithodactylus [Allmänt krisslefjädermott]
Tebenna bjerkandrella [Krisslegnidmal]
Coleophora conyzae (NT) [Skarplinjerad krisslesäckmal]
Apodia bifractella [Krisslekorgmal]
Epiblema obscurana [Krisslestjälkvecklare]
Ebulea crocealis [Guldgult krisslemott]
Cassida murraea (NT) [Svartbent sköldbagge]
Nemophora cupriacella (EN) [Väddantennmal]
Nemophora minimella [Kärrantennmal]
Levipalpus hepatariella (VU) [Leverplattmal]
Scrobipalpa murinella (NT) [Kattfotsmåstävmal]
Platyptilia tesseradactyla (NT) [Kattfotfjädermott]
Hemaris tityus (NT) [Svävflugelik dagsvärmare]
Antennaria dioica [Kattfot]
Succisa pratensis [Ängsvädd]

Scientific	English	Svenska	Deutsch
Anemone nemorosa	Wood Anemone	Vitsippa	Buschwindröschen
Anthericum ramosum	St Bruno´s Lily	Liten Sandlilja	Ästige Graslilie
Anthoxanthum odoratum	Sweet Vernal-grass	Vårbrodd	Gewöhnliches Ruchgras
Anthyllis vulneraria	Kidney Vetch	Getväppling	Wundklee
Arctostaphylos uva-ursi	Alpine Bearberry	Mjölon	Echte Bärentraube
Asperula tinctoria	\	Färgmåra	Färber-Meier
Avenella flexuosa	Wavy Hair-Grass	Kruståtel	Drahtschmiele
Avenula pratensis	Meadow oat-grass	Ängshavre	Echter Wiesenhafer, Trifthafer
Betula pendula	Birch Tree	Vårtbjörk	Hänge-Birke
Brachypodium pinnatum	False Brome	Backskafting	Fiederzwenke
Briza media	Quaking Grass	Darrgräs	Zittergras
Calamagrostis epigejos	Wood Small-reed	Bergrör	Land-Reitgras
Calluna vulgaris	Heather	Ljung	Heidekraut
Campanula persicifolia	Peached-leaved Bellflower	Stor Blåklocka	Pfirsichblättrige Glockenblume
Campanula rotundifolia	Harebell	Blåklocka	Rundblättrige Glockenblume
Carex flacca	Glaucous Sedge	Slankstarr	Blaugrüne Segge
Carex montana	Soft-leaved Sedge	Lundstarr	Berg-Segge
Carex panicea	Carnation Sedge	Hirsstarr	Hirse-Segge
Carex sylvatica	Wood Sedge	Skogsstarr	Wald-Segge
Convallaria majalis	Lily of the Valley	Liljekonvalj	Maiglöckchen
Corylus avellana	Hazel	Hassel	Hasel
Cynosurus cristatus	Crested Dogstail	Kamäxing	Weide-Kammgras
Dactylis glomerata	Cocksfoot	Hundäxing	Gewöhnliches Knaulgras
Deschampsia cespitosa	Tufted Hair-grass	Tuvtåtel	Rasen-Schmiele
Epipactis helleborine agg.	Broad-leaved Helleborine	Skogsknipprot	Breitblättrige Sitter
Epipactis palustris	Marsh Helleborine	Kärrknipprot	Sumpf-Sitter
Festuca ovina agg.	Sheep´s Fescue	Fårsvingel	Schaf-Schwingel (Gruppe)
Filipendula ulmaria	Meadowsweet	Älgört	Großes Mädesüß
Filipendula vulgaris	Dropwort	Brudbröd	Kleines Mädesüß
Frangula alnus	Alder Buckthorn	Brakved	Faulbaum

Fraxinus excelsior	Ash Tree	Ask	Esche
Galium boreale	Northern Bedstraw	Vitmåra	Nordisches Labkraut
Galium verum	Lady´s Bedstraw	Gulmåra	Echtes Labkraut
Geranium sanguineum	Bloody Cranesbill	Blodnäva	Blut-Storchschnabel
Geranium sylvaticum	Wood Cranesbill	Midsommarblomster	Wald-Storchschnabel
Geum rivale	Water Aven	Humleblomster	Bach-Nelkenwurz
Gymnadenia conopsea	Fragrant Orchid	Brudsporre	Große Händelwurz
Gymnadenia conopsea var. densiflora	\	Stor Brudsporre	\
Gymnadenia odoratissima	Short-spurred Fragrant Orchid	Luktsporre	Kleine Händelwurz
Helianthemum nummularium	Common Rock Rose	Solvända	Gewöhnliches Sonnenröschen
Hepatica nobilis	Hepatica	Blåsippa	Leberblümchen
Hypochoeris maculata	Spotted Catsear	Slåtterfibbla	Geflecktes Ferkelkraut
Inula salicina	Irish Fleabane	Krissla	Weidenblättriger Alant
Juniperus communis	Juniper	En	Gemeiner Wacholder
Listera ovata	Common Twayblade	Tvåblad	Großes Zweiblatt
Luzula campestris	Field Wood-rush	Knippfryle	Feld-Hainsimse
Melica nutans	Mountain Melick	Bergslok	Nickendes Perlgras
Molinia caerulea	Purple Moor-grass	Blåtåtel	Pfeifengras
Nardus stricta	Mat-grass	Stagg	Borstgras
Orchis mascula	Early Purple Orchid	Sankt Pers Nycklar	Stattliches Knabenkraut
Orchis militaris	Military Orchid	Johannesnycklar	Helm-Knabenkraut
Orchis ustulata	Burnt Orchid	Krutbrännare	Brand-Knabenkraut
Paris quadrifolia	Herb Paris	Ormbär	Vierblättrige Einbeere
Pinus sylvestris	Pine Tree	Tall	Wald-Kiefer
Plantago lanceolata	Ribwort Plantain	Svartkämpar	Spitz-Wegerich
Platanthera bifolia	Lesser Butterfly-orchid	Nattviol	Weiße Waldhyazinthe
Platanthera chlorantha	Greater Butterfly-orchid	Grönvit Nattviol	Grünliche Waldhyazinthe
Poa nemoralis	Wood Meadow-grass	Lundgröe	Hain-Rispengras
Poa pratensis	Narrowleaved Meadow-grass	Ängsgröe	Wiesen-Rispengras
Polygala amarella	Dwarf Milkwort	Rosettjungfrulin	Sumpf-Kreuzblümchen
Polygonatum odoratum	Angular Solomon´s Seal	Getrams	Duftende Weißwurz

Populus tremula	Aspen	Asp	Zitter-Pappel
Potentilla erecta	Tormentil	Blodrot	Blutwurz
Primula veris	Cowslip	Gullviva	Wiesen-Schlüsselblume
Prunus spinosa	Blackthorn	Slån	Schlehe
Pteridium aquilinum	Bracken	Örnbräken	Adlerfarn
Quercus robur	Oak Tree	Ek	Stiel-Eiche
Ranunculus acris	Meadow Buttercup	Smörblomma	Scharfer Hahnenfuß
Rhinanthus angustifolius	\	Höskallra	Großer Klappertopf
Rubus spec.	Bramble/ Blackberry	Björnbär	Brombeere
Sagina nodosa	Knotted Pearlwort	Knutnarv	Knotiges Mastkraut
Salix caprea	Goat Willow	Sälg	Sal-Weide
Scorzonera humilis	Viper's-grass	Svinrot	Niedrige Schwarzwurzel
Senecio jacobaea	Common Ragwort	Ståndsl	Jakobs-Greiskraut
Sesleria caerulea/ albicans	Blue Moor Grass	Älväxing	Kalk-Blaugras
Solidago virgaurea	Goldenrod	Gullris	Gewöhnliche Goldrute
Sorbus aucuparia	Rowan	Rönn	Eberesche/ Vogelbeere
Sorbus suecica/ intermedia	Whitebeam	Oxel	Schwedische Mehlbeere
Stachys recta	Stiff Hedgenettle	Styvsyska	Aufrechter Ziest
Succisa pratensis	Devilsbit Scabious	Ängsvädd	Teufelsabbiß
Taraxacum	Dandelion, Priests Crown	Maskrosor	Löwenzahn
Tragopogon pratensis	Yellow Salsify	Ängshaverrot	Großer Bocksbart
Trifolium montanum	Mountain Clover	Backklöver	Berg-Klee
Trifolium pratense	Red Clover	Rödklöver	Rot-Klee/Wiesen-Klee
Ulmus minor/ carpinifolia	Small-leaved Elm	Lundalm	Feld-Ulme
Vaccinium myrtillus	Bilberry	Blåbär	Heidelbeere
Vaccinium vitis-idaea	Whortleberry/ Cowberry	Lingon	Preiselbeere
Viburnum opulus	Guelder-rose	Olvon	Gewöhnlicher Schneeball

Eucosma obumbratana	/	Fettistelfrövecklare	/
Eucosma scorzonerana	/	Svinrotvecklare	/
Euphydryas aurinia	Marsh fritillary butterfly	Väddnätfjäril	Goldener Scheckenfalter
Cnephasia genitalana	/	Småprickig Gråvecklare	/
Melitaea didyma	Spotted Fritillary	Fläckig Nätfjäril	Roter Scheckenfalter
Tortricidae	Tortrix / Twist	Vecklare	Wickler
Chalcidoidea	Chalcidoid wasps	Glanssteklar	Erzwespen