Journal of Applied Entomology

WILEY

JOURNAL OF APPLIED ENTOMOLOGY

ORIGINAL ARTICLE OPEN ACCESS

Geographic Distribution, Flight Phenology and Infestation Level of the Lepidopteran Pests *Euhyponomeutoides albithoracellus*, *Lampronia capitella* and *Synanthedon tipuliformis* on Black Currants in Northern Europe

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Received: 13 February 2025 | **Revised:** 18 April 2025 | **Accepted:** 5 May 2025

Funding: This study was supported by grants from the Swedish Farmers' Foundation for Agricultural Research (grant number O-20-20-452), the Research Council of Norway (grant number 34631/L10) and the European Agricultural Fund for Rural Development (EAFRD) (grant number 145143).

Keywords: crop damage | Lepidoptera | monitoring | pest management | pheromone trap | *Ribes nigrum*

ABSTRACT

The currant bud moth, *Euhyponomeutoides albithoracellus*, the currant shoot borer, *Lampronia capitella* and the currant clearwing, *Synanthedon tipuliformis*, are destructive pests on currants in the Nordic countries, but detailed information about their relative abundance in commercial crop fields is lacking. We used pheromone-baited monitoring traps to analyse the presence and flight period of the three species in 28 commercial black currant fields in Finland, Norway and Sweden during 4 years. We also estimated moth-induced damage in the same fields and analysed within- and between-generation relationships of catches and damage to find patterns to predict current and future pest pressures. At least two of the species were found at all sites. The shoot borer was the most widespread and abundant species, followed by the clearwing, which was relatively common at all sites except in northern Sweden, whereas the bud moth was not detected at all in Norway and southern Sweden. Geographic variation in flight phenology was observed for both the shoot borer and the clearwing. We found a significant positive correlation in all between-year analyses of damage and in most between-year analyses of catches, but a less consistent pattern when relating catches to damage within and between generations. Combining catch and damage data may be a useful tool to predict future overall infestation levels of the three pests in black currant fields in the Nordic countries.

1 | Introduction

Currants (*Ribes* spp), mainly black currant (*Ribes nigrum* L.), are small but important high-value crops, which have received a lot of attention from health and nutrition scientists for their high levels of vitamins and antioxidants. Currants are cultivated in most European countries, including northern Europe. A wide range of diseases and pests is associated with this crop, but there is still limited knowledge about how the composition of these species in cultivation fields varies across Europe and how it impacts the berry yield and decisions about plant protection measures. Mitchell et al. (2011) reviewed the arthropod pests associated with currant production in the UK, where the black currant leaf curling midge, *Dasineura tetensi*

(Rübsaamen), the black currant gall mite, *Cecidophyopsis ribis* (Westwood) and the currant aphid, *Hyperomyzus lactucae* (L.), were listed as the most important species. In contrast, two lepidopteran species not on the UK list are important pests in currant cultivation in northern Europe: the currant shoot borer, *Lampronia capitella* (Clerck) (Prodoxidae), and the currant bud moth, *Euhyponomeutoides albithoracellus* Gaj (syn. *Kessleria rufella* (Tengström)) (Yponomeutidae). A third moth, the currant clearwing, *Synanthedon tipuliformis* (Clerck) (Sesiidae), is considered a global pest on currants, including the UK and northern Europe (Ozolina-Pole et al. 2013; Tuovinen et al. 2008; Hellqvist 1998).

The life history of the three currant-infesting moths has been investigated in detail (Heikinheimo 1978; Hellqvist 1981, 1990; Hellqvist et al. 2006; Scott and Harrison 1979). They are all univoltine and overwinter as larvae inside, on or below the host plant. Depending on species, females lay their eggs on the fruitlets, leaves or bark of *Ribes* spp. and the small larvae feed on these plant parts until they overwinter. After hibernation, they resume feeding before pupation occurs on the plant or on the ground. In the spring, each larva of the bud moth and the shoot borer can consume 2–3 buds, and high population densities of these species can result in severe yield reduction (Öberg 2012). Feeding and tunnelling by clearwing larvae cause weakening and breakage of twigs and shoot dieback, resulting in yield loss. Adult flight and mating occur during the early summer months for all three pests, but detailed information about the flight phenology of each species in currant fields in northern Europe is currently lacking. Due to their cryptic lifestyle, with larval feeding inside shoots and branches, these pests are difficult to control with chemical or biological insecticides. In addition, as the damage caused by the different moth species is difficult to distinguish, and protocols used for estimating damage on currant bushes do not include species identification of larvae, detailed information about the species composition in individual currant fields has been lacking.

Currants are one of a few berry crops that can produce high yields also when cultivated at higher latitudes. The crop has been a small but important niche product in Finland, Norway and Sweden for a long time, despite small growing areas compared with global markets. However, the total production area in this region has decreased from ≈3000 to ≈2000 ha during the last two decades, mainly due to a drastic reduction in the crop area in Sweden (FAO 2024). Several factors have contributed to this rapid decline, but the most important reason is the increase in damage caused by the lepidopteran pests mentioned above, for which there are no efficient pesticides available (Öberg 2012). Previously, application with insecticides early in the spring to kill the small larvae during their dispersal to new feeding sites had some effect on the pest populations (Hellqvist 1981), but due to new stricter regulations on pesticide use, these plant protection products are now banned, although Norway and Finland still allow use of pyrethroids. The only available control method for organic currant production is application with *Bacillus thuringiensis* (Swedish Board of Agriculture 2024), which is not sufficiently efficient. The lack of robust pest management tools and competition from other currant-producing countries with lower production costs and less strict regulations on pesticide use make Nordic berries less competitive on both the regional and global market.

Moths rely on female-produced long-range sex pheromones to facilitate mate-finding, and these chemical signals are exploited in integrated pest management (IPM) for detection, monitoring and control of many important agricultural pests globally (Rizvi et al. 2021). The sex pheromones of the moths associated with currant cultivation in northern Europe have also been investigated. The identification of the pheromone of the clearwing, the most widespread species, has received a lot of attention (e.g., Voerman et al. 1984; Priesner et al. 1986; Szöcs et al. 1985, 1990, 1991), and a 97:3 blend of (*E,Z*)-2,13-octadecadienyl acetate and (*E,Z*)-3,13-octadecadienyl acetate has been characterised. The sex pheromone of the shoot borer, the major pest on currants in northern Europe, consists of (*Z,Z*)-9,11-tetradecadienol and the corresponding acetate and aldehyde in a 100:26:13 ratio (Löfstedt et al. 2004), and recently Svensson et al. (2023) revealed the sex pheromone of the bud moth to be a blend of (*E*)-11-tetradecenyl acetate and (*Z*)-11-tetradecenyl acetate with a 25:75 to 50:50 ratio. Commercial lures are available for the shoot borer and the clearwing, and efficient monitoring of the bud moth is possible by using commercial lures for the large fruit-tree tortrix *Archips podana* (Scopoli) (Tortricidae) (Tuovinen 1989) as these two species use sex pheromones with very similar chemical compositions (Persoons et al. 1974). Whereas pheromone-based mating disruption has been employed successfully for the clearwing, for example, in New Zealand (Thomas and Burnip 1991; Suckling et al. 2005), attempts to control populations of the other two pests with this technique have been restricted to recent pilot studies (O. Anderbrant et al. 2025).

In this study, we used pheromone-baited traps to monitor the bud moth, the shoot borer and the clearwing in 28 individual black currant (*R. nigrum*) fields in Finland, Norway and Sweden during 2021–2024 to collect information about the geographic distribution, relative abundance and flight phenology of these species. We also estimated overall moth-induced damage in these fields and performed correlation analyses to check how catches of adults and infestation levels were related both within and between generations of the moth species in search of patterns to predict present and future pest pressures in the crop fields.

2 | Materials and Methods

2.1 | Field Sit

Ten *R. nigrum* fields per country were selected in Finland, Norway and Sweden, including both conventional and organic production (Figure 1). The fields were relatively small, ranging from 0.3 to 5.2 ha, and in most fields a single cultivar was grown, but at three sites several cultivars were used (Table 1). No pesticides to control the currant moths were applied in these fields, except for FIN9 in 2021, when the pyrethroid Karate Zeon was used. One site each in Finland and Sweden was only used during the initial year 2021 because the farmers in charge of these fields dropped out of the project. In addition, one field in Sweden and six fields in Finland were not included in 2024. Thus, data from

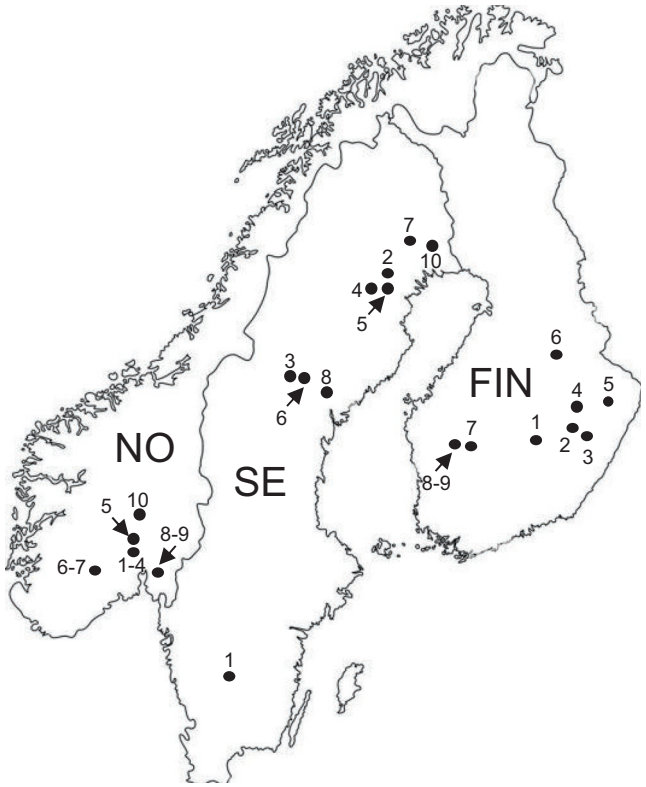

FIGURE 1 | Location of black currant crop fields in Finland (FIN), Norway (NO) and Sweden (SE) included in this study.

all 4 years were collected from 21 fields, and data from 2021 to 2023 were collected from seven additional fields (Table 1).

2.2 | Traps and Lures

Two types of delta traps with replaceable sticky inserts were used for monitoring the three currant moths. Transparent RAG plastic traps from Csalomon (Plant Protection Institute, Hungarian Academy of Sciences, Budapest, Hungary) were used in 2021, and white plastic Biobest traps (Borregaard BioPlant/Biobasiq, Malmö, Sweden) were used during the remaining years of the study. For the field experiments in 2021, rubber septa loaded with the attractive blend for each of the three moth species were purchased from BioChemTech IPM (Amsterdam, the Netherlands), the load comprising at least 3 mg of active ingredients according to the manufacturer. The baits for the shoot borer were not functional, however, and for the remaining years of the study, lures for this species were instead purchased from Pherobank (Wijk bij Duurstede, the Netherlands) with a 0.14 mg/lure dose, whereas we continued to use baits from BioChemTech IPM for the other two species.

2.3 | Trap Deployment

In each crop field, four clusters of three pheromone traps (one trap per moth species) were placed approximately 50 m from each other in the middle of the field. In smaller fields, the distance between trap clusters was shorter. Traps were placed at 1 m height in currant bushes, attached to branches with a metal wire. Traps for all three species were placed in the fields in late May or early June, at the time of flowering, and removed from the fields in late July to mid-August. Traps were checked approximately every week in 2021 and approximately every second week during the remaining years of the study. Sticky inserts were replaced at each trap check. The trap baits were replaced after 4 weeks. In 2021, traps baited with lures for all three moth species were used in all crop fields. If no or few males of a pest were captured in a field during 2021–2022, no traps for that species were used in that specific field during the remaining years of the study (see Table 1). For each site, total catch per species was used in the statistical analyses.

2.4 | Phenology Estimates

The flight phenology of each moth species was estimated using cumulative catches. For each site, a mean curve based on weekly/biweekly catches across years was generated, and these individual curves from all sites within a country were then used to produce an average flight curve for that country. To test if the flight phenology of a species differed between countries, data from individual fields on the timing of peak flight, that is, the week when trap catch exceeded 50% of the total catch, were collected, and mean values across years per site were used in a Kruskal–Wallis test to compare the peak flight between countries for a given species. In Sweden, the southernmost site differed greatly in catch data compared to the northern sites and was not included in the statistical analyses. Catches of the clearwing were generally poor at the northern sites in Sweden, with a maximum seven males captured at a site and year, and many sites had zero catches. Thus, no phenology analysis was performed for the clearwing in northern Sweden. In addition, data for sites with ongoing mating disruption experiments for the bud moth and the clearwing were excluded, whereas such data for the shoot borer were included in the analyses because the treatment had no discernible effect on trap catches of that species (O. Anderbrant et al. 2025).

2.5 | Catch Data

To check if the abundance of the three currant pests varied significantly during the 4 years of the study, the pooled annual catches of a species were compared among years using a Kruskal–Wallis test. In addition, Pearson correlation analyses were performed using catch data between years to predict future abundance in the crop fields. Analyses were performed on each species separately and on the pooled catches for all three species. For sites where mating disruption experiments had been performed for the bud moth and the clearwing, catch data for that year and the next year were excluded from these analyses. Also, catch data for the shoot borer in 2021 were excluded due to malfunctioning lures (see above).

2.6 | Damage Estimates

Visual inspection of currant bushes was performed in late May or early June along eight transects of 10 m in each crop field to estimate damage caused by the moth pests. Four transects

TABLE 1 | General information about the black currant fields included in this study, and which years the pests *Euhyponomeutoides albithoracellus* (Ea), *Lampronia capitella* (Lc) and *Synanthedon tupiliformis* (St) were monitored using pheromone traps.

Field	Country	Cultivar	Management	Coordinate N	Coordinate E	Area (ha)	Isolation (m)	2021[a]	2022	2023	2024
FI1	Finland	Titania	Conventional	62.2278	27.4507	2.6	600	Ea, Lc, St	Ea, Lc, St	Lc, St	
FI2	Finland	Ben Tron	Organic	62.3745	29.3836	0.5	300	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St
FI3	Finland	Mortti	Organic	62.2274	29.6664	1.5	250	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	
FI4	Finland	Titania	Organic	62.6536	29.6987	1.1	150	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St
FI5	Finland	Mortti	Conventional	62.6322	30.9122	1.0	200	Ea, Lc, St	Ea, Lc, St	Ea, Lc	
FI6	Finland	Mikael, Marski	Conventional	63.7080	28.9073	3.0	> 10,000	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	
FI7	Finland	Ben Tron	Conventional	62.3309	24.9261	3.0	250	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	
FI8	Finland	Mortti	Conventional	62.3760	24.2014	0.7	100	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St
FI9	Finland	Öjebyn	Conventional	62.3871	24.1874	0.6	250	Ea, Lc, St	Ea, Lc, St	Ea, Lc, St	
NO1	Norway	Narve Viking	Organic	59.8793	10.2888	1.8	0	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO2	Norway	Ben Tron	Conventional	60.0751	10.1808	1.8	0	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO3	Norway	Ben Tron	Conventional	60.0800	10.1876	0.9	0	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO4	Norway	Ben Alder	Conventional	60.0860	10.2243	1.3	500	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO5	Norway	Ben Tron	Conventional	60.1751	10.3458	5.2	> 1000	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO6	Norway	Narve Viking	Conventional	59.5577	9.2125	2.4	350	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO7	Norway	Narve Viking, Ben Tron	Conventional	59.5490	9.2077	1.0	780	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO8	Norway	Narve Viking	Conventional	59.5019	11.6735	4.2	> 1000	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO9	Norway	Narve Viking	Conventional	59.6055	11.3514	1.5	> 1000	Ea, Lc, St	Lc, St	Lc, St	Lc, St
NO10	Norway	Ben Tron	Conventional	60.7654	10.9262	0.3	0	Ea, Lc, St	Lc, St	Lc, St	Lc, St
SE1	Sweden	Benalder, Benconon	Conventional	57.8486	14.2988	0.6	175	Ea, Lc, St	Lc, St	Lc, St	Lc, St
SE2	Sweden	Hildur	Conventional	65.7253	21.6194	0.3	> 10,000	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc
SE3	Sweden	Innat	Organic	63.4550	16.7479	1.3	700	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc
SE4	Sweden	Hildur	Organic	65.5049	21.5081	1.0	500	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc
SE5	Sweden	Hildur	Organic	65.5352	21.1947	0.4	300	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc
SE6	Sweden	Innat	Organic	63.4512	16.8293	2.5	600	Ea, Lc, St	Ea, Lc, St	Ea, Lc	

(Continues)

TABLE 1 | (Continued)

Field	Country	Cultivar	Management	Coordinate N	Coordinate E	Area (ha)	Isolation (m)	2021[a]	2022	2023	2024
SE7	Sweden	Innat	Organic	66.5346	22.7531	0.9	4000	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc
SE8	Sweden	Hildur	Organic	63.1486	17.7323	1.5	> 10,000	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc
SE10	Sweden	Innat	Organic	66.3106	23.5509	4.5	> 10,000	Ea, Lc, St	Ea, Lc, St	Ea, Lc	Ea, Lc

[a]In 2021, malfunctional lures for *L. capitella* were used. One site each in Finland and Sweden was only used in 2021 and not included in the list.

were at the positions of the trap clusters, and the remaining transects were at the corners of the crop field (second row and 10 m from the field edge). All bushes within a transect were inspected. Damage scores, ranging from 0 to 10, were based on the percentage of dead or severely damaged shoots (0: no visible damage; 1: 1%–10% dead/damaged; 2: 11%–20% dead/damaged and so on up to 10: > 90% dead/damaged). Due to a strong edge effect during the inspections 2021–2023 in the Finnish fields, only data from the four interior transects were used for these fields. The mean value of the damage scores from the four or eight transects per site was then calculated. Kruskal–Wallis tests were applied to compare the annual damage scores across countries as well as the damage scores between years within a country. In addition, correlation analyses were applied to analyse the damage scores in individual crop fields between years. For sites where mating disruption experiments had been performed for the bud moth and the clearwing, damage data from the year after such experiments were not included in the statistical analyses.

2.7 | Relating Catch Data to Damage Estimates

Pearson correlation analyses were performed to study the relationship between damage scores and abundance of a currant pest in a crop field, based on total catches over the season for each species and for all species present at a site. Data for each country were analysed separately. For fields with ongoing treatment for mating disruption of the bud moth and the clearwing, catch data for these species were excluded from the analysis. Because the shoot borer was not affected by the treatment for mating disruption, the catch data from such fields were included in the analyses of this species. Catches of a pest were related to damage both during the same year (within generation analysis) and during the subsequent year (between generation analysis) to evaluate the predictive value of catch data in relation to damage.

3 | Results

3.1 | Geographic Distribution and Relative Abundance of the Three Currant Pests

The relative species composition of the three pests surveyed was different in Finland, Norway and Sweden. The most widespread species was the shoot borer, which was observed at all sites, and the catch data also indicated that this species is the most abundant pest in Nordic currant fields (Figure 2). The second most widespread species was the clearwing, which was observed in relatively high numbers at all sites in Finland and Norway, and at the southernmost Swedish site. In northern Sweden, the species only occurred sporadically, with a maximum seven males trapped at a given site and year, and at three sites, no clearwing males were trapped during the first 2 years of the study. In 2023–2024, no pheromone traps for this species were used in these fields (Table 1). At some sites in Finland and northern Sweden, stray catches of another clearwing species, *Synanthedon culiciformis* (L.), were observed in traps aimed for *S. tipuliformis*. Finally, the bud moth was not detected at any site in Norway or at the southernmost site in

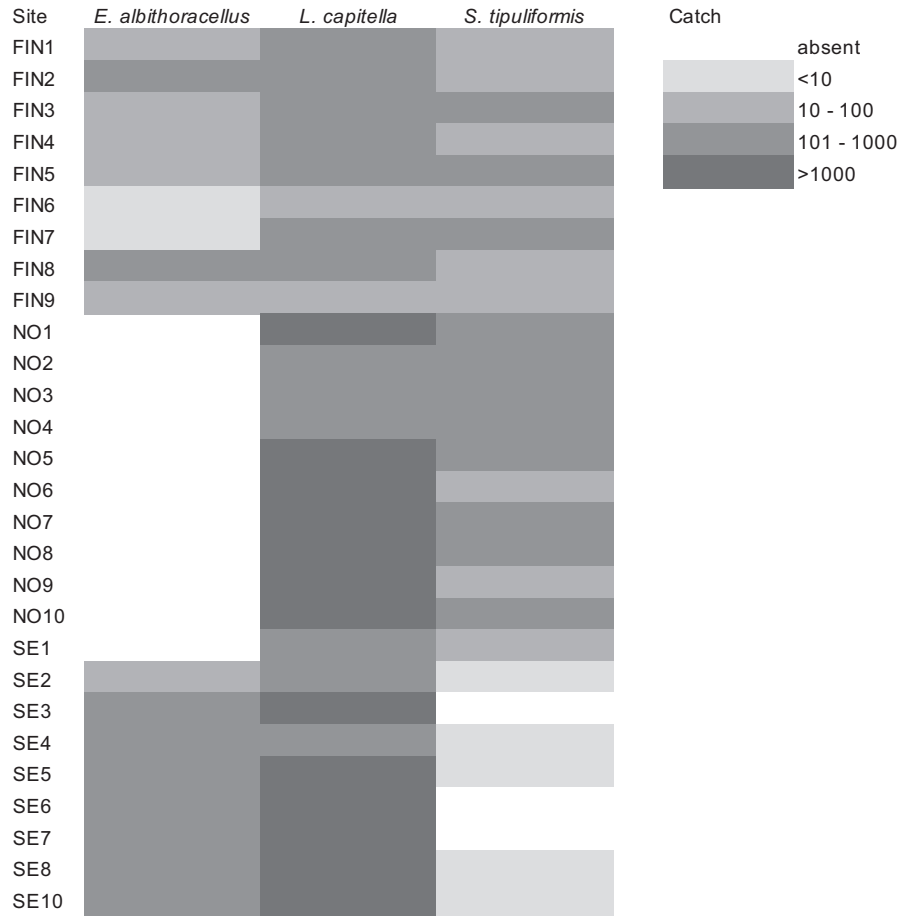

FIGURE 2 | Presence and relative abundance of the currant pests *Euhyponomeutoides albithoracellus*, *Lampronia capitella* and *Synanthedon tipuliformis* in 28 black currant crop fields in Finland (FIN), Norway (NO) and Sweden (SE) based on mean total annual catches of males in pheromone-baited traps (see Table 1 for information on which years a site was included in the study).

Sweden in 2021, and no traps for that species were used at these sites in 2022–2024. In Finland, this pest was detected at all sites, but in some fields at very low numbers. In northern Sweden, it was observed in relatively high numbers. The other species attracted to this lure, *A. podana*, was trapped in high numbers at most sites in Norway as well as in south Sweden in 2021.

3.2 | Phenology of Currant Pests

Catch data revealed different flight periods for the three moth species. The first to appear in all three countries was the shoot borer. In Norway, and at the southernmost site in Sweden, high catches of males were observed already at the first trap check in early June. In contrast, the peak flight in northern Sweden and Finland occurred several weeks later (Figure 3a) and differed significantly from the peak flight in Norway ($p \leq 0.001$). A different pattern was observed for the clearwing, with the peak flight at the Norwegian sites being several weeks later than at the southernmost Swedish site, but highly synchronised with the Finnish sites ($p > 0.05$; Figure 3b). The few catches of this species in northern Sweden indicated that the flight period at these sites was the same as in Finland and Norway. Finally, the bud moth had a flight period from mid-June to late July and catch data from Finland and Sweden were highly synchronised ($p > 0.05$; Figure 3c). For all sites included in the study, most catches of all three pests occurred within a month, but there was a slight variation between years in the timing of the flight period (±1–2 weeks) for each species and region.

3.3 | Pest Population Fluctuations Among Years

A significant relationship in trap catches between two consecutive years was observed in most of our correlation analyses and for all three pest species investigated (Table 2, Figure S1). For the bud moth, a strong positive correlation was found for catch data 2021 versus 2022 ($p < 0.001$) and for 2022 versus 2023 ($p = 0.003$), whereas a negative relationship was observed for catch data 2023 versus 2024, but only three sites were included in that analysis. For the shoot borer, a positive correlation was found for catch data 2022 versus 2023 ($p = 0.034$), whereas no significant relationship was found for catch data 2023 versus 2024 ($p = 0.896$). For the clearwing, a strong positive correlation was found in all between-year analyses (2021 vs. 2022, $p < 0.001$; 2022 vs. 2023, $p = 0.005$; 2023 vs. 2024, $p = 0.008$). Finally, when pooling catches for all species, there was a strong positive correlation for catch data 2022 versus 2023 ($p = 0.010$), but not for 2023 versus 2024 ($p = 0.416$), due to the strong influence of the weakly correlated catches of the shoot borer in these years (Table 2).

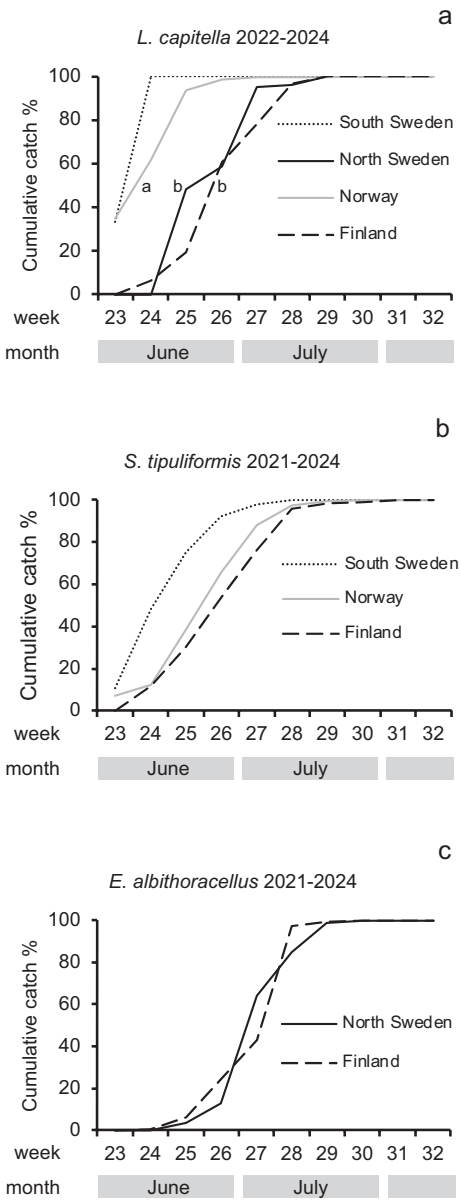

FIGURE 3 | Flight phenology of *Euhyponomeutoides albithoracellus*, *Lampronia capitella* and *Synanthedon tipuliformis* in black currant fields in Finland, Norway and Sweden based on cumulative catches of males in pheromone-baited traps. In Sweden, the southern site differed greatly in flight phenology of *L. capitella* and *S. tipuliformis* compared to the northern sites and was treated as a separate unit and not included in the statistical analyses. For *L. capitella*, peak flight for populations in Norway occurred signficantly earlier ($p \leq 0.001$) than populations in Finland and northern Sweden (as indicated by different letters), whereas no difference in flight periods among regions was observed for the other two pest species.

3.4 | Crop Damage Estimates

The mean damage scores at individual sites in this study ranged from 0 to 9. There were no significant differences ($p > 0.05$) in infestation levels between countries in any of the 4 years of the study, but damage tended to be higher in Swedish fields 2023 ($p = 0.056$). Neither were there any between-year differences in damage scores within any of the three countries (Figure 4). In contrast, when using pooled data from all countries, there was a strong positive correlation in infestation levels in all between-year analyses (Figure 5).

3.5 | Relating Catch Data to Damage Estimates

The correlation analyses did not reveal a consistent pattern for the different pest species regarding the relationship between trap catch and damage scored earlier during the same year or damage scored during the subsequent year (Figures S2–S4). We found a strong positive correlation between catches of the bud moth 2021 and damage the next year ($p = 0.003$), and a similar between-generation pattern was observed also for the other years of the study (Table 3). In contrast, no significant relationship was found in any of the within- and between-generation analyses for the other two pests, except for the shoot borer catches 2022, which were positively correlated with damage 2023 ($p = 0.033$) (Tables 4 and 5). Finally, analyses of the pooled trapping data revealed a significant positive relationship between catches 2022 and damage the following year ($p = 0.009$) (Table 6, Figure S5).

4 | Discussion

Our study using pheromone-baited traps generated novel information regarding the geographic distribution of three major pests in *R. nigrum* fields in Finland, Norway and Sweden. Whereas the shoot borer was found at all 28 sites, the other two species were less widespread (Figure 2). In Norway and southern Sweden, the bud moth was not detected at all, and our catch data indicate that the clearwing only occurs sporadically in crop fields in northern Sweden, whereas this species seems to be more common in currant fields in Norway than was known before. At half of the sites, all three moth species coexisted, and at the remaining sites, two species were found. Thus, all sites had a combination of pests causing damage to the crop, and the species composition differed between regions. This information should be considered when planning pest management tactics in the different currant-producing regions. Based on the number of males trapped, our study indicated that the shoot borer was the most abundant species at all sites (Figure 2). Thus, finding efficient control methods for this species is a key to improving plant protection and increasing the berry yields in currant fields in the Nordic countries in the future.

Our flight phenology estimates based on the catch data showed that the shoot borer is the first species to appear in the crop fields, followed by the clearwing and the bud moth (Figure 3). At the sites in Norway and southern Sweden, adults of the shoot borer were often observed in the field when monitoring traps were installed, and catches of males often peaked at the first trap check. Thus, the onset of the flight period of the shoot borer in these regions may have started 1 or 2 weeks earlier. Interestingly, our catch data indicated that the flight of shoot borer populations in Finland occurs several weeks later than in Norway, whereas the flight of clearwing populations in the two countries were highly synchronised, indicating that different factors may determine the timing of adult phenology in these two moth species. Our

TABLE 2 | Summary of correlation analyses on total catches between years in individual *Ribes nigrum* crop fields for the moth pests *Euhyponomeutoides albithoracellus*, *Lampronia capitella* and *Synanthedon tipuliformis* in this study.

Species	Parameter 1	Parameter 2	Pearsons corr. coefficient	*N*	*p*
E. albithoracellus	Catch 2021	Catch 2022	0.821	14	<0.001
E. albithoracellus	Catch 2022	Catch 2023	0.861	9	0.003
E. albithoracellus	Catch 2023	Catch 2024	−0.997	3	0.045
L. capitella	Catch 2022	Catch 2023	0.425	25	0.034
L. capitella	Catch 2023	Catch 2024	−0.030	21	0.896
S. tipuliformis	Catch 2021	Catch 2022	0.935	12	<0.001
S. tipuliformis	Catch 2022	Catch 2023	0.841	9	0.005
S. tipuliformis	Catch 2023	Catch 2024	0.847	8	0.008
All species	Catch 2022	Catch 2023	0.508	25	0.010
All species	Catch 2023	Catch 2024	0.188	21	0.416

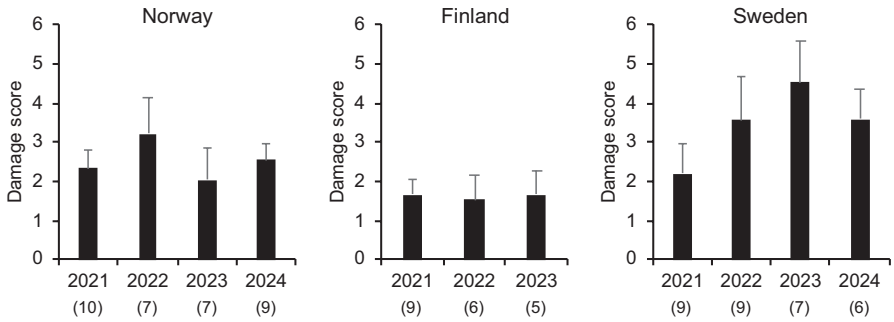

FIGURE 4 | Damage scores (mean + SEM) of moth pests in black currant crop fields in Finland, Norway and Sweden in different years of the study. The number of fields used in each country and year are shown in brackets. Only three fields were censused in Finland in 2024 and thus not included.

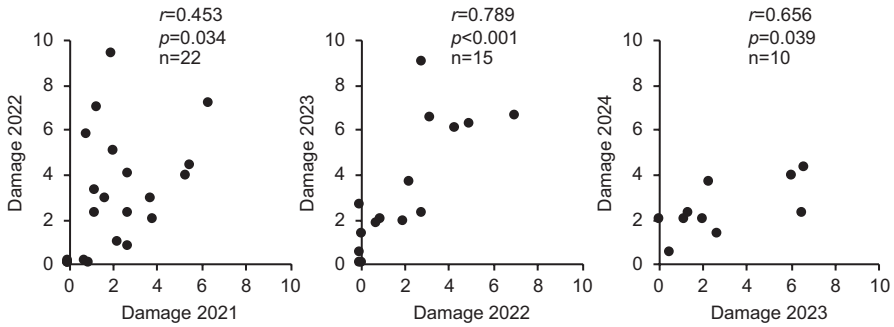

FIGURE 5 | Between-year correlations of damage scores of moth pests in black currant crop fields in Finland, Norway and Sweden.

data show that most catches of all three species occur within a 4-week period in the same field and year. Interestingly, previous catch data for the shoot borer from one of the Swedish sites (SE5), collected in 2003 by Hellqvist et al. (2006), allowed us to compare the flight periods and possible shift in the phenology of this species over the last two decades due to a warmer climate. In contrast to the advanced phenology documented for many species (e.g., Roy and Sparks 2000; Fitter and Fitter 2002; Willems et al. 2022), we found no difference in the timing of first or peak appearance of the shoot borer in our study versus Hellqvist et al. (2006).

We found that trap catches of a pest species in individual currant fields often correlated significantly between years, indicating that catches in pheromone-baited monitoring traps can provide important information about the pest pressure the following year (Table 2). The pattern was, however, not consistent among years and may be influenced by both abiotic and biotic factors, for example, variation in winter mortality and abundance of natural enemies of the pests (Hellqvist 1990). Similarly, we found that the infestation levels correlated significantly in all between-year analyses (Figure 5). By combining the use of monitoring traps and visual inspection of damage on currant

TABLE 3 | Summary of within-year or between-year correlations of total catches of *Euhyponomeutoides albithoracellus* and damage scores in individual *Ribes nigrum* crop fields in this study.

Parameter 1	Parameter 2	Pearsons corr. coefficient	*N*	*p*
Damage 2021	Catch 2021	0.411	18	0.091
Catch 2021	Damage 2022	0.705	15	0.003
Damage 2022	Catch 2022	0.710	11	0.014
Catch 2022	Damage 2023	0.552	11	0.078
Damage 2023	Catch 2023	0.450	7	0.311
Catch 2023	Damage 2024	0.995	3	0.064
Damage 2024	Catch 2024	−0.991	4	0.001

TABLE 4 | Summary of within-year or between-year correlation of total catches of *Lampronia capitella* and damage scores in individual *Ribes nigrum* crop fields in this study.

Parameter 1	Parameter 2	Pearsons corr. coefficient	*N*	*p*
Damage 2022	Catch 2022	0.339	22	0.123
Catch 2022	Damage 2023	0.553	15	0.033
Damage 2023	Catch 2023	0.028	19	0.908
Catch 2023	Damage 2024	−0.142	14	0.628
Damage 2024	Catch 2024	−0.018	15	0.948

TABLE 5 | Summary of within-year or between-year correlation of total catches of *Synanthedon tipuliformis* and damage scores in individual *Ribes nigrum* crop fields in this study.

Parameter 1	Parameter 2	Pearsons corr. coefficient	*N*	*p*
Damage 2021	Catch 2021	0.170	20	0.474
Catch 2021	Damage 2022	0.464	14	0.095
Damage 2022	Catch 2022	−0.002	10	0.996
Catch 2022	Damage 2023	0.180	13	0.557
Damage 2023	Catch 2023	0.057	10	0.875
Catch 2023	Damage 2024	−0.399	8	0.327
Damage 2024	Catch 2024	−0.548	10	0.101

TABLE 6 | Summary of within-year or between-year correlations of total catches of *Euhyponomeutoides albithoracellus*, *Lampronia capitella* and *Synanthedon tipuliformis* and damage scores in individual *Ribes nigrum* crop fields in this study.

Parameter 1	Parameter 2	Pearsons corr. coefficient	*N*	*p*
Damage 2022	Catch 2022	0.249	22	0.264
Catch 2022	Damage 2023	0.583	19	0.009
Damage 2023	Catch 2023	0.043	19	0.862
Catch 2023	Damage 2024	0.188	15	0.448
Damage 2024	Catch 2024	−0.181	15	0.518

bushes, reliable predictions of future pest pressure may be possible. It would also be desirable to combine these methods with dissections of twigs and estimates of the species composition of larvae feeding on the bushes to enable more detailed analyses of the relative abundance of the different moth species in individual fields.

A less consistent pattern was observed when relating trap catches of individual pest species with the damage scored earlier the same year (within generation) or the following year (between generations). Catches of the bud moth correlated with damage estimates in most of these analyses (Table 3), whereas no consistent pattern was observed for the other two species (Tables 4 and 5), which indicates that the bud moth may contribute more to the observed crop damage than previously thought. When using pooled catch data for all three species, we found a significant relationship between catches 2022 and damage 2023, but such a pattern was not observed for the remaining between-generation analyses (Table 6). In summary, we found no consistent association between trap catches and moth-induced damage that could be used to predict future pest pressure in the currant fields.

Since the larvae of the three currant pests investigated feed inside shoots and branches of the plants and are difficult to observe, the relative abundance of these moths in individual crop fields in northern Europe has been unknown. However, commercial lures are now available for monitoring of all three

species, facilitating the development of standardised protocols for long-term monitoring of these pests in currant fields. Our study shows that monitoring with pheromone traps is a relatively cheap and easy method that can give detailed information about the presence and flight period of the moth species, which in combination with estimates of crop damage can be used to predict future infestation levels. Pheromone traps can also help evaluate the effect when testing different methods of moth control in IPM. Finally, optimising mating disruption protocols for the three pests may offer an environmentally friendly method to reduce pest pressure and increase berry yield in Nordic currant cultivation in the future. Indeed, recent mating disruption experiments in the region have revealed the potential to use this control tactic against the clearwing and the bud moth (O. Anderbrant et al. 2025).

Author Contributions

Glenn P. Svensson: conceptualization, formal analysis, funding acquisition, investigation, visualization, writing – original draft. **Hanh Huynh:** investigation, writing – review and editing. **Ann-Kristin Isaksson:** funding acquisition, investigation, writing – review and editing. **Line Beate Lersveen Myhre:** investigation, writing – review and editing. **Christer Löfstedt:** conceptualization, funding acquisition, writing – review and editing. **Sigrid Mogan:** funding acquisition, investigation, writing – review and editing. **Elisabeth Öberg:** investigation, writing – review and editing. **Marja Rantanen:** funding acquisition, investigation, writing – review and editing. **Nina Trandem:** writing – review and editing. **Olle Anderbrant:** conceptualization, data curation, formal analysis, funding acquisition, investigation, visualization, writing – original draft.

Acknowledgements

We thank the currant growers for access to their crop fields, and for helping us with checking traps. We also thank Johanna Jonasson, Markus Karlsson, Aulis Leppänen, Karri Pasanen and Saara Tuohimetsä for field assistance, Erling Jirle for logistics support and Pål Axel Olsson for identification of *Synanthedon culiciformis*. This study was supported by grants from the Swedish Farmers' Foundation for Agricultural Research (grant number O-20-20-452), the Research Council of Norway (grant number 34631/L10) and the European Agricultural Fund for Rural Development (EAFRD) (grant number 145143).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The trap catch and damage estimate data have been deposited in the DORIS database at the Swedish National Data Service at the following link: https://doi.org/10.5878/vrak-4t29 (to be active at publication). Temporary link for inspection: https://snd.gu.se/en/catalogue/dataset/preview/e40a3a7c-9218-4715-ac83-d783a0aec033/1.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.